



TITLE:

**3x660 MW NABINAGAR STPP
TECHNICAL SPECIFICATION FOR
MISCELLANEOUS FGD TANKS**

SPECIFICATION No: PE-TS-457-167-A101

SECTION-I, SUB-SECTION-C1

REV. 00

DATE: FEB.2020

SUB SECTION-C1A

SPECIFIC TECHNICAL REQUIREMENT-TANKS

	TECHNICAL SPECIFICATION FOR MISCELLANEOUS FGD TANKS 3X660 MW NABINAGAR STPS	SPECIFICATION NO. PE-TS-457-167-A101	
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1.0 SCOPE OF SUPPLY

- 1.1 Steel tanks fabricated and supplied at site under this specification shall be as per enclosed FGD Tank schedule (Section-III, Annexure-8) and GA drawing of miscellaneous FGD tanks (Annexure-III, sub Section-D, Section-I). Modifications may be made by the bidder to suit good engineering practice to the satisfaction of the customer. The customer, however, reserves the right to reject any modifications.
- 1.2 General design, selection of rubber materials, construction features, manufacturing, shop inspection, testing at manufacturer's works, surface preparation, lining, inspection & testing of the lined surface at Nabinagar site. For detail specification of rubber lining refer Sub Section-C1-B, section-1.
- 1.3
 - a) The connections and accessories which are required to be supplied with each tank by the bidder shall be as indicated in the enclosed FGD Tank schedule (Section-III, Annexure-8) and GA drawing for Miscellaneous FGD tanks.
 - b) The piping material inside the tank shall be supplied by the bidder. All inlet piping shall be extended up to the bottom of the tank and the clearance between the bottom of the tank and the edge of the inlet piping shall be kept as 500 mm (maximum). The inlet pipes shall be lined with replaceable wear resistant natural rubber lining of minimum 10 mm thickness. Additional thickness of 2 mm in rubber lining shall be provided at bends.
 - c) The inside piping shall be adequately supported and shall be provided with adequately sized vent connection at pipe top.
 - d) Weir plates of adequate thickness (minimum 8 mm) shall be provided for all inlet piping.
 - e) Pad plates on the tanks for supporting outside piping shall be provided by the bidder. Details of the pad plates (sizes, quantity etc.) shall be informed to bidder during detail engineering.
 - f) Fabrication and supply of all flanges and counter flanges for all nozzles of tank connections shall be included in the scope of work of the bidder. Necessary bolts, nuts and gaskets for these connections shall also be supplied by the bidder. Further rubber lining of these nozzles including flanges, counter-flanges shall be in bidder's scope of work.
 - g) The manhole shall be of hinged and bolted type with nuts, bolts and gaskets in bidder's scope of supply. The size of the manhole shall be minimum 800 mm if not specified in the respective GA drawings (Annexure-III, sub Section-D, Section-I).
 - h) Supply and erection of vent valves shall be in bidder's scope.
- 1.4 The scope of works shall also include supply and installation of special accessories including agitator supporting arrangements, agitator platform, baffle plates etc. as indicated in FGD Tank schedule (Section-III, Annexure-8) and GA drawing for Miscellaneous FGD tanks. The necessary fixtures and other accessories for mounting these special accessories shall be included in the scope of work of the bidder.
- 1.5 Baffle plates for the agitators shall be mounted on the tank. The supply and erection of the baffle plates shall be in bidder's scope of work. The minimum no. of baffle plates and minimum dimension

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of the baffle plates have been indicated in the drawing attached with the tank schedule (Section-III, Annexure-8). The final quantity and dimensions of the baffle plates shall be decided during detail engineering.

- 1.6 Quantity and size of spare nozzles as per FGD Tank schedule (Section-III, Annexure-8) and GA drawing for Miscellaneous FGD tanks shall be supplied by the bidder.
- 1.7 Pipes, fittings, nozzles, flanges and counter flanges along with the rubber lining shall be supplied by the bidder. The minimum requirement like quantity, size, type etc. are indicated in the FGD Tank schedule (Section-III, Annexure-8) and GA drawing for Miscellaneous FGD tanks and may undergo change during detail engineering stage and these shall be supplied by the bidder as per the approved drawings / documents for which no commercial implication shall be entertained by BHEL. Material of construction of all pipes, fittings, nozzles, flanges and counter flanges shall be as per tank schedule (Section-III, Annexure-8) and GA drawing for Miscellaneous FGD tanks.
- 1.8 The minimum number of anchor bolts along with the minimum size has been specified in GA drawing for Miscellaneous FGD tanks. However, any additional anchor bolts of higher size if found applicable during detailed Engineering shall be provided by bidder without any commercial implication.
- 1.9 Painting of the tanks is included in bidder's scope of work. Painting specifications of storage tanks are given under Painting schedule in Sub Section-C2-C, section-1. Painting requirement specified under Painting schedule are minimum requirement. Any modification in painting requirement found applicable during detained engineering, shall be under bidder's scope without any commercial implication.
- 1.10 Commissioning spares as required for commissioning of the tanks are in bidder's scope.
- 1.11 Platforms, inter-connecting platforms, platforms for agitator maintenance, monkey ladder inside tank and for agitator platform approach, staircase (hand railing, knee guard and toe guard (in stair case, agitator platform and all along the periphery of roof of the tank) etc. as per the relevant design code / good engineering practice (as indicated in the GA drawing for Miscellaneous FGD tanks/tank schedule) shall be included in bidder's scope of work. All stair tread and platforms shall be made from 8 thk. chequered plate. Roof level interconnection between Limestone slurry tanks shall be done and in bidder's scope of work.

2.0 SCOPE OF SERVICES

Services shall include but not be limited to the followings:

- 2.1 Design, engineering, preparation of detailed fabrication drawings, design calculation, bill of material, tag and piece numbers, welding procedures etc. Stiffeners and other structural framing for supporting the tank shall be designed by the fabricator and properly shown in the fabrication drawings.
- 2.2 Erection & Commissioning of Tanks.
- 2.3 Erection & Commissioning of rubber lining.
- 2.3 Erection of all foundation bolts / anchor bolts etc. as required for any equipment/ foundation /concrete.

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2.4 Minor civil work like chipping of foundation, grouting below base plate for all structures, equipment, grouting of pockets, excavation & filling of earth for buried MS pipes if and as required. 2.5 Inspection & testing and carrying out demonstration test. 2.6 Inspection & testing and carrying out demonstration test for the rubber lining of tanks. 2.7 Painting of tank and other equipment within the battery limit. 2.8 Any other equipment / material / services as required to make the installation complete in all respects shall be deemed to be included in bidder’s scope of work whether mentioned above or not. 3.0 <u>DESIGN CONSIDERATIONS</u> 3.1 The successful bidder shall furnish design calculations to BHEL during detailed engineering stage for approval along with the Xerox copies of relevant pages of authentic supporting literature e.g. Code, Hand book, National / international Standards etc. Calculation shall be necessarily done in SI UNITS only for the followings: - a) Tanks shall be designed as per IS – 803 / API – 650 / AWWA – D 100 / IS –2825 / BS – 2594 / Good engineering practice as applicable and referred code shall be of latest edition. However, requirement of codes and standards shall be as indicated in the GA drawing for tanks b) Weight calculation of plates, appurtenances, platforms & structures separately shall be included in the Design calculation. c) Design of roof and roof structures for vertical storage tanks along with agitators & agitator platforms shall be designed based on guidelines given in the book titled “Process equipment design” by Brownell and Young. d) Tank stability calculation (wind load / seismic / overturning stability) considering static and dynamic loads of Agitator and its platforms and supporting arrangement shall be done as per API – 650/IS-803, latest edition. However, factors / coefficients as required for the design of tank shall be obtained from BHEL by the bidder after placement of order. d) Vent sizing calculation shall be done as per API – 2000, latest edition e) Sizing calculation for vent valve. 3.2 The successful bidder shall indicate references of all the clauses indicating their page number from respective standard in the design calculation during detail engineering stage. All calculations shall necessarily be done in SI units only. All steps including formulas and abbreviations shall be clearly shown in the calculation. All inputs / assumptions shall be indicated in the first sheet of the calculation. 3.3 a) Bottom plate shall be 8.0 mm thick (minimum). Minimum 6 mm (excluding tolerance on plate as per relevant IS) thick plates including corrosion allowance shall be provided for shell plates and			

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minimum 8 mm for roof plates for all tanks. Calculation for the plate thickness shall be got approved from BHEL / Customer during detailed engineering stage. However, if the addition / summation of calculated value of plate thickness (excluding tolerance on plate as per relevant IS) / nominal minimum thickness specified in the relevant design code / standard and corrosion allowance of 1.5 mm comes out more than 6 mm then the nearest available (higher side) plate thickness in the market shall be provided for shell and roof plates without any commercial implication. For calculating shell plate thickness. IS 803 to be used. Further minimum thickness of bottom, shell and roof plates have been specified in the GA drawing for Miscellaneous FGD tanks (annexure-III, sub Section-D, Section-I).

- b) Negative tolerance on plate thickness shall not be considered in the plate thickness calculation and also shall not be provided in the tank. Only positive tolerance shall be considered.
- 3.4 All appurtenances and mountings shall also be designed as per relevant clauses of IS: 803 / API – 650 as per the design code indicated in GA drawing for Miscellaneous FGD tanks (annexure-III, sub Section-D, Section-I).
- 3.5 Tank shall be suitably constructed for safe, proper and continuous operation under all conditions that can be expected in a plant life without undue strain, corrosion or other operating difficulties.
- 3.6 In calculating the minimum plate thickness, the specific gravity of the liquid shall be taken as per tank schedule (Section-III, Annexure-8).
- 3.7 For cylindrical tanks, the plates shall be cold rolled through plate bending machine by several number of passes to true curvature. The flanges shall be made by V-die and the corners welded, provided no cracks are developed.
- 3.8 Vessels seams shall be so positioned that they do not pass through vessel connections. For cylindrical vessels consisting of more than two sections longitudinal seams shall be offset.
- 3.9 Wherever possible, the inside seam weld shall be ground smooth, suitable for application of corrosion resistant primer.
- 3.10 Due consideration shall be given by the supplier for wind load and earthquake effect in the design of tanks.
- 3.11 For the tanks being of diameter larger than 3.75 m added structural supports in the form of rafter shall be provided.
- 3.12 Reinforcement in tanks shall be provided as per design code as indicated in GA drawing for Miscellaneous FGD tanks (annexure-III, sub Section-D, Section-I). The reinforced connection shall be completely pre - assembled into shell plate.
- 3.13 The joint efficiency factor to be adopted for design calculation shall be in accordance with the GA drawing for Miscellaneous FGD tanks (annexure-III, sub Section-D, Section-I).
- 3.14 All roofs and supporting structures shall be designed to support dead load plus a uniform live load of not less than 150 kg/m² of projected area. Further, the static and dynamic loads of the agitator assembly along with the agitator platform shall be considered over and above the uniform live load.

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- 3.15 Staircase / access ladder and hand railing shall be provided as per the relevant codes and standards and tank schedule (Section-III, Annexure-8) & GA drawing for Miscellaneous FGD tanks (annexure-III, sub Section-D, Section-I).
- 3.16 -VOID-
- 3.17 Code conformance for flanges / counter flanges shall be ANSI B 16.5. Code conformance for bolts and nuts shall be SA 193 & 194 respectively. Further, all fasteners used in wetted condition must be of Alloy 926 or better material so that even if it comes in contact with liquid by swelling of rubber, thread remains unaffected. Raw material of fastener must undergo Inter-Granular Corrosion test as per ISO-3651, Part-1 for Nitric Acid test.
- 3.18 The number & size of nozzles (including flanges, counter flanges and inside piping) indicated in the tank schedule (Section-III, Annexure-8) & GA drawing for Miscellaneous FGD tanks (annexure-III, sub Section-D, Section-I) are tentative and bidder guidance purpose only and the same may undergo change during detail engineering stage for which no commercial implication shall be entertained by BHEL.
- 3.19 Bidder shall furnish the STADD calculation along with the roof structure calculation during detail engineering for checking the stability of roof.
- 3.20 The tank shall be designed for filled water head / atmospheric pressure and design temperature for the tank shall be as specified tank schedule (Section-III, Annexure-8) & GA drawing for Miscellaneous FGD tanks (annexure-III, sub Section-D, Section-I)
- 3.21 Bidder to note that surface cleaning shall be of Blast clean type. However, Grit blasting shall be decided during detail engineering for which no commercial implication shall be entertained by BHEL. Further, the surface cleaning of the tanks shall be in line with the requirements specified in the specification for rubber lining (Section-I, Sub Section-C1B)
- 3.22 Bidder to note that foundation drawing along with loading data & anchor bolt details shall be provided by bidder within two weeks' time from the LOI. However, Bidder to provide minimum anchor bolts for the Miscellaneous FGD tanks, as specified in the GA drawing for Miscellaneous FGD tanks (annexure-III, sub Section-D, Section-I).
- 3.23 All materials, furnished shall conform to the latest editions of America National Standard Code for Pressure piping, Power piping, ANSI B311.1, ANSI B16.11, ASME Boiler and Pressure Vessel Codes, IBR and other applicable ASME, ANSI and Indian Standards. Schedule numbers, sizes and dimensions of all carbon steel, stainless steel and alloy seamless steel pipe shall confirm to ANSI B.36.10 and of stainless steel pipe shall confirm to ANSI B 36.19 unless otherwise specified.

4.0 WELDING

- 4.1 Welding shall be in accordance with the requirement of IS: 803, 816, 817 and 823 or equivalent and as specified in the specification for rubber lining (Section-I, Sub-Section-C1B).
- 4.2 Welding sequence shall be adopted in such a way so as to minimize the distortion due to welding shrinkage. Contractor shall indicate in his drawing the sequence of welding proposed by him, which should meet prior approval of the Engineer.



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- 4.3 All welders shall be BHEL / customer / consultant qualified as per the approved quality plan / field quality plan which will be submitted by the successful bidder during detail engineering stage. WPS and PQR shall be submitted by the successful bidder to BHEL / customer / consultant for review and approval.

5.0 TEST AND INSPECTION

- 5.1 The particulars of the proposed tests and the procedure for the tests shall be submitted to the Owner / Engineer for approval before conducting the tests. The successful bidder shall submit FQP (field quality plan) and demonstration test procedure for BHEL / customer / consultant's approval during detail engineering stage. In the event of any change in the field quality plan and demonstration test procedure, the same shall be incorporated by the bidder in the document and approved document shall be adhered by the bidder without any commercial implication.

- 5.2 DPT / MPI on all welds (100%).

- 5.3 All cross / Tee joints and butt welds to be Radio graphed in line with the joint efficiency as specified in the design code / the GA drawing for Miscellaneous FGD tanks (annexure-III, sub Section-D, Section-I).

- 5.4 For the offered tanks, fill test shall be carried out for at least 24 hours. Atmospheric storage tanks on inside surface shall be leak tested before painting.

- 5.5 All quality plans / checklists for various items shall be furnished during detail engineering stage for BHEL / customer's approval and any changes required by BHEL / customer shall be incorporated in the documents and adhered without any price implication. However, minimum requirement of MQP as indicated in the technical specification shall be followed. All necessary items as required for inspection and testing of the tank including instruments shall be arranged by the bidder.

6.0 MANDATORY SPARES:

Not Applicable.

7.0 LIST OF COMMISSIONING SPARES:

SL. NO.	DESCRIPTION OF ITEMS	QUANTITY
1	CAF Gasket of each size	2 nos.
2	Nuts, bolts & washers of each size (nos. of bolts, nuts & washers as required for each nozzle) as per approved Drg.	1 lot
3	Any other item required for successful commissioning of the tanks including rubber lining (to be specified clearly by bidder)	1 lot

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8.0 TERMINAL POINTS

- Matching counter flanges for all nozzles mounted on the tank and its accessories. However, counter flanges for all nozzles of tank shall be provided by the bidder.

9.0 EXCLUSIONS

- 1) Tank foundation & associated civil works, all instruments like level gauges, Level Transmitters, etc are excluded from bidder's scope of work. However, required no. of nozzles for the same shall be in bidder's scope of work.
- 2) The agitator components of all agitators including the agitator of drain pits/ sumps shall be provided as a free issue item to the bidder. The erection and commissioning of the agitators shall be in bidder's scope of work. However, BHEL shall arrange for the supervision of the erection and commissioning of the agitator assembly to the bidder as a free issue service.
- 3) The Sumps/drain pits indicated in the tank schedule (Section-III, Annexure-8) is excluded from bidder's scope of work. However, the erection and commissioning of the agitators and rubber lining within the sump/drain pits shall be in bidder's scope of work.
- 4) All valves are excluded from bidder's scope of work.
- 5) All external piping from the counter flange of the nozzles of respective tanks is excluded from bidder's scope of work. However, matching counter flanges for all nozzle shall be in bidder's scope of work. Further the supply and erection of the piping material inside the tank shall be in bidder's scope. The rubber lining of the inlet pipes shall be in bidder's scope of work.

10.0 DRAWINGS AND DOCUMENTS TO BE SUBMITTED WITH THE BID

The bidder must submit the drawings / documents as mentioned under "CHECK LIST FOR DOCUMENT TO BE SUBMITTED" (In Section-III, Annexure-I) along with their bid. In absence of any of these documents, BHEL reserves right not to evaluate the offer of the concerned bidder.

11.0 DRAWINGS/ DOCUMENTS REQUIRED DURING DETAIL ENGINEERING

The successful bidder shall submit the drawing / documents as mentioned under SECTION-I, Sub-Section-D, Annexure-IV during detail engineering for approval / information / reference (as the case may be).

12.0 OTHER TECHNICAL REQUIREMENTS

- 1) 15 days' time is required by BHEL to offer their comments on the drawings and documents being submitted by the bidder (during detailed engineering stage in the event of L.O.I being placed) from the date of receipt.
- 2) Bidder to depute competent designer (s) at BHEL's office during detailed engineering stage to discuss drawings and other technical documents as and when required by BHEL.
- 3) Bidder to assess the capability of their sub-vendors in terms of preparation of drawings, calculations, documents, quality assurance, supply of material etc. as per project schedule before placing the order on them. No deviations shall be entertained.

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- 4) Commercial implication includes price implication as well as delivery implication.
- 5) Size of hand rails on stairway and tank roof / top shall be minimum 32 NB and shall conform to IS 1239 (M).
- 6) Type of roof for vertical cylindrical storage tanks shall be either supported cone roof or self-supporting cone roof as per latest edition of relevant design code.
- 7) Commissioning of tanks will consist of installation of all accessories of tanks as per approved drawing/specification, charging of tank, water-fill test (for minimum 24 hours after complete filling of tank), satisfactory functioning of all accessories, emptying of tank, subsequent painting of complete tanks and changing of gaskets as per specification requirement.
- 8) Bidder to furnish prices and unit price of each item of proposed tanks as per BHEL's price format only along with the final price bid.
- 9) Bidder shall check that specifications of all the items are available in the NIT specification. However, in the event of absence of specification for any item, bidder will approach BHEL to furnish the specification of missing items and new specification will be adhered by the bidder for which no commercial implication shall be entertained by BHEL.
- 10) All tools and plants including welding machines, crane, hydra, fork lift, batching plant etc. and instruments as required for construction, erection and commissioning, trial run and functional demonstration test at site shall be arranged by the bidder.
- 11) Bidder to furnish list of sub-vendors based on sub-vendor list enclosed with the specification during detail engineering stage for BHEL's / Customer review and approval and items shall be procured from these suppliers only.
- 12) Dealers are not acceptable for any item of the package. Bidder shall procure all items including plates, structural, flanges, counter flanges etc. from BHEL approved sub vendor only. No argument on this account shall be entertained.



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SUB SECTION-C1B

**SPECIFIC TECHNICAL REQUIREMENT-RUBBER
LINING**



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1.0 SCOPE OF SUPPLY

- 1 Design, manufacture, testing and supply of rubber lining material for the duty condition for FGD Tanks as specified in Annexure- 8 (Tank schedule).
- 2 Erection and Commission. Delivery of material at site, surface preparation for lining surfaces, lining the surface to the satisfaction of the customer shall be under bidder's scope, cost for Erection and Commission shall be included in the offer.
- 3 10 copies of Operation manuals containing all details of reference drawings and technical data shall be furnished by the Bidder.

2.0 SURFACE PREPARATION

- 1 The Tanks surface to be lined should be blasted to a bright grey metal finish (Sa 2½ requirement), free from rust, weld marks, oil and any other foreign matter. The blasting is carried out with the help of dry grit (copper sludge)/Sand under dry air pressure of 7 kg/cm² by Compressor. Surface roughness shall be 50-60 Microns.
- 2 After blast cleaning, blasted surface will be applied by surface protecting primer to prevent the corrosion. After 100% blasting of the particular Tank is completed, the surface is cleaned by appropriate solvent, so as to see that all the small dust particles are removed. Sharp corner shall be suitable rounded off. Surface should not have any sharp notch.
- 3 After this procedure suitable bonding agent and 3 to 4 coating of the specially formulated rubber adhesive should be applied for proper bonding of the Rubber Sheets to be lined.
- 4 Compressor and any other facilities required for grit/shot blasting shall be arranged by vendor. Any hoses provided in the compressed air line shall be tested with air before commencement of grit blasting job.
- 5 The grit/shot blasting machine shall be provided with safety valve (safe trip) as a protection against over pressure.
- 6 Scaffolding shall be done by the vendor. Any scaffolding provided by the vendor shall be of steel only.

3.0 GUIDELINES FOR DESIGNING AND FABRICATION OF STEEL CONSTRUCTIONS FOR RUBBER LINING:

1. Please refer Section-II Sub-Section-A

4.0 RUBBER LINING

- 1 The lining shall completely cover the roof, sides and internals of Slurry Tanks, support angle, insert plates, openings, Man Hole / Inspection / Flange openings. etc.,
- 2 The rubber used for the lining of the tank is given below:

Sl. No	Tank	Rubber Lining
1	Auxiliary absorbent tank	Bromine butyl rubber lining with hardness 55±5 (Shore A Hardness).



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2	Limestone slurry Tank, Waste water Tank, Primary hydro cyclone Tank, Secondary Hydro cyclone Tank, Filtrate water Tank, , Process water Tank, Belt Filter Water Tank, Clarified (Cake wash) Water Tank, Absorber Area Drain Pit, Gypsum Dewatering Area Drain Pits, Ball Mill Area Drain Pit.	Bromine butyl rubber lining with hardness 55±5 (Shore A Hardness).
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- 3 After Rubber sheet applied on the surface, rubber sheets should be systematically pressed to the metal surface by the help of mechanical tools like Rubber Rollers and metal thin rollers to remove the air between metal and rubber sheet. All rubber joints are properly overlapped by 25 to 35 mm wide tapered cut rubber sheet. All the joints will be covered by 75 mm X 1.5 - 1.7 mm thick rubber strip.
- 4 Vendor shall specify the shelf life of the rubber material being supplied and shall furnish the storage methods to be followed at site to ensure that the rubber material shall not be spoilt during storage.
- 5 Vendor shall submit the surface preparation and lining procedure to the purchaser for approval. The lining work shall start only after obtaining approval from Purchaser.

5.0 INSPECTION AND TESTING OF RUBBER LINING

- 1 Ageing Test : 70°C for 24 hrs. (IS: 3400 Pt.4)
Change in Tensile Strength: ± 5%
Elongation at break: ± 10%
- 2 Abrasion Test : Wt. loss – Max. 25%
- 3 Tensile Strength : 35 kg/cm² (min) for Bromo Butyl and
40 kg/cm²(min) for Chloro Butyl Rubber
- 4 Elongation at break : ≥ 300% minimum for 4mm thk rubber specimen
- 5 Peeling strength : ≥ 3 N/mm
- 6 Hardness : 55 ± 5° Shore A
- 7 Spark Test : 1.5 KV/ mm
- 8 Lining shall be visually inspected to ensure free from poorly weed out fibers, entrapped air and exposed fires. Defects are to be repaired by sandblasting a generous area around the defected portion and applying a layer of rubber material.
- 9 Spark test shall be carried out at appropriate areas in the presence of Purchaser. Vendor should conduct test as per relevant standards.
- 10 After installation, the Rubber lining shall be subjected to testing at site as per relevant standards. If the performance is found not to meet the requirements as specified, the Rubber lining shall be rectified or replaced by the Vendor without any extra cost to the Purchaser.

5.1 FINISHING & INTERNAL TESTING

- 1 Rubber surface of all flanges and manhole of Equipment will be finished by the mechanical tools to get leakage free surface during commissioning.
- 2 After above finishing, 100% testing will be carried out for continuity by high frequency high voltage spark tester. If there is any puncture, they are checked and rectified as per the standard procedure of repair (Clause 6.1) as mentioned in procedure.

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5.2 REPAIRING PROCEDURE

- 1 Faulty spots on the rubber lining are cut off down to be substrate and the seams of the remaining rubber are beveled.
- 2 Rubber sheet with a broad bevel cut is glued on the substrate laid bare.
- 3 On spots to be repaired of a diameter < 300 mm a second layer of Rubber sheet is glued covering the seams of the first layer.
- 4 Several spots to be repaired in a small area are jointly covered with a second layer of Rubber sheet.

6.0 PERFORMANCE GUARANTEE

The lining material shall be guaranteed for **an uninterrupted minimum life of 25000 hrs.** Performance parameters to be guaranteed by the vendor and tolerances permitted shall be as indicated in the data sheet. Rubber lining or any portion thereof is liable for rejection, if it fails to give any of the guaranteed performance parameters. The lining should be guaranteed for faultless material and workmanship. During Guarantee period any defects noticed due to faulty material and workmanship, shall be rectified by vendor free of cost.

7.0 PACKING

1. The part items of the Rubber lining should be identified by Tag numbers and should be packed as to minimize the possibility of damage during storage or transit. The packing should be suitable for tropical conditions. Vendor should specify the storage requirements for the Rubber lining materials.
2. The list of items identified as dispatch able units shall be furnished along with unit weight and the quantity for preparation of packing slip at BHEL end for dispatch to site and for easy identification, storage and erection at site.
3. Please refer Sub Section- C2 – B, SECTION – I for Packing Procedure.

8.0 DOCUMENTATION

8.1 DATA TO BE FURNISHED BY THE VENDOR AFTER RECEIPT OF PURCHASE ORDER

- 1 List of Drawing and documents to be submitted for review, approval and information with submission dates
- 2 Quality Assurance Plan to be submitted for approval.
- 3 Detailed dimensional General Arrangement drawing of the lining surfaces.
- 4 This drawing shall indicate all the design data and information about the material, scope of work and weight of the material supply, Packing procedure etc.
- 5 Installation, operation and maintenance manual.
- 6 Surface preparation and Lining procedures.



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CUSTOMER SPECIFICATION



TITLE:

**3x660 MW NABINAGAR STPP
TECHNICAL SPECIFICATION FOR
MISC. FGD TANKS**

SPECIFICATION No: PE-TS-457-167-A101

SECTION-I, SUB-SECTION-C2

REV. 00

DATE: FEB'2020

SHEET : 2 OF 1

Sub Section-C2 - A

CUSTOMER SPECIFICATION: TECHNICAL REQUIREMENT

SUB-SECTION-I-M1

FLUE GAS DESULPHURISATION SYSTEM



LOT-IA PROJECTS
FLUE GAS DESULPHURISATION (FGD) SYSTEM PACKAGE

TECHNICAL SPECIFICATION
SECTION-VI
BID DOCUMENT NO.: CS-0011-109(1A)-2

FLUE GAS DESULPHURIZATION (FGD) SYSTEM

1.00.00

GENERAL

The design/specifications/sizing of various plants/systems/equipment offered for Flue Gas Desulphurisation (FGD) System shall comply with the requirements detailed hereinafter:

1.01.00

System Description

The Flue Gas Desulphurisation (FGD) System shall be based on Wet Limestone Forced Oxidation process. The FGD system shall be installed downstream of the Induced Draft (ID) fans (Employer's scope). The flue gas shall be drawn from air preheater outlets of the balanced draft, pulverised coal fired Steam Generator and guided through adequately sized duct work into the specified number of independent gas streams of each Electrostatic Precipitators. The flue gas after the Electrostatic Precipitators shall be led to the suction of the ID fans. The flue gas temperature may approach the economiser outlet temperature of about 300°C in case the regenerative airpreheaters fails to operate. The Contractor shall take this aspect into account while designing the Flue Gas Desulphurisation (FGD) System.

1.02.00

Service Conditions

The Steam Generators, being provided by Employer, are designed to burn pulverised coal having properties as indicated in Sub-section-II-A (Project Information), Part-A, Section-VI. Also HFO/HPS/LSHS and LDO shall be used during startup and at low loads for warm up and flame stabilization as specified in respective Project Information Chapter. The design of Steam Generator shall not call for any oil support for flame stabilization beyond 40 % BMCR load when firing any coal. Further, the frequency and duration for startup and low loads operation may be quite long during the first year of unit commissioning and operation. The Steam Generator has been designed for cyclic/two shift operation. Expected numbers of Steam Generator start-ups during 25 years of design life are as follows:

	Type of Starts	Number of Starts
a.	Hot start (after 8 hours of unit shut down)	4000
b.	Warm start (after 36 hours of unit shut down)	1000
c.	Cold start (after 72 hours of unit shut down)	150

The Contractor, shall take into account the entire characteristics of expected combination of fuels to be fired and the expected numbers of Steam Generator start-



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	ups while designing the FGD system.		
1.03.00	Design Criteria		
1.03.01	The Flue Gas Desulphurisation (FGD) System shall be designed to meet all the conditions specified above. Representative coal and ash analysis for the expected coal and oil are given in Sub-section-II-A (Project Information), Part-A, Section-VI for each project. The FGD system and all the associated auxiliaries shall be designed to comply with the requirements stipulated under 'Guarantee Point' and 'Design Point' conditions indicated in Sub-Section-V, Part-A, Section-VI of the Technical Specification for the respective projects. The values indicated for FGD sizing shall be considered as minimum design criteria. These shall be modified to more conservative values if Contractor experience warrants the same. However, no credit shall be given to the Contractor for this during evaluation of the bids. Utilization of these values in no way relieves the Contractor of his responsibility to meet all the guarantee requirements. The Contractor shall also furnish along with his offer the detailed calculations and data along with his Bid to establish as to how the Bidder will meet the efficiency requirements both at design and guarantee point as specified in FGD sizing criteria.		
1.03.02	The FGD system shall be installed downstream of the ID fans and shall be based on wet Limestone Forced Oxidation Process. The FGD system shall be designed to achieve the required SO₂ capture without the use of oxalic acid or any other additives. The FGD System shall be designed so as to be in operation whenever the Steam Generator is in operation. However, provision shall be made by the Contractor for facilitating operation of unit with emergency FGD bypass. This shall also facilitate the online maintenance of absorber system and associated equipment's. The arrangement of the flue gas system shall allow complete isolation of the absorber from the gas side, with the unit in operation. For this purpose. Motorized Guillotine type gates has be provided at (i) hot gas inlet to Booster Fans, (ii) Outlet of Booster Fans and (iii) in the bypass duct (common Flue Gas Duct going towards the existing Chimney). Further, Quick opening Bi-plane motorized/pneumatic damper along with 2x100% seal air fans shall be provided in the by-pass duct by the Contractor. The same shall also be taken into account while designing the control & logics for the FGD System.		
1.03.03	The wet absorber system shall be designed to maintain the required SO ₂ removal.		
1.03.04	In order to be compatible to all possible modes of operation, the design of the FGD plant shall enable short start-up times, compatible with load changes in the Steam Generator and shall ensure reliable mode of continuous operation.		
1.03.05	The flue gas desulphurization plant (FGD) shall be designed to be operated with limestone as specified in Sub-Section-V, Part-A, Section-VI of the Technical Specification.		
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1.03.06	The FGD and the ancillary facilities shall be suitable for unlimited operation with all transients and at any load point between the minimum and maximum load point of the Steam Generator. Further, the FGD plant shall be suitable for an unlimited operation at any pollutant concentrations between minimum and maximum without exceeding the emission values of SO ₂ emission of less than 100 mg/Nm ₃ (6% O ₂ dry).			
1.03.07	In case of failure of the SG and ancillary equipment, the FGD plant shall be brought automatically to the off-load operation without restriction by the current load case by suitable measures.			
1.03.08	In case of a power failure all items of equipment (e.g. minimum one agitator in absorber and limestone slurry tank, flue gas damper upstream & downstream of FGD, Process water pump & lube oil system of Booster Fan & Ball Mill) which may cause irreversible damage to the FGD System shall be connected to the emergency power supply system to be provided by the Contractor. Bidder shall furnish a list of all such Auxiliaries in their bid proposal.			
1.03.09	In case of shutdown and outage periods, draining and flushing of limestone slurry and gypsum slurry pipe work, tanks and all other items being in contact with limestone slurry or gypsum slurry shall be possible without restriction and without necessity of extensive or unusual preparation and activity. Draining and flushing which are required even during short time outages or an emergency shutdown shall be started automatically and by remote control from the Control Room.			
1.03.10	All items or equipment which are subject to wear, abrasion or failure (e.g. nozzles, pumps, pipe work, etc.) shall be designed and installed for easy replacement, repair and maintenance.			
1.03.11	The design and the construction shall be performed so as to avoid stress corrosion cracking, galvanic or other types of corrosion. Especially when using two different alloys, appropriate measures shall be taken to avoid corrosion. This is subject to approval by the Employer.			
1.03.12	All items of equipment including flue gas ducts, expansion joints, etc. shall be designed considering thermal and mechanical strength as a function of the maximum temperature which might occur in case of a failure of any upstream equipment.			
1.03.13	Waste water which might be generated during flushing and cleaning procedures of the equipment (e.g. lime slurry bins, pipes, trucks, etc.) shall be collected in sump and shall possibly be reused in the wet absorber.			
1.04.00	Justification of Proposed Design			
1.04.01	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.			
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1.04.02	The Bidder shall submit with the offer, comprehensive information on how the L/G ratio, mass balance, spray nozzle cone angle, spray nozzle arrangement, limestone consumption etc. of the proposed design has been arrived at. The Contractor shall also submit alongwith the offer, a detailed write up on the proposed design features with recent design modifications, if any, and their specific advantages over the previous designs.	
1.05.00	Statutory Approval The engineering, design, supply and installation of FGD system and the associated auxiliaries shall comply with the applicable safety code and regulation of the locality where the system is being installed.	
1.06.00	Location & Layout Requirements	
1.06.01	The Contractor shall offer the best design to accommodate the Flue Gas Desulphurisation (FGD) System and Lime stone & Gypsum handling & storage system within the confines of the space available. The location of FGD System and associated facilities shall be decided by the Bidder after visiting the Project site.	
1.07.00	Capital Overhaul of FGD System Employer envisages to carryout the capital overhaul of units once in three (3) years. The design and materials for various equipments/auxiliaries etc. shall be selected by the Contractor keeping in view the above requirement of the Employer, such that no major repairs/replacements, requiring shutdown of the unit, are needed in between the capital overhauls.	
1.08.00	Maintenance	
1.08.01	The Contractor shall provide adequate handling facilities & approach as for carrying out on-line and off-line maintenance of the FGD system and its auxiliaries. In order to carry out on-line maintenance, it shall be possible to readily disassemble, repair and reassemble the equipment supplied in the shortest period.	
1.09.00	Noise level The equivalent weighted average of sound level measured at a distance of 1.5 m above floor level in each elevation and one meter horizontally from the base of any equipments furnished and installed under these specifications, expressed in decibel to a reference of 0.0002 microbar, shall not exceed 85 dB(A).	
2.00.00	EQUIPMENTS AND SYSTEMS SPECIFICATIONS Specified hereafter are the minimum acceptable functional requirements of the Employer, and all components, equipments and systems for the Flue Gas	
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Desulphurisation System shall be designed to cater to these requirements. Compliance to various stipulations of the Technical Specifications, functional requirements of Employer and utilization of various parameters and their values in the specification by the Contractor shall in no way relieve the Contractor of his responsibilities to meet all guarantee requirements or of providing completely safe and reliable operating equipment/systems.

The complete FGD system and the associated auxiliaries shall be designed by the standard industrial practices. The FGD system shall be designed to achieve the required SO₂ capture without the use of oxalic acid or any other additives. Only field proven materials for similar application shall be used for the system. The complete installation of liners shall be made under the supervision of the liner supplier as per their guidelines. In the execution of the welds contractor must ensure that welding material has same corrosion resistance as the actual plate surface.

Alloy to carbon steel welds must either be hidden behind a covering strip of alloy material, or be executed by a special welding procedure ensuring the same quality at the weld surface as the alloy lining. All welding which shall be in the contact with process fluids shall be executed under the supervision of the designer/manufacture.

3.00.00

FLUE GAS SYSTEM

3.01.00

The entire flue gas system, flue gas ducts, absorber etc. shall be designed to meet the following conditions:

1.	Design internal pressure at 67% yield strength (mm wc)	+660 and -150 mmwc or maximum conceivable head of Booster fan (if provided), whichever is higher
2.	Design Inlet Gas Temperature (deg.C)	150
3.	Short temp excursion temperature of inlet gas (for approx. fifteen (15) minutes at a time) (deg. C)	300
4.	Inlet Dust Burden in Gas (mg/Nm ³)	200
5.	Maximum flue gas velocity through the Absorber (M/sec)	Not more than 4 m/s at Design Point Conditions
6.	Recirculation Slurry pH	Not less than 5.5 under all operating conditions



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3.02.00	Design	
3.02.01	The flue gas ducts shall be sized and designed to meet all the criteria as specified in Cl. No 16.00.00 this subsection.	
3.02.02	All ducts with operating temperature above 60°C shall be insulated in accordance with cl. No. 17.00.00 of this sub section.	
3.02.03	The duct layout shall ensure that there is no accumulation of acid mist on the duct floor.	
3.02.04	The duct to Absorber inlet shall be made of Carbon steel of minimum 7mm thickness. The duct to Absorber inlet shall be made of Carbon steel of minimum 7mm thickness. The duct from Absorber outlet to bypass duct shall be made of Carbon steel of minimum 7mm thickness with 2 mm (minimum) thickness lining / cladding / wall paper of Alloy C276 / Alloy 59 or better material.	
3.02.05	In addition to the base offer as described above, the bidder may also submit an alternate offer for a different material / lining of duct from Absorber outlet to stack, if the bidder has previous experience of the same. The bidder should have supplied a similar design of duct in previous installations for similar application. Bidder shall indicate the applicable price implication for such an alternate offer in the relevant Bid Proposal sheet. The Bidder shall also furnish details of the previous installations of such system and bring out all the technical features of the system proposed. Bidder to note that application of lining material in the ducts shall be carried out under the supervision of designer/manufacture. Bidder to note that application of lining material in the duct shall be carried out under supervision of Designer/Manufacturer.	
3.02.06	Wherever required, expansion joints of proven design shall be provided in the ducts to take care of differential expansion in the system. The material chosen for expansion joints shall suitable for the duty conditions and the corrosive atmosphere of the FGD system and shall be field proven for similar applications. The expansion joints shall be guaranteed for faultless material and workmanship, for a minimum guaranteed life of not less than 20000 hrs. of operation. During Guarantee period any defects noticed in the expansion-joints due to faulty material and workmanship shall be rectified by the Contractor free of cost.	
3.02.07	The Contractor, shall take into account the entire characteristics of expected combination of fuels to be fired, for the complete load range of operation and the expected numbers of Steam Generator start-ups while designing the Chimney flue liner. The chimney flue liner cladding shall be made of 2 mm thick Titanium (Grade 2 as per ASME SB265) or C-276 alloy over 8 mm thick (minimum) mild steel base metal of flue liner. Cladding shall be done to achieve the required quality as per ASTM B 898-11. External surface of chimney flue liner projecting over the chimney roof shall be wrapped with 2 mm thick Titanium / C-276 sheet over insulation.	
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	The stack shall be designed as per the latest guidelines of EPRI Wet Stack Design Guide. The design of wet ducts and stacks system shall consider the Stack liquid discharge (SLD), Corrosion/chemical attack, Condensate collection system and its drainage etc. 3.03.00 Gates & Dampers 3.03.01 The arrangement of the flue gas system shall allow complete isolation of the absorber from the gas side, with the unit in operation. Guillotine gate type damper shall be provided by the Contractor before the suction of each Booster fan. A gas tight, motor operated Guillotine gate shall be provided by the Contractor at the outlet of each Booster fan. A gas tight, motor operated Guillotine gate shall be provided by the Contractor in the bypass duct (flue gas duct connecting the existing chimney). 3.03.02 All gates/dampers shall be designed to withstand the operating flue gas temperature without distortion. 3.03.03 There shall not be any backlash, play, etc. with linkage mechanism, actuator and final control element. 3.03.04 Thermal expansion of ducting shall not produce stress in louvers, linkage arrangement etc. 3.03.05 Outlet dampers of seal air fans shall be pneumatically operated, suitable for remote manual operation. 3.03.06 All pneumatically operated interlocked dampers actuators shall be provided with solenoid valves. 3.03.07 A quick acting biplane damper shall be provided by the Contractor in the bypass duct (flue gas duct connecting the existing chimney) for quick opening to allow bypass to come into operation in case of emergency. The damper shall be capable of quick opening during emergency conditions within a time of 10-20 secs. Bidder should indicate the required opening time for bypass damper for emergency operating condition. 3.03.08 All the gates shall be designed for tight shut off. The Guillotine gate type dampers mentioned at Clause No. 3.03.01 above shall have a guaranteed gas tightness efficiency (on flow) of not less than 99.95% along the duct as well as from the duct to atmosphere or from atmosphere to the duct, depending on the pressure in both the damper open and damper closed condition without the use of seal air fans of the damper. The bypass damper shall have a guaranteed gas tightness efficiency (on flow) of not less than 99.5% and 100% leak tight with seal air fans under operation. The gas tightness shall be demonstrated at shop for minimum one type of damper of each type and size. 3.03.09 The dampers shall be pneumatically operated and controlled from the control room. Provision shall be made for giving signal automatic bypass controls of the absorber in case of failure of the absorber spray system or the GGH. The dampers shall have provision for manual operation, through a hand wheel. The force required for manual operation of the gate shall not exceed 35 kg (max.) at the rim of the hand wheel.
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3.03.10	The isolating gates shall be provided with locking devices to permit locking in fully closed position.													
3.03.11	Pressurization Fans: a) All gates shall be provided with 2x100% pressurization fans to achieve 100% sealing efficiency. b) The location and scheme for pressurization system shall be subject to Employer's approval.													
3.03.12	All gates shall be designed to withstand the operating air and flue gas temperature without distortion.													
3.03.13	All guillotine gates shall be located in horizontal duct to avoid fly ash build up when in closed position and shall be of top entry type.													
4.00.00	BOOSTER FAN:													
4.01.00	The Booster Fans shall be located downstream of the ID Fans (Induced Draft Fans) in the inlet duct to Absorber shall be capable of handling the pressure drop in the FGD system & ducting and wet stack of 150 m height also considering the exit loss from wet stack over the entire load range with any one or both Booster fans in operation in conjunction with one or both ID fan in operation while firing the specified range of fuels. Additionally a pressure loss of 100 mm wcl (excluding margin) shall be built up in booster fan design criteria as mentioned below to take care of pressure loss due to future installation of De-Nox system. Booster Fans shall be sized such that they satisfy the criteria stipulated below.													
4.01.01	<table border="1"> <thead> <tr> <th>S.N.</th><th>Description</th><th>Booster Fan</th></tr> </thead> <tbody> <tr> <td>1</td><td>Type of fans</td><td>Constant speed, axial type.</td></tr> <tr> <td>2</td><td>No. of fans per unit</td><td>Two</td></tr> <tr> <td>3</td><td>Fan sizing criteria with all the following conditions occurring together :</td><td>Booster Fan to be sized for one (1) Booster Fan stream in operation taking into account following factors occurring</td></tr> </tbody> </table>	S.N.	Description	Booster Fan	1	Type of fans	Constant speed, axial type.	2	No. of fans per unit	Two	3	Fan sizing criteria with all the following conditions occurring together :	Booster Fan to be sized for one (1) Booster Fan stream in operation taking into account following factors occurring	
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4.02.00		together:
	(i) Flue Gas Flow through fan	920 m ³ /sec for all 800 MW units
		724 m ³ /sec for 660 MW units of Mouda, Tanda , Nabinagar STPP & Barh-I
		802 m ³ /sec for 660 MW units of Meja
		893 m ³ /sec for 660 MW units of Solapur
		297 m ³ /sec for 250 MW units of Nabinagar TPP
	(ii) Power supply frequency	47.5 Hz
	(iii) Pressure at Booster Fan suction	0 mmWc
	(iv) Gas temperature (degree Celsius)	150
	The fans shall also fulfill following sizing criteria in addition to those mentioned at clause 4.02.01 above	Each fan to be sized with following conditions occurring together.
	(i) No. of fans in operation	2
	(ii) Flue gas flow through each fan	727 m ³ /sec for all 800 MW units
		600 m ³ /sec for 660 MW units of Mouda, Tanda , Nabinagar & Barh-I 645 m ³ /sec for 660 MW units
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	of Meja 678 m³/sec for 660 MW units of Solapur 237 m³/sec for 250 MW units of Nabinagar TPP (iii) Margin over flow 20% (iv) Margin over pressure requirement 44% over the calculated value (v) Power supply frequency 50 Hz (vi) Pressure at Booster Fan suction 0 mmWc (viii) Gas temperature (degree Celsius) 150 (viii) Flue gas control Blade pitch control Note to 4.02.01 & 4.02.02: Booster fan shall have a minimum stall margin of 10% over the Design duty points. 4.02.01 Both fans shall operate with highest possible efficiency which shall be nearly equal at the Guarantee point flow and test block points. 4.03.00 Fan components along with servo/blade pitch control mechanism shall be designed to withstand and continuously operate with the maximum air or flue gas temperature that these fans will be required to handle. Fan component shall also be designed to withstand the excursions in flue gas temperature up to 300 degree Celsius, which may persist for about 30 minute duration. Such temperature excursion will not inhibit the safe and smooth operation of fans or cause any damage or increased maintenance. 4.04.00 The construction of Booster fans shall also comply with following requirements	
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	DESCRIPTION Booster Fans Type of fan blades stream lined, aerofoil shaped section Blade material Nodular Cast Iron or High Wear Resistant Steel with or without Hard coating as per the proven practice of the fan manufacturer Fan rotational speed 600 rpm (max.) Air/Flue gas flow blade pitch control Fan critical speed not less than 125% of fan maximum operating speed Fan component design* to withstand torsional stresses three (3) times the normal full load motor torque at all speeds Fan casing material thickness Abrasion and wear resistant, high BHN steel having minimum 8.0mm thickness or 12mm mild steel with liner of thickness 10mm (min.) Fan Housing design for shut off head of fan *Note : (a) Contractor shall submit detailed calculations, for Employer's approval, to confirm compliance with above requirements for all fan components, specifically for fan shafts, impeller hubs and impeller as a whole. Areas of high stress concentration and residual stresses, like welded attachments shall be avoided on the fan rotor/shafts. Combined static, dynamic as well as residual stresses shall be demonstrated to be within allowable limits. These fan components shall last the life of the plant with such combined stresses present in them. (b) Although employer envisages to install highly efficient electrostatic precipitator to control particulate emission, however. Bidder shall select the Booster fan components such as blades, hubs, casing etc. to encounter the high dust burden of the order of 250 mg/Nm³. The minimum wear life of Booster fan components shall not be less than 25000 hours of operation from the date of commissioning.		
4.05.00	Fan Bearings (a) Bearing shall be provided with oil bath to prevent damage in case of complete loss of plant auxiliary power when the fans must coast down		
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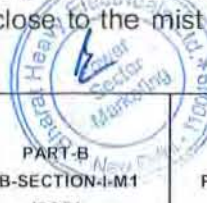
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4.06.00	without power. (b) Size oil reservoir in bearings housing for maintaining lubrication for extended periods in case of oil circulation system is out of service. (c) Cooling air circulation to be provided across main bearing (d) Adequate numbers of duplex Pt-RTD (100 ohm at 0 degree Celsius) and temperature indicator shall be provided for each bearing. Local as well as remote monitoring features shall be provided. (e) For mounting of vibration pads/pickups, flat surfaces shall be provided both in X and Y directions, by the Contractor on the bearing housing.									
	Fan balancing (a) The fans shall be statically and dynamically balanced before shipment. (b) Balancing of each fan shall be checked and adjusted at site, if necessary. (c) Natural frequency of all fan components shall be established by vibration testing to ensure that no part of the wheel is adversely excited by any force generated at operating speeds. (d) The fan blade shall be subjected to natural frequency test. The other components of fan wheels need not be subjected to natural frequency test if supplier can prove that these component are very rigid and have very high natural frequency compared to the operating frequency of respective fans giving justification.									
4.07.00	Booster fans shall meet following operational requirements. <table><tr><th>Description</th><th>Booster Fans</th></tr><tr><td>(a) Mode of operation</td><td> i) two fans in parallel. ii) one fan (one stream in operation) </td></tr><tr><td>(b) Fan control system</td><td> i) capable of operating in automatic mode for all regimes of operation in a steady and stable manner ii) The final control element shall not have any backlash, plays etc., and shall operate in the range of 20% to 80% depending upon generating loads upto Boiler MCR </td></tr></table>				Description	Booster Fans	(a) Mode of operation	i) two fans in parallel. ii) one fan (one stream in operation)	(b) Fan control system	i) capable of operating in automatic mode for all regimes of operation in a steady and stable manner ii) The final control element shall not have any backlash, plays etc., and shall operate in the range of 20% to 80% depending upon generating loads upto Boiler MCR
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	(c) Vibration For mounting of vibration pads/pickups (in the Employer's scope) flat surfaces shall be provided, both in X & Y directions, by the Contractor on the bearing housing in such a way, so that welding/screwing of the pads shall be possible. (d) Bearing metal temperature monitoring Shall be possible from remote as well as locally, using atleast 2 nos. of duplex platinum RTD's (100 ohms at 0 deg. C) per bearing	
4.08.00	The fans shall be suitable for parallel operation and sharing the load capacity over the entire range of operation without hunting. Pulsation shall be avoided by suitable design of fans and	
4.09.00	Fan Casing : (a) The fan casing shall be split to provide easy removal of the fan hub/impeller for replacement and repairs. (b) The sections shall have gasket joints to ensure airtight sealing. (c) Access doors shall be provided in each suction chamber casing and diffuser.	
4.10.00	Drain Connection: Drain connections shall be provided at bottom most point of the fan housing to the nearest trench.	
5.00.00	ABSORBER The unit shall be provided with an independent/dedicated absorber.	
5.01.00	The contractor may offer either a spray type absorber, with single or multiple levels of spray, or an absorber with gas bubbling through the slurry, as per Bidders/Colaborator's proven practice. Only proven system in successful operation in previous installations supplied by the contractor shall be offered. A Spray System (if offered) (i) The contractor shall provide spray system and minimum spray levels required to meet the stipulated guarantee and design requirement. The spray system (including slurry recirculation pump & nozzles) shall be sized to achieve a desired L/G ratio required to meet the guarantees SO₂ removal efficiency, with redundancies specified	
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	under this clause. (ii) In case the contractor offers an absorber with multiple levels of spray nozzles, each spray level shall be provided with independent 2x100% pumps. Alternatively, the contractor may offer a spare spray level with each spray level served by an independent 100% capacity pump. In case the contractor offers a single level of spray, one number of standby pump of the same capacity & head as the working slurry recirculation pumps shall be provided. The contractor shall provide spray system / spray levels only as per his proven practice, which should be in successful operation elsewhere. (iii) The slurry recirculation pumps shall have a minimum margin of 10% on flow and 10% on frictional head, over the actual requirement for meeting the guarantee and design point conditions. All slurry recirculation pumps including motors shall be of the same size and type. (iv) The slurry recirculation pumps shall have motor driven knife gate valve at pump suction and discharge side. (v) The slurry recirculation pumps shall be wear-resistant and equipped with flushing devices to prevent sedimentation and shall be designed and installed in a manner to allow easy replacements, repair and maintenance. The slurry recirculation pumps shall be equipped with oil level indication, coupling guard and collecting equipment for leakage, made of resistant material. Single mechanical seals with automatic flushing with a connection for additional manual flushing shall be provided. (iv) The slurry pumps shall also comply with the requirements stipulated in Clause 8.00.00 of this sub-section. (v) Sufficient redundancy, as per the proven practice of the contractor, shall be provided in the spray nozzles. Minimum 10% spare nozzles shall be provided at each level. B Bubbling Type Absorber (i) In case the bidder offers an absorber with gas bubbling through the slurry, the complete gas distribution system to the slurry shall be in bidder's scope. No re-circulating pump and spray header and nozzles shall be required in such case. However, 2x 100% Cooling Pumps instead of Slurry Recirculation shall be provided. The spray headers & piping for cooling pump discharge shall be made of Alloy 59 or C276 and nozzles shall be made of Silicon Carbide or ceramic or equivalent having a minimum guaranteed life of 20,000 hrs. The Cooling Pumps shall be installed inside a building.	NAHAR PEAR POWER GENERATING CO. PVT. LTD. NPGC Naar Heavy Electricals Sector Marketing New Delhi
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5.02.00	The sparger and gas riser tubes shall be made proven material which shall have a minimum life of 5 years.			
	Minimum 10% redundancy, shall be provided in the Sparger Tubes.			
	Absorber Recirculation Tank			
	Sufficient number of agitators, as per the proven practice of the contractor, shall be provided for thorough mixing of the re-circulating slurry. In case the Contractor's Absorber includes side entry agitators, the contractor shall offer and demonstrate mixing arrangement such that n-1 number of agitators are sufficient to avoid the slurry settlement in the absorber tank in case of one agitator under breakdown (n-total no. of working agitators). In case vertical agitators in Absorber are offered, one complete mechanical assembly of agitator shall be supplied as warehouse spare for each Absorber.			
5.03.00	Absorber Oxidation Systems			
5.03.01	The contractor may offer either a grid type oxidation system or a sparge jet oxidation system or lance type or air rotary sparge system or jet air sparger system for oxidation of sulfite sludge to sulfates, or any other proven system as per the practice of the FGD vendor.			
5.03.02	The oxygen required for oxidation shall be supplied by 2x100% oxidation air blowers for each absorber. The compressor/blower shall be sized to supply at least 2.5 times the stoichiometric air requirement for spray tower process & at least 4.0 times the stoichiometric air requirement for Bubbling Type process or the actual requirement, whichever is higher, under the following condition, all occurring simultaneously. The natural oxidation of sulfite by residual oxygen in flue gas shall not be considered for this purpose.			
	Load	Design point Flow		
	Flow	Minimum 2.5 times for spray tower process & 4.0 for Bubbling Type process the stoichiometric requirement		
	Head	For spray tower process actual requirement considering choking/ blockage of minimum 10% of the oxidation nozzles / sprayers or minimum 8500 mmwc whichever is higher.		
		For Bubbling Type process actual requirement considering choking/ blockage of minimum 10% of the oxidation nozzles / sprayers or minimum 3500 mmwc		
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		whichever is higher.	
	Margin on Head	10% under above conditions.	
	Ambient Conditions	45°C / 60% RH.	
5.03.03	Oxidation nozzles / spargers shall have a minimum redundancy of 10% or as per the contractor's proven practice whichever is maximum.		
5.03.04	The oxidation system shall be complete with a quenching system to cool down heated oxidation air in order to prevent any scaling or buildup that could occur at the sparger tips due to localized evaporation of recycled slurry.		
5.04.00	Gypsum Bleed Pump Each absorber shall be provided with 2x100% Gypsum Bleed Pumps for supply of gypsum slurry to Gypsum Dewatering system. Each Gypsum bleed pump shall be sized to bleed-off the gypsum slurry from the absorber with slurry solid concentration not exceeding 30%, under the following conditions, all occurring simultaneously:		
	Load	Design point	
	Flow	100% of gypsum produced at Design point condition	
	Head	As per system requirement	
	Margins	Flow – 15% Head – 20%	
	The pumps shall be designed to meet the stipulations of Clause No.9.00.00 of this Sub-Section.		
	Provision shall also be provide in the Gypsum Bleed Pumping system by provision of tap off, valves etc. for pumping the gypsum bleed to alternate source.		
5.05.00	Emergency Spray System An emergency cooling system for automatic spray of quenching water for a sufficient time (minimum 15 min) at the inlet to the absorber, in case the gas temperature exceeds the design temperature due to failure of upstream equipment's shall be provided to protect the FGD and all other sensitive downstream equipment against high flue gas temperatures. The water shall be supplied from an elevated tank (emergency water tank) installed near to the absorber. The tank volume and the		
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	injection lances/nozzles shall be designed to protect the inlet duct and the lining of the absorber. The inlet duct shall be sloped towards the absorber.			
5.06.00	Design			
5.06.01	The design and arrangement of the absorber shall be field proven for successful long-term operation in conjunction with a coal fired power plant.			
5.06.02	The design of flue gas ducts and inlet and outlet hoods of the FGD as well as guide vanes and baffle plates shall ensure a homogeneous flue gas flow with respect to the distributions of: (i) temperature (ii) velocity (iii) dust content (iv) slurry injection and distribution. The above shall be proven by two phase Computational Fluid Dynamics simulations (liquid and gas). The scope of modelling shall include flue gas path inside the absorber vessel including inlet and outlet duct. Homogeneity shall be ensured, if the deviation from average is less than $\pm 10\%$. Further, in the Absorber outlet hood no internals such as guide vanes and baffle plates shall be allowed.			
5.06.03	The fabrication of the absorber vessel shall follow common practice as there shall be no longitudinal seams located behind any attachment or obstruction which would prevent inspection of the welds. Nozzles, access ways, and their reinforcements shall not be located in or on any seam. Inaccessible gaps or hollow beams shall be avoided.			
5.06.04	The absorber shell shall be designed for pressure loads, piping forces and moments, wind and seismic loads and all other loads imposed on the absorber. Bracing and reinforcement shall be adequate to prevent deflection and vibration. Internal supports for mist eliminator sections, etc. shall be designed to withstand the flooded weight of the supported section. The absorber and its structural supports shall be designed for the maximum operating loads including design positive & negative internal pressure, static head, external attachment loads (such as exerted by piping) wind load using the allowable stresses permitted by the applied standards.			
5.06.05	It shall be possible to reach the SO ₂ emission guarantees, at Guarantee point condition, with at least one spray level continuously out of service (in case the absorber is equipped with several spray levels) or one spare pump continuously out of service.			
5.06.06	Three stage chevron type Mist Eliminators (ME) made of polysulfone or stainless steel shall be provided at the exit of the absorber. Provision shall be made for continuous washing of both ends of the first & second stage and the front section of the third stage of mist eliminators. Wash water arrangement shall also be provided at the back end of the second stage of mist eliminator. If the mist eliminator washing system is designed for cyclic washing of different sections, all the valves required for cycling shall be motorized or pneumatically operated. The automatic valve for the spray system shall be easily accessible on a platforms close to the mist eliminator.			
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	Entrained slurry shall be collected by mist eliminators downstream of the slurry spray system to avoid carry-over of slurry to the stack. The ME system shall be equipped with washing and drain provisions, where drains are directed into the absorber. Washing provisions shall include external and internal piping systems with replaceable nozzles, water pressure booster pumps (if required) complete with all piping, valves, instrumentation and controls. The mist eliminator wash piping/header shall be constructed of rubber lined carbon steel or glass fiber reinforced plastics. Polypropylene or PVC is also acceptable for mist eliminator wash headers provided Contractor or its Collaborator has proven experience for the same. Ease of replace ability and placement of the mist eliminator on maintenance platforms is an important requirement. The ME shall be designed to allow for efficient cleaning in process. Test ports shall be provided downstream of the mist eliminator to enable performance testing. The mist eliminator system shall be capable of withstanding high velocity spray water jets typically employed during manual cleanings. The ME shall be constructed in individual cells. The design shall safely avoid ME vibration and/or humming. The individual cells shall be sized so that no more than two maintenance personnel are needed to handle them manually when they are fully scaled or plugged, and the cells shall be capable of passing through the access doors for the mist elimination section. Easy access for placement and replacement of the mist eliminator shall be incorporated in the design of the mist eliminator arrangement and the absorber vessel. Walkways shall be arranged and also measures shall be taken as appropriate to permit the internal components to be disassembled and reassembled during repairs without the necessity for time-consuming preparatory work. The headroom shall have a height of more than 2200 mm. The mist eliminator support beams shall be designed to act as maintenance walkways approximately 300 mm wide and shall allow for a minimum 500 Kg/m² load. The support beam/walkways shall provide personnel access to all mist eliminator modules, wash headers and wash nozzles. Adequate number of viewing ports with flushing devices connected to automatically operating washing system shall be delivered at following locations: (i) upstream of 1st stage (ii) between 1st and 2nd stage (iii) downstream of 2nd stage. (iv) downstream of 3rd stage The regular flushing shall be done in a defined time sequence. 5.06.07 The absorber oxidation tank shall be provided with an over flow line (for spray tower process) complete with sealing pot, over flow and drain line. The absorber over flow shall be taken to a sump in the absorber region, from where the slurry shall be pumped back to the absorber by a sump pump. 5.06.08 Materials used shall be suitable for the chemistry of the absorber process and resist abrasion from any particulate contained in the incoming flue gas and from the		
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	particulate of desulphurization process. 5.06.09 All equipment located in the gas path or connected to such equipment shall be designed to withstand the maximum inlet gas temperature fluctuations. There shall be no damage whatsoever to any equipment as a result of these fluctuations. 5.06.10 The raw gas inlet duct of the absorber shall be equipped with a flushing device of the side walls and the ground, which shall operate continuously as well as intermittently. 5.06.11 The absorber vessel shall be made of minimum 7 mm thick carbon steel. The absorber oxidation tank, absorber tower & absorber outlet duct shall be provided with 2 mm (minimum) thickness lining / cladding / wall paper of Alloy C276 / Alloy 59 or better material. 5.06.12 The material of process equipments of flue gas desulphurization system shall be appropriate for the chloride content and pH level at which the process is to operate. 5.06.13 All internal members shall be lined with minimum 2 mm Alloy 59/ C276 . All metallic fasteners which are provided inside the absorber/absorber wet-dry interface ducting shall be of Alloy 59/ C276. 5.06.14 The absorber wet-dry interface shall be made of solid Alloy 59 or C276 of minimum 6 mm thickness. 5.06.15 The other bridges (supports) shall be lined with minimum 2 mm Alloy 59/ C276. 5.06.16 Lining material and technical application requirements shall be furnished by manufacturer experienced with similar FGD plants. Proof of such experience shall be provided by the Contractor. 5.06.17 The spray headers (if provided) and air supply headers shall be made of FRP or Carbon Steel with rubber lining (minimum 10 mm natural rubber lining), corrosions and erosion resistant in the inner and outer side (Silicon Carbide coating on metal/FRP surface exposed to slurry). Optionally ceramic coating is also acceptable provided bidder/Collaborator has proven experience for the same. The slurry spraying system shall be made of material resistant to erosion and corrosion. During the lifetime of the plant, only the nozzles shall be replaced. The distribution system of the slurry shall be hydraulically optimized. The spray nozzles shall be of silicon carbide or ceramic or equivalent having a minimum guaranteed life of 20,000 hrs. The design of the spray nozzles shall be such that rapid wear, encrustation and plugging are avoided. Nozzle pipes and slurry spray nozzles shall be with bolted flanged connections. Nozzle pipes shall be installed easily to be removed partially through absorber modules. 5.06.18 In case the absorber is equipped with several spray levels they shall be designed as follows:			
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	(i) The last spray level upstream the mist eliminator shall be operated only in counter-flow. (ii) Depositions at downstream spray level and mist eliminator by co-flow injection of slurry shall be avoided. (iii) The spray lances shall be equipped with bars for installation of scaffolding without any offset. The spray levels shall be designed for a load of min. 500 kgf/m². (iv) A flushing device of the spray levels with water shall be installed. Flushing shall take place if spray levels are out of operation.
5.06.18	The absorber shall be self-supported from the bottom to suit site conditions. Absorbers which are externally supported from the structure are also acceptable provided Bidder or its Technology Collaborator has proven experience of supplying such Absorbers which are operating for more than 5 years. The absorber shall have adequate stiffening arrangement on the external side. Internal stiffeners shall be used only where it is not possible to provide proper external stiffening with approval of employer.
5.06.19	It should be possible to build platforms inside the absorber for access to all parts of the absorber during maintenance. In case the contractor offers a multiple spray level design, minimum distance of 1.5 m shall be maintained between individual spray levels. Arrangement shall be properly designed to facilitate access for maintenance and replacement of spray nozzles.
5.06.20	The spray piping, mist eliminators and its supporting structure shall be designed to carry sufficient load during maintenance.
5.06.21	The bottom of the absorber sump shall be designed so that there will be an easy entrance for a man with a wheelbarrow. Therefore the arrangement and dimensions of the inspection door of the absorber at ground level shall be designed to allow for this. The bottom of the absorber sump shall be designed in such a way that complete drainage of the absorption liquid/slurry is possible and is accessible without damage of lining/rubber.
5.06.22	In case of Spray Tower System, Suction screens shall be installed inside the Absorber vessel to protect the Slurry recirculation pumps. In case Bubbling type, suction strainers shall be installed at the suction side of Gas Cooling Pumps. For the agitators a flushing system for start ups shall be provided.
5.06.23	It should be possible to discharge the absorber sump into the emergency drain tank within 2 hours.
5.06.24	At the head of the absorber two manholes shall be provided to reduce the draught of the stack during outage.
5.06.24	Equipment's required for internal & external inspection shall be furnished by the contractor in brand new condition. List of all such items shall be furnished along with the Bid. The formation of agglomeration, deposition & caking shall be avoided. For

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	areas, where this might occur, (e.g. mist eliminators, spray levels) the Contractor shall submit a cleaning procedure including the required safety measures as part of the inspection concept.	
6.00.00	LIMESTONE GRINDING AND SLURRY PREPARATION SYSTEM	
6.01.00	Type	
	A common limestone and slurry preparation system is envisaged for each project. Contractor shall supply wet limestone grinding and slurry preparation system complete with all auxiliaries and slurry storage tank of proven design.	
6.02.00	Limestone Silo:	
6.02.01	The Contractor shall provide 2X100% Limestone storage silos each silo having minimum 24 hours storage capacity equivalent to the requirements of FGD system of all the units operating at Design point. The storage silo shall be complete with supporting steel structure, platforms, staircase, air canons power operated gates, gravimetric feeders, level switches, air relief devices, etc..	
6.02.02	The storage silos and hopper cones shall be fabricated of minimum 10 mm thick carbon steel with a SS lining of grade SS304 of minimum 4 mm thickness in the complete cones to ensure reliable discharge of material. The design of storage silos shall confirm to IS 9178 (Part 1 to 3). The storage silo shall be capable of feeding the limestone by means of gravimetric feeder to the wet ball mills. The top of the unloading hopper shall be equipped with a grate to protect the downstream equipment from gravel lumps or tramp waste.	
6.02.03	Each Silo shall be provided with sufficient no. of level transmitters.	
6.02.04	Each silo shall be provided with minimum 3nos. of air canons at necessary location, capable of removing the jamming/clogging/blockage in the silos.	
6.02.05	For dust free operation each silo should be provided with a covering arrangement and a self cleaning bag filter system of suitable capacity containing blower, automatic/on-load cleaning system, etc.	
6.02.06	For each silo facilities shall be provided for unloading the bunker, through feeder, to a truck at ground level, along with all necessary chutes and diversion chutes.	
6.02.07	Lime stone silo with hopper may be fabricated at factory in segments, transported and welded at site.	
6.03.00	Bunker Shut-off Gates	
6.03.01	A bunker outlet chute shall be provided for feeding limestone from bunker to the feeder. The size of the opening chute shall be sufficient to ensure proper flow of the limestone. There shall be no reduction of section in the bunker outlet chute from	
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	bunker to feeder. The inlet chute shall be provided with suitable poke doors/holes in order to remove jamming/blockage. A motorized bunker shut-off gate shall be provided at the inlet to each feeder.	
6.03.02	All parts of the gate in contact with limestone shall be of stainless steel construction.	
6.03.03	The shut-off gates and its actuator shall ensure 100% closing of the gate even with 'bunker full of limestone'.	
6.03.04	Facility shall be provided to open/close the bunker outlet gate, through actuator, from remote as well as local.	
6.03.05	In addition, a hand wheel with proper access shall also be provided for manual operation of the gate. The force at the rim of the hand wheel shall not exceed 35 kg with bunker full of coal.	
6.03.06	For each bunker facilities shall be provided for unloading the bunker, through feeder, to a truck at ground level, along with all necessary chutes and diversion chutes.	
6.04.00	Gravimetric Feeders	
6.04.01	Gravimetric feeders shall be sized to meet 110% of the maximum mill capacity.	
6.04.02	The limestone feeder belt shall be of seamless rubber construction. It should be possible to adjust the belt tension from outside without opening the feeder body.	
6.04.03	All parts in contact with limestone except belt shall be of stainless steel construction.	
6.04.04	The feeder shall have adequate instrumentation to detect 'loss of flow'.	
6.04.05	The feeder shall have a motor/pneumatic operated gate at the outlet.	
6.05.00	Wet Ball Mill	
6.05.01	There shall be 2X100% tube mills for grinding of limestone. Each mill shall be sized to meet 110% of the maximum limestone requirement of all the units in a project operating under the following conditions, all occurring together.	
	(i) Load Design point flow	
	(ii) Flow 110% of limestone requirement of two absorbers at Design point	
	(iii) Input Limestone Size 1" (max.)	
	(iv) Output Fineness Output Fineness 90% or higher (as per the requirement of absorber) through 325 mesh (for spray tower process) OR 90% or higher (as per	
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	the requirement of the absorber) through 200 mesh (for bubbling process) (v) Mill Wear Part Near Guaranteed Wear Part Life. Conditions (vi) Limestone bond 13 (min) index(kWh/sh.T)		
6.05.02	All integral auxiliaries of the mills like hydro-cyclones, separator tank & mill circuit pumps shall be sized to meet the above conditions. A 100% stand-by pump shall be provided for the mill circuit pump.		
6.05.03	The mill hydro-cyclone set shall have sufficient redundancy. A minimum 10% spare hydro-cyclone shall be provided in each set of hydro-cyclone. Hydro-cyclones shall be of modular construction. It shall be possible to remove and replace individual hydro-cyclone with the set in service. Individual isolation valve shall be provided for each hydro-cyclone for this purpose. The hydro-cyclone shall be of proven design and shall be provided with replaceable rubber lining. The hydro-cyclone shall be provided with replaceable rubber lining of thickness 12 mm for the feed chamber and 12 mm for the overflow launder.. The liners shall have a minimum wear life of not less than 7000 hrs.		
6.05.04	All parts of the mill including mill body, trunnion, hydro-cyclones, integral pipes, mill circuit pumps and other parts in contact with limestone slurry shall be provided with replaceable rubber wear liners. The wear liners or wear parts shall have a minimum guaranteed wear life of not less than 8000 hrs without reversal of the liners. The guaranteed capacity and fineness of the mill shall not be affected within the guaranteed life of the mil wear parts.		
6.05.05	The material of the balls shall be chosen to ensure that the balls do not lose their original shape and to ensure minimum ball consumption. The contractor shall also guarantee ball consumption per ton of limestone throughput. The contractor shall furnish the minimum ball diameter below which the balls shall be replaced.		
6.05.06	Facility shall be provided for on-load loading of steel balls to the mill.		
6.05.07	The ball mill shall be driven by a motor through a peripheral gear/ central drive system. An auxiliary motor shall also be provided for inching of mills after trip and during maintenance.		
6.05.08	The lube oil system shall have 100% stand-by arrangement for lube oil pumps and oil coolers of each circuit with independent pump / cooler. Wherever required duplex oil filters shall be provided.		
6.05.09	The mill auxiliaries like separator tanks, mill circuit pump, hydro-cyclones and all connecting pipes handling limestone slurry shall have replaceable rubber linings.		
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6.06.00	Limestone Slurry Preparation / Storage Tank	
6.06.01	The contractor shall provide two (2 nos.) slurry storage tank, common for all mills. Each tank shall be sized to meet 12 hours continuous limestone requirement of all the units operating at Design point. For tank volume calculation, solid concentration (by weight) in the slurry shall be assumed, not more than 20% or actual required whichever is lower.	
6.06.02	The storage tanks shall be equipped with sufficient number of agitators, to avoid settling of limestone, as per the proven practice of the supplier. The agitators shall be designed to meet the requirements stipulated in Cl. No. 11.00.00 of this Sub-Section.	
6.06.03	The limestone mill circulation tanks shall be installed indoor beneath the hydro cyclone stations. The slurry storage tank shall be located outdoor.	
6.06.04	The slurry preparation tank shall be CS construction with replaceable chlorobutyl/bromobutyl rubber lining of minimum 5 mm thickness.	
6.07.00	Limestone Slurry Supply Pumps & Piping	
6.07.01	2x100% centrifugal type limestone slurry pump shall be provided for each unit. Each limestone slurry pump shall be sized to supply the limestone requirement of one (1 no.) unit, under the following conditions all occurring together.	
	(i) Load Design point	
	(ii) Flow 110% of one absorber requirement with the limestone requirement at Design point.	
	(iii) Head As per system requirement.	
	(iv) Margins Flow 10% (minimum) Heads 15% (minimum)	
	(v) Solids Concentration Max. 30% by weight or actual as per suppliers practice, whichever is minimum.	
6.07.02	The limestone slurry pumps shall be designed to meet the requirements stipulated in Cl. No.8.00.00. of this Sub-Section.	
6.07.03	The limestone slurry pipes shall be sized to minimize erosion and avoid settling of the limestone at part load operation. The slurry pipes shall be lined with replaceable wear resistant natural rubber lining of minimum 10 mm thickness. Additional thickness of 2 mm in rubber lining shall be provided at bends.	
6.07.04	Automatic flushing equipment for all lime slurry pumps and pipes shall be supplied.	
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7.00.00	GYPSUM DEWATERING SYSTEM	
7.01.00	A common gypsum dewatering system for all the units operating at Design point is envisaged. Contractor shall supply a two stage gypsum dewatering system, consisting of a primary stage of sets of hydro-cyclones and secondary stage of vacuum belt filters for dewatering of gypsum from absorber up to less than 10% moisture. All the equipments supplied shall be proven design with previous installations for similar capacities.	
7.02.00	The Contractor shall provide 2x100% gypsum dewatering system with each stream sized to dewater 110% of the maximum gypsum produced by all the units operating at Design point. All other stipulations with respect to sizing and design of the dewatering system, auxiliaries and other systems shall be in line with this specification.	
7.03.00	Primary Dewatering Hydro-cyclones	
7.03.01	Each set of primary dewatering hydro-cyclone shall be sized to dewater the gypsum slurry produced by the unit operating at Design point with an additional 10% margin. The outlet water content in the gypsum shall be as per the requirement of the vacuum belt filters.	
7.03.02	Each set of primary hydro-cyclone shall be provided with 10% spare hydro-cyclones. The capacity defined in the previous clause shall be met with spare hydro-cyclones out of service.	
7.03.03	The primary hydro-cyclone shall be installed directly above the belt filters. The overflow of the hydro-cyclones shall be taken to Hydro-cyclone Waste Water tank via secondary hydro-cyclone feed tank and secondary waste water hydrocyclone as shown in the relevant tender drawing.	
7.03.04	Hydro-cyclones shall be of modular construction. It shall be possible to remove and replace individual hydro-cyclone with the set in service. Individual isolation valve shall be provided for each hydro-cyclone for this purpose.	
7.03.05	The hydro-cyclone shall be of proven design. The primary hydro-cyclone shall be made up of polyurethane or urethane materials. It shall be possible to remove and replace individual hydro-cyclone with the set in service. Individual isolation valve shall be provided for each hydro-cyclone for this purpose. The feed chamber shall be provided with a minimum rubber lining thickness of 12mm. The liners shall have a minimum wear life of not less than 7000 hrs.	
7.04.00	Vacuum Belt Filters	
7.04.01	Each vacuum belt filter shall be sized to meet the following requirements, all occurring together, with an inlet solid concentration of not more than 45% or outlet of hydro-cyclones whichever is minimum:	
 LOT-1A PROJECTS FUEL GAS DESULPHURISATION (FGD) SYSTEM PACKAGE	TECHNICAL SPECIFICATION SECTION-VI BID DOCUMENT NO.: CS-0011-109(1A)-2	 PART-B SUB-SECTION-I-M1 (FGD) PAGE 25 OF 51

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	a. Capacity 110% of gypsum produced by Absorbers of all the units operating at Design point. b. Outlet Moisture 10% max. c. Gypsum Purity 90% (minimum) d. Chloride content < 100 ppm 7.04.02 The vacuum belt filter shall be proven design in operation for similar capacities. The filter cloth shall be polyester or polypropylene as per the proven design of the supplier and shall be guaranteed for a minimum life of not less than 7000 hrs. 7.04.03 The complete frame of the filter and all parts in contact with gypsum shall be made of corrosion resistant material or shall be provided with corrosion resistant liners of proven design. 7.04.04 In case, the contractor offers a design with an underlying belt for carrying the filter cloth, the same shall be endless, factory vulcanized rubber belts. The belt shrouds and the sealing belts shall provide a leak tight arrangement to prevent overflow of gypsum slurry. The sealing belt shall have minimum life of not less than 7000 hrs. 7.04.05 The vacuum box shall ensure tight sealing with the belt/cloth and shall be of proven design. 7.04.06 The belt filter shall have an automatic cloth tracking mechanism and shall be provided with all required instrumentation as per the supplier's proven practice. The belt filter shall have an automatic cloth tensioning mechanism. 7.04.07 The filter shall be provided with minimum 2 stages of cake washing for removing impurities in the gypsum. For cake washing only clarified water shall be used. For this purpose, one (1) clarified water storage tank (minimum 1 hr storage) shall be provided along with 2x100 cake washing pumps for each Vacuum Belt Filter. One stage of cloth washing arrangement shall also be provided along with 2x100 cloth washing pumps for each Vacuum Belt Filter. 7.04.08 The filtrate from gypsum slurry and from cake washing shall be taken to a common or separate vacuum receiver tank(s) as per the proven practice of the supplier. Each belt filter shall have an independent vacuum pump. 7.04.03 Gypsum cake from each belt filter shall be discharged through a hopper onto belt conveyor being provided by the Employer. 7.04.04 A 2 m (min.) wide platform shall be provided around each belt filter for easy approach & maintenance. Handling facilities for replacement of heavy components	
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	of the belt shall also be provided.	
7.05.00	Vacuum System	
7.05.01	The filtrate from each belt filter, cake washing & cloth washing shall be taken to a common or separate receiver tank(s) as per the supplier's proven practice.	
7.05.02	Each belt filter shall be provided with an independent vacuum pump sized to meet the requirements of the belt filter operating at its maximum capacity. An additional margin of 10% (min.) over the above capacity shall be provided for each vacuum pump.	
7.05.03	The vacuum pump shall be of low speed liquid ring type of proven design. The design of the vacuum pumps shall avoid cavitations under all operating conditions. The seals shall be of proven design.	
7.05.04	Silencers shall be provided, if required, to limit the noise level to values stipulated elsewhere in this specification.	
7.05.05	The vacuum receiver and pump internals shall be suitably lined to protect against the corrosive environment. The material selected for vacuum pumps & vacuum receivers shall be proven for similar application.	
7.05.06	Each vacuum receiver tank(s) shall be provided with slide plate type pneumatic vacuum breaker. The plate shall be stainless steel with a min. thickness of 3 mm.	
7.06.00	Filtrate System	
7.06.01	Water from vacuum receiver tank(s) and the secondary waste water hydrocyclone underflow shall be taken to a common filtrate tank for recirculation to the absorber tanks.	
7.06.02	2x100% horizontal centrifugal pumps shall be provided for recirculation of filtrate water to absorber. 2x100% horizontal centrifugal pumps shall be provided for wash water requirements of belt filter. Alternatively, wash water pump may take suction from the vacuums receiver tanks. Each pump shall be provided with 100% standby in such a case.	
7.06.03	The pump shall be capable of pumping of filtrate water with solid concentration of not less than 10% & particle lumps of 6-7mm. A 10% margin shall be provided in each of the pump.	
7.07.00	Waste Water System	
7.07.01	The overflow of the primary hydro-cyclones shall be taken to a secondary hydrocyclone feed tank for feeding the secondary waste water hydro-cyclones.	
7.07.02	The secondary hydrocyclone feed tank shall be sized to provide a minimum storage	
 LOT-1A PROJECTS FLUE GAS DESULPHURISATION (FGD) SYSTEM PACKAGE	TECHNICAL SPECIFICATION SECTION-VI BID DOCUMENT NO.: CS-0011-109(1A)-2	 PART-B SUB-SECTION-I-M1 (FGD) PAGE 27 OF 51

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7.07.03	of 1 hr of primary hydro-cyclone overflow with all the units operating at Design Point and no outflow from the tank.			
7.07.04	2x100% horizontal centrifugal pumps shall be provided to feed the secondary hydro-cyclones.			
7.07.05	Each set of hydro-cyclone shall be sized to process the maximum discharge from the secondary hydro-cyclone feed pumps. A minimum 10% spare hydro-cyclones shall be provided in each set. Secondary Hydro-cyclones shall be of modular construction and of proven design. The secondary hydro-cyclone shall be made up of polyurethane or urethane materials. It shall be possible to remove and replace individual hydro-cyclone with the set in service. Individual isolation valve shall be provided for each hydro-cyclone for this purpose.			
7.07.06	The secondary waste water underflow shall be taken to the adequately sized filtrate tank, while the overflow shall be taken to a waste water Tank.			
7.07.07	1x100% Waste water tank shall be provided (in projects where separate Zero Liquid Discharge system for waste water treatment is not in the scope of the contractor) which shall be sized for 8 hrs storage of waste water with all the units operating at Design point and no out flow from the tank. The Waste water Tank shall be complete with Agitator, level transmitters etc. The waste water collection tank shall be of Steel construction with rubber lining. 2x100% horizontal centrifugal pumps shall be provided for pumping the waste water from waste water tank at required pressure to waste water terminal point as indicated in Sub-section IV, Part A, Section VI of the Technical Specification. The material of Casing and impeller shall be rubber lined Cast Iron (IS:210 Gr FG260). Shaft and Shaft Sleeves shall be Stainless Steel-410.			
7.07.07	All piping, valves & instrumentation upto the employer's terminal point shall be in the contractor's scope. Contractor shall provide the complete lime dosing system (in projects where separate Zero Liquid Discharge system for waste water treatment is not in the scope of the contractor) to correct the pH of the waste water by lime (83% purity) dosing shall be provided and after mixing of the effluent (using re-circulation system of the pumping system), the effluent shall be discharged once the waste water has been neutralized to desired pH. A pH monitor shall be provided at the discharge of the pumps for measurement and control. Complete lime storage, feeding & dosing system shall be in contractor scope. The complete waste water neutralization system shall be automated and controlled from the control room.			
7.07.07	Contractor shall provide 2x 100% Lime Neutralization tanks (in projects where separate Zero Liquid Discharge system for waste water treatment is not in the scope of the contractor) which shall be of minimum 8 hr capacity made of carbon steel with rubber lining along with 2x100% Lime storage silos. The tanks shall be provided with SS dissolving basket, Agitator of SS construction, drain, over flow and dosing connection, level transmitters, Agitators etc. The storage silos and hopper cones shall be fabricated of minimum 10 mm thick carbon steel with a SS lining of grade SS304 of minimum 4 mm thickness in the complete cones to ensure reliable discharge of material. The design of storage silos shall confirm to IS 9178 or any			
LOT-1A PROJECTS FLUE GAS DESULPHURISATION (FGD) SYSTEM PACKAGE	TECHNICAL SPECIFICATION SECTION-VI BID DOCUMENT NO.: CS-0011-109(1A)-2	Heavy Electricals Power Sector PART-B SUB-SECTION-I-M1 (FGD)	NTPC PAGE 28 OF 51	

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	other proven international standards. The storage silo shall be capable of feeding the lime by motorized rotary feeding system to the Lime Neutralization tank.			
7.07.09	Contractor shall provide 2x 100% Lime Storage Silos (in projects where separate Zero Liquid Discharge system for waste water treatment is not in the scope of the contractor) for feeding lime to the Lime Neutralization tanks. The lime storage silo shall be of minimum 24 hr capacity equivalent to the requirements of FGD system of 2X800 MW at Design point and shall be complete with supporting steel structure, platforms, power operated outlet gates, level switches, air relief devices, etc.. For dust free operation each silo should be provided with a covering arrangement and a self cleaning bag filter system of suitable capacity containing blower, automatic/on-load cleaning system, etc.			
7.07.10	Bucket conveyors shall be provided by the contractor to feed lime to each of the lime storage silos from ground level. The Bucket conveyors shall be sized to completely feed each lime silo within 2hrs. Adequate storage and feeding system required for feeding the lime to the Bucket conveyors is also in the Contractor's scope.			
7.07.10	A storage room for storing minimum one (1) month requirement of lime for all the units shall also be provided by the contractor.			
7.08.00	Auxiliary Absorbent Tank			
7.08.01	The Contractor shall provide an auxiliary absorbent tank, for the unit, sized to contain the complete slurry of one absorber tank at its maximum level equipped with all necessary pumps, valves, piping and controls to transfer the tank's contents back to the absorber to refill the absorber sump. It should be possible to discharge the each absorber into the emergency drain tank within 2 hours.			
7.08.02	The contractor shall provide 2 x100% pump to pump back the slurry from the sump back to the absorber in a maximum time of 8 hours.			
7.08.03	Agitation shall be provided to prevent settlement of slurry by side entry agitators with emergency flush start system. Sufficient number of agitators shall be provided in the tank by the contractor to prevent the solids from settling down.			
7.08.04	The Auxiliary Absorbent tank shall be made of minimum 7 mm thick carbon steel with minimum 4 mm thick rubber lining of best quality bromine butyl rubber and shall also be equipped with all necessary pumps, valves, piping and controls to transfer the tank's contents back to the absorber.			
7.08.05	The Auxiliary Absorbent tank shall be equipped with an opening to enable easy entry of a man with wheelbarrow.			
7.08.06	Coarse-screen(s) of suitable material at suction-side of the pumps shall be provided.			
8.00.00	SLURRY PUMPS			
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CLAUSE NO.	TECHNICAL REQUIREMENTS	
8.01.00	This Clause covers the design, manufacture and erection of all slurry pumps for the FGD system including the Absorber slurry recirculation pumps, Gypsum bleed pumps, Limestone slurry feed pumps, Mill circuit pumps and any other pump handling slurries.	
8.02.00	The Contractor shall offer only proven design in successful operation in similar application at previous installations. The design, manufacture, installation and testing of the pumps shall follow the latest applicable Indian / International (ASME / EN / Japanese) Standards.	
8.03.00	The pumps shall be designed for continuous operation. The pump shall be single stage centrifugal type capable of delivering the rated flow at rated head with margins as specified in the respective clauses. The slurry concentration in the pump shall not exceed 30% by weight except for Mill circuit slurry pumps for which the slurry concentration in the pump shall not exceed 55% by weight.	
8.04.00	All the slurry pumps shall be provided with motorized suction and discharge valves. In addition, flushing water lines with motorized valves shall be provided for each pump for automatic flushing of the pump after each shut down. The flushing water for the pumps shall be taken from the process water supply	
8.05.00	The pump casing should be radially split to allow easy removal of impeller.	
8.06.00	All the pump wear parts in contact with the slurry shall be provided with replaceable rubber/elastomer liners suitable for the fluid handled. The Bidder can also offer an hi chrome alloy line pump if the Bidder has previous experience of the same for similar applications. The material used by the contractor shall be proven in previous installations.	
8.07.00	For absorber recirculation service a Silicon carbide impeller and SiC lining for casing can also be accepted if the manufacturer has supplied a similar pump for a previous installation for similar service.	
8.08.00	The material and thickness of the liners shall ensure a minimum service life of 2 years before replacement. All the wear parts of the pump shall be guaranteed for a minimum wear life of not less than 14000 hrs.	
8.09.00	The design of the shaft shall ensure that the operating speed is at least 20% above the critical speed of the shaft.	
9.10.00	The pump shall be provided with seals of proven type and shall be designed for minimization of seal water consumption. The shaft shall be supported on heavy duty ball/roller bearings.	
9.00.00	VERTICAL SUMP PUMPS	
9.01.00	Contractor shall provide sumps of adequate capacity in the each absorber area, limestone grinding area and gypsum dewatering area for containing the overflow	
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CLAUSE NO.	TECHNICAL REQUIREMENTS	एनटीपीसी NTPC	
	from the respective systems. Contractor shall make arrangements for pumping the drainage water back to the respective system with vertical sump pumps. Agitators shall also be provided to avoid settling of solids in the sump. Adequate redundancy in line with the standard practice adopted by the bidder shall be provided. This Clause covers the design, manufacture and erection of all vertical sump pumps for the FGD system.		
9.02.00	The contractor shall offer only proven design in successful operation in similar application at previous installations. The design, manufacture, installation and testing of the pumps shall follow the latest applicable Indian / International (ASME / EN / Japanese) Standards.		
9.03.00	The pumps shall be designed for continuous operation. The pump shall be single stage centrifugal type with semi open or open impeller. The pump impeller shall be cantilever type and shall not be supported below the base plate for easy withdrawal.		
9.04.00	The pump shall deliver the rated flow at rated head with margins as specified in the respective clauses. The pump shall be capable of pumping of filtrate water with solid concentration upto 10% & particle lumps of 6-7mm. Sump pumps handling slurry shall be designed with a maximum concentration of 30% solid by weight.		
9.05.00	The material chosen for the pump components shall be suitable for the fluid handled and shall be proven in similar application.		
9.06.00	The pumps shall not be supported below the base plate level for easy withdrawal without entering the sump.		
10.00.00	SLURRY & PROCESS WATER TANKS		
10.01.00	All the slurry tanks (Slurry Tanks, Filtrate Tank, Secondary hydro cyclone feed tank, vacuum receiver tank, Waste water Tank, Lime Neutralization tanks etc.) shall be designed, fabricated, erected and tested in accordance with the IS:803, latest edition. Additional Corrosion allowance of 3mm on the minimum tank shell thickness as calculated by IS:803, latest edition shall be provided by the Contractor. Tanks shall be made from IS:2062 quality mild steel plates of tested quality. The tanks shall be of welded construction. Interior surface of the tanks shall lined with replacable chlorobuty/bromobutyl rubber lining of minimum 5 mm thickness and the outside surface shall be coated with paint as approved by the Employer. The Tanks shall be provided with drain, manholes, over flow & inlet level control valves etc. Coarse-screen(s) at suction-side of these pumps shall be provided.		
11.00.00	AGITATORS		
11.01.00	Agitators shall be supplied in tanks and vessels to prevent caking and settlement of particles out of the slurry, e.g. in the absorber vessel, limestone mill recycle tanks, limestone slurry tank, Auxiliary Absorbent tank, and sumps etc.		
11.02.00	All agitators shall be designed for continuous operation unless otherwise specified.		
ERATING CO GC LOT-1A PROJECTS FLUE GAS DESULPHURISATION (FGD) SYSTEM PACKAGE		TECHNICAL SPECIFICATION SECTION-VI BID DOCUMENT NO.: CS-0011-109(1A)-2	AGITATORS SECTION-VI MARKET * NEW * * 1100 * PART-B SUB-SECTION-I-M1 (FGD) PAGE 31 OF 51

CLAUSE NO.	TECHNICAL REQUIREMENTS	एनटीपीसी NTPC	
	Horizontal agitators shall be used for Absorber. Vertical agitators can also be used for Absorber, if it is only the standard & proven practice of the Contractor for the offered Absorber design. In other vessels and tanks vertical agitators are also acceptable if they are of proven make and the Bidders standard practice which can be proven by means of suitable references. The design of the agitators shall be of proven type. 11.03.00 Standard type agitators with suitable characteristics shall be used wherever practical. The agitators shall be complete with motor, gearbox, agitator shaft, coupling, safety guards, mechanical seal (for side entry agitators), impeller, support legs, agitator mounting flange including bolts nuts and gasket etc. 11.04.00 All agitator parts and accessories in contact with the stirred fluid shall be constructed of materials specifically designed for the conditions and nature of the stirred fluid and be resistant to erosion and corrosion. 11.05.00 The material for the shaft (which is continuously in contact with slurry) and agitator blades of the Absorber Agitators shall be made with Alloy 926 or better material. For Agitators in other tanks, agitator blades shall be made with Alloy 926 or better material & shaft can be rubber lined. This does not release the Contractor of the responsibility for selecting the correct materials. 11.06.00 Each agitator and its associated equipment shall be arranged in such a manner as to permit easy access for operation, maintenance and agitator removal without interrupting plant operation. It shall be possible to remove the sealing devices of the Agitators of the absorber vessel without having to drain completely the absorber. 11.07.00 To prevent mechanical blocking load start-up after standstill of pumps, piping and agitators for slurries shall be applied with C-hose connection. 11.08.00 Lifting lugs and eyes and other special tackle shall be provided as necessary to permit easy handling of the agitators and their components. 11.09.00 Static and dynamic (as far as applicable) balancing of all agitators shall be carried out after assembly. 11.10.00 All agitator parts and components shall be designed and calculated for fatigue life, considering maximum bending loads, induced by fluctuating hydraulic forces and torsional loads, based on the installed motor power. For side entry agitators the alternating bending moment resulting from impeller and shaft weight has to be considered additionally. 11.11.00 All exposed moving parts shall be covered by guards. 11.12.00 Side entry agitator shall be flange mounted. 11.13.00 The shape of the impeller blades of side entry agitators shall be designed to avoid wear on the impellers which will affect the agitator performance as specified for a minimum period of 2 years of continuous operation under design conditions for the range of coal & limestone specified in the specification. In order to avoid excessive wear impeller tip speeds must not exceed 12 m/s. 11.14.00 Belt drives (if applied) shall be properly designed to provide a minimum lifetime of 2 years under design conditions		
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CLAUSE NO.	TECHNICAL REQUIREMENTS			
12.00.00	SLURRY LINES AND VALVES			
12.01.00	Slurry pipes shall be designed to keep the velocity above the settling velocity under all operating conditions. The contractor may provide a recirculation line with motorized isolation valve for the above purpose.			
12.02.00	All the pipes handling slurry shall be provided with replaceable rubber lining of proven quality. The Contractor can provide slurry pipes of size lower than 3" made up of FRP material (silicon carbide coating on slurry exposed surface) if it has previous experience of providing the same.			
12.03.00	The isolation valves provided in all the slurry lines shall be of knife gate type/butterfly type unless specifically mentioned. Motorized actuators shall be provided for valves requiring frequent operation as indicated in the relevant scheme.			
12.04.00	The valves shall be of proven type and the contractor shall submit a detailed valve schedule for employer's approval. Reference list for previous installations for similar application shall also be furnished to the employer.			
12.05.00	Bidder shall provide all necessary arrangements for purging & flushing of all the process pipelines, equipments etc.			
13.00.00	PROCESS WATER STORAGE TANKS & PUMPS			
13.01.00	Two (2) Process water Storage tanks (each tank catering to the requirements of all the units operating at Design Point) along with two numbers of 2x100 % Booster water pumps, if required, (Each pump catering to the process water requirements of all the units operating at Design Point) along with all necessary piping, valves, control & instrumentation to feed the clarified water shall be provided by the Contractor. Process water Storage level shall be automatically controlled at operating level by controlling the water flow from the makeup water from terminal point. The process water storage tank shall be designed to store 15 minutes of total maximum water required for the entire FGD process (including absorber system and mist eliminator washing system, limestone grinding and slurry preparation system and gypsum dewatering system, etc.) for the units operating at Design point. All the process water storage tanks shall be designed, fabricated, erected and tested in accordance with the IS:803, latest edition. Additional Corrosion allowance of 1.50 mm on the minimum tank shell thickness as calculated by IS:803, latest edition shall be provided by the bidder. Tanks shall be made from IS:2062 quality mild steel plates of tested quality. The tank shall receive water supplied (as identified in Subsection titled "Terminal points" in Part-A of Technical Specification) by Employer. The Tanks shall be provided with drain, manholes, over flow & inlet level control valves etc.			
13.02.00	2x100% Process Water Pumps shall be provided for each unit connected to each of the Process water Storage tanks along with all necessary piping, valves, control &			
 LOT-1A PROJECTS FLUE GAS DESULPHURISATION (FGD) SYSTEM PACKAGE		TECHNICAL SPECIFICATION SECTION-VI BID DOCUMENT NO.: CS-0011-109(1A)-2	PART-B SUB-SECTION-I-M1 (FGD)	 PAGE 33 OF 51

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13.03.00 13.03.04 13.03.05 13.03.06 13.03.07 14.00.00	instrumentation. Each pump catering to process water requirement of one unit. The capacity of the pumps shall be such that it shall meet the maximum process water requirement of each unit. A further 10% margin shall be provided over the above capacity for all the above pumps. 2x100% Mist Eliminator Wash Water Pump for each unit connected to each of the Process water Storage tanks along with all necessary piping, valves, control & instrumentation shall be provided by the Contractor. Alternatively, Contractor can use process water pumps for mist eliminator washing if it is the standard & proven practice of the Contractor or its Technology Collaborator. Each pump shall cater to maximum mist washing requirement of one unit. The capacity of the pumps shall be such that the total capacity of working pumps is sufficient to meet the maximum wash water requirements of mist eliminators of the absorber. A further 10% margin shall be provided over the above capacity for all the above pumps. Two (2) clarified water Storage tanks along with two numbers of 2x100 % clarified Booster water pumps from terminal point shall be provided by the Contractor. The two tanks shall be interconnected with an isolation valve. 2x100% clarified water Pumps connected to each of the clarified water Storage tanks for each dewatering stream. Each pump catering to clarified water requirement of each dewatering stream. The type of pumps shall be horizontal centrifugal type designed for continuous operation with semi open or closed impeller. Casing, Gland and Stuffing Box shall be of 2.5 Ni Cast Iron to IS:210 Grade FG 260 or equivalent. Impeller, Wearing rings (as applicable) shall be of Stainless Steel -316 grade and Shaft & Shaft sleeves shall be of SS-410 grade. Pump re-circulation line shall be provided for pumping system. Pumps shall be provided with accessories such as Y-type suction strainers, Coupling guard, drain plugs, vent valves etc. All the Process water tanks (Process water Storage tanks, Clarified water tank, Emergency water storage tanks etc.) shall be designed, fabricated, erected and tested in accordance with the IS:803, latest edition. Additional Corrosion allowance of 3mm on the minimum tank shell thickness as calculated by IS:803, latest edition shall be provided by the Contractor. Tanks shall be made from IS:2062 quality mild steel plates of tested quality. The tanks shall be of welded construction. Interior surface of the tanks shall lined with replacable chlorobutyl/bromobutyl rubber lining of minimum 4 mm thickness or with vinly ester based flake glass lining of minimum 3 mm thickness and the outside surface shall be coated with paint as approved by the Employer. The Tanks shall be provided with drain, manholes, over flow & inlet level control valves etc. APPROACH and Handling Facilities	 	
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