Selective Catalytic Reduction System

Project DN109

High Pressure Boiler Plant
BHEL, Tiruchirapalli

Specification for High Dust SCR system

1. The specification Contains :
   - Part I – General Requirements
   - Part II – Detail specification Requirements
   - Part III – Contract specific Technical Requirements

2. If the requirement of Part-I and Part-II is differing with Part III, then the requirement of Part III will be mandatory.
3. Vendor should fill up all datasheets for evaluation of offer.
4. Vendor shall submit all the documents identified in the specification.
5. Incomplete offers will not be considered.

PREPARED BY:	REVIEWED BY:	DATE:
CFT	CFT	21.10.2016

REV No.	DETAILS	REVISED BY	APPROVED BY	DATE

Part-I
General Requirements

1.0. GENERAL

Selective Catalytic Reduction (SCR) System shall reduce overall NOx (oxides of nitrogen) produced in the Steam Generator to the specified values. This system shall be based on catalysts which will enable reduction of NOx by ammonia (NH3). The complete SCR system shall be designed for outdoor location connected to the coal fired steam generator. The SCR system shall be designed to contain ammonia slip to specified values under all operating conditions. Ease of maintenance, repair and overhaul shall be a central consideration in the SCR equipment design/arrangement, assembly, access, provisions for spares/tooling etc. The design/specifications/sizing of various plants/systems/equipment offered for the SCR System & Auxiliaries shall comply with the requirements detailed hereinafter.

The SCR system supplier (the Vendor) shall design, fabricate, deliver and place the selective catalytic reduction (SCR) system into commercial operation for treating the flue gas NOx emissions exiting the steam generators. The SCR system design conditions shall be as specified in Part II of this specification.

2.0. DESIGN CRITERIA FOR THE SCR SYSTEM

The design of the SCR system shall be based on proven concept of reduction of NOx in the flue gas emanating from pulverized coal fired steam generator through mixing ammonia and passing it through catalyst bed placed in reactor. Ammonia shall be mixed to the flue gas upstream of the SCR reactor. The flue gas shall flow from top to the bottom of the reactor unless otherwise specified elsewhere in the specification. A reactor gas side by-pass shall be provided for operational flexibility. The total catalyst requirement shall be arranged in layers, on horizontally arranged support frames inside the reactor. Further provision for one spare future layer of catalyst shall be made within the reactor. Anhydrous ammonia shall be used as the reagent for the SCR system. Unloading from truck, Storage and forwarding facility for ammonia shall be provided including facility for its vaporization and dilute air-ammonia mixture preparation for feeding in to the flue gas through an injection system.

2.1 Materials and Equipment

2.1.1 Materials and equipment must be new and of proven design. Equipment deemed to be prototype in nature are unacceptable.

2.1.2 The use of asbestos, asbestos containing materials, or polychlorinated biphenyls (PCBs) is prohibited in any of the equipment furnished.

2.1.3 Parts subject to wear, corrosion, or deterioration, or requiring adjustment, inspection or repair shall be accessible and capable of convenient removal, replacement and repair.

3.0 REGULATIONS, CODES, STANDARDS AND SPECIFICATIONS

3.1 Referenced Standards

3.1.1 Reference to the standards of any technical society, organization, or association, or to the laws, ordinances, or codes of government authorities shall mean the latest standard, code, or specification adopted.

3.1.2 The referenced codes and standards shall govern in all cases except where they conflict with the requirements of these specifications. In case of conflict between this specification and codes or standards and, the stringent requirement shall be followed and the same shall be brought to the notice of the Purchaser.

3.1.3 Publications of the following agencies shall form a part of these specifications to the extent specified therein. References to the sponsoring agencies will be made in accordance with the abbreviations indicated:

ACI,	American Concrete Institute
AHI,	American Hydraulic Institute
AMCA,	Air Movement and Control Association, Inc.
ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
ASTM,	American Society Testing and Materials
AWS,	American Welding Society
BIS,	Bureau of Indian Standards
ISA,	Instrument Society of America
IEEE,	Institute of Electrical and Electronics Engineers
NEMA,	National Electrical Manufacturers' Association
NEC,	National Electrical Code
NFPA,	National Fire Protection Association
OSHA	Occupational Safety Health Act
SMPV,	Static Mobile Pressure Vessel Code

3.1.4 Other Regulations and Codes:

a. IS 4544, Ammonia - Code of Safety, Ammonia Code of Safety. This includes providing process safety information as well.

b. IS 662/ 799 – Indian Standard for specification for Anhydrous Ammonia / Ammonia Liquor

c.ANSI Pamphlet CGA G_2.1—2014 6th Edition (formerly ANSI K61.1), - Safety Requirements for the Storage and Handling of Anhydrous Ammonia

d. ASME Boiler and Pressure Vessel Code, Section VIII- Pressure Vessels

e. All local safety and handling ordinances concerning automatic sprinkler systems, canopies, impoundments, and venting requirements

f. AISC specification for the Design, Fabrication and Erection of Structural Steel for Buildings (latest edition)

Omission of any codes or standards does not relieve the Vendor of his responsibility to follow all applicable codes, standards and regulations. Any conflict among standards shall be referred to the Purchaser who shall determine which standard governs. Should codes and standards be revised after the issue of these specifications, the Vendor should inform the Purchaser immediately upon receipt of such information. Before adoption of any subsequent issue, or case ruling, the Vendor shall discuss the effect of these requirements with the Purchaser and proceed with material and/or fabrication changes only after the Purchaser's written approval.

4.0 SCOPE OF SUPPLY

The SCR system scope of supply shall include the following:

4.1 SCR Reactor

a. Reactor chamber including duct plate housing, insulation, lagging and all structural internal supports. The reactor chamber housing shall include provisions for access as required to maintain the system, test ports, equipment mounted instrumentation for monitoring the performance & tuning the system, access doors for catalyst loading, removal & inspection. In addition, a permanent sealing system along the bottom support beams and between catalyst modules, baffle and seal bars on top of each module, internal reactor guide vanes

& an upstream flow straightening system (if required), and reactor external sliding supports shall be furnished.

Note: The Vendor shall size/match the Purchaser's arrangement drawings (Refer Part III) in order to confirm adequate access provisions for all furnished equipment. Vendor shall furnish SCR arrangement drawing indicating all access requirements including external stairways, ladders, platforms, handrails and handling requirements and accessories supplied by the Purchaser.

b. An internal and external monorail/hoist system shall be utilized to remove, install and handle catalytic modules. Internal reactor monorail steel shall be provided by vendor at each catalyst layer to accommodate the installation and removal of modules. External monorail support steel and an interconnecting transition piece (if required) shall be provided by the Purchaser. Vendor to recommend the locations of catalyst removal access doors and loading scheme in the SCR arrangement drawing to be submitted for Purchasers review.

c. Scope of SCR duct work including external stiffeners, internal supports, duct expansion joints, dampers, insulation and lagging shall be as per Terminal Point indicated in P&ID. Required test ports for sampling, fixed monitoring probes, guide vanes design and location, if required in the duct of Purchaser's scope, shall be provided by the Vendor.

Note: The external steel for ductwork support design shall be by Purchaser. The Vendor shall supply all relevant ductwork loading and expansion information to the Purchaser.

4.2 Catalyst Modules

a. SCR catalyst modules including all equipment to safely install the modules within the reactor chamber. Activity testing of sample catalyst elements during the guaranteed service of the catalyst shall be provided. Catalyst instruction manuals describing short and long term storage requirements, installation procedures, permissible inlet operating conditions and disposal procedure shall be furnished. Correction curves for off-design field operating conditions shall also be provided.

4.3 Flue Gas Mixing Device and Flow Model Study

a. Flue gas mixing devices, as required, to ensure a uniform distribution of ammonia, temperature and gas velocity entering the first catalyst layer. A physical flow model will evaluate the necessity for such a device.

b. A 1/10th scale, Plexiglas flow model study of the SCR system arrangement shall be provided. This shall be supported with CFD study of the full scale model. Physical modelling for SCR reactor, upstream duct work from economizer outlet (including economizer gas bypass) along with cyclone separator (if applicable) and downstream ductwork from SCR reactor outlet upto Air preheater inlet including Ammonia injection grid/nozzle shall be carried out to examine and finalize the design options for the duct system, flow modification devices, Ammonia Injection system, etc. This shall confirm the Vendor's SCR system performance with respect to ammonia distribution, ammonia injection grid design and location, internal duct guide vane arrangement, areas of possible dust accumulation, flue gas mixer design and location, and reactor design and inlet ductwork arrangement. Based on the model test

studies, the Vendor shall finalize the geometry of the reactor, ductwork, flow modification devices, sampling points etc. The model study shall be carried out in the presence of the Purchaser. The physical model shall use fan(s) to draw air through the model at a flow rate that provides similar fluid dynamic behaviour to the full scale system.

4.4 De-dusting System

a. Steam assisted soot blowers shall be provided above each catalyst layer. All blowers, piping, valves, fittings, drains, reactor soot blower steel supports and complete controls and wiring shall be furnished.

Note: Steam piping shall be furnished by the Purchaser up to a single terminal point at the SCR boundary.

Alternatively, sonic horn and air cannon for blowing/dislodging accumulated/sticking ash and fouling on catalyst surface. Type of de-dusting system shall be offered based on Vendor's standard practice/ past supply experience.

The contractor shall establish/ recommend de-dusting device frequency and their performance tuning based on the actual operation through controlled tests/measurements. Cleaning effectiveness shall target recovery, as measured through gas pressure drop and visual inspection, up to a near pressure drop value with reference to completely clean reactor as measured at the time of commissioning. In case if above de-dusting systems are not sufficient for effective cleaning of the catalyst than the bidder may provide Dry Cleaning System for in-situ cleaning of the catalyst in addition to above.

For the de-dusting system, offered by vendor the de-dusting control logics, interlocks and sequence of operation shall be provided by the vendor for implementation in purchaser's DCS.

4.5 Ammonia Unloading, Storage, Handling and Preparation System

a. An ammonia handling and storage facility including unloading system, compressor to unload for supply truck, storage tanks, , equipment mounted instrumentation and valves required for the safe unloading and storage of anhydrous ammonia with all equipment's, fittings, hose connections, monitoring and safety devices. All equipment shall meet international and local regulations codes.

b. Two (2) x 100 % Ammonia vaporizers with all associated connecting piping to vaporise the ammonia required for the SCR system. If steam assisted vaporization system is offered associated accumulators, piping, instrumentation and controls shall be offered. Condensate formed due to the condensation of steam shall be connected to the condensate tank by the Purchaser from Vendors terminal point. Vendor to provide steam requirements and terminal points.

c. Two (2) x 100 % common ammonia forwarding pumps skid (if applicable) (1 working and 1 standby pump) with recirculation line shall be provided to ensure steady supply of ammonia to the vaporizer and flow control units (located at the steam generator).

d. Ammonia accumulators and associated systems capable of handling the ammonia to meet the requirements of SCR system.

e. A dyke shall be provided around storage tank area with storage capacity equivalent to one storage tank, for collection of liquid ammonia in case of emergency. This dyke shall be connected to waste water retaining basin. Civil works are under Purchaser's scope.

f. One (01) no. Waste water retaining basin near ammonia unloading & storage system along with 2x100% waste water/ ammonia disposal pumps with motors for transferring drains to Water Treatment Plant (WTP). Chemical dosing system for controlling pH of waste water before sending to WTP.

g. A dilution air skid including an ammonia/air mixer, two (2) x 100 % dilution air blowers, two (2) x 100 % dilution air heaters (if required), instrumentation, valves and local controls. The ammonia flow instrumentation shall include all necessary control, shutoff, bypass and relief valves and monitoring devices to ensure a safe operational system. The required control logics and interlocks for implementation in purchaser's DCS shall be furnished by vendor.

h. An ammonia dilution tank of adequate capacity shall be provided with all interconnecting piping to allow the safe disposal of any excess ammonia vented or drained from the system.

i. All interconnecting piping from the ammonia storage tank / vaporizer skid to the dilution air skid, and from the dilution air skid to the ammonia injection inlet manifold shall be provided. Fittings, hangers and supports shall be provided for all piping in the Vendor's scope of supply.

j. Personnel safety equipment in order to comply with all local requirements. As a minimum, the following shall be provided:
   i. Shower/eyewash stations located in the vicinity of the ammonia storage tanks and the dilution air skid
   ii. Face masks and canisters
   iii. Goggles
   iv. Gloves and boots
   v. Ammonia sensor alarms (for local & remote) located in the vicinity of the ammonia storage tanks and the dilution air skid

4.6 Ammonia Injection System

a. Ammonia injection system including an inlet manifold with local temperature and pressure gauges, ammonia injection nozzles, flow control valves, flow orifices and manometers, flex hoses, compressed air valve connections and all required piping with internal and external structural supports. The space and access requirement shall be indicated in the AIG arrangement drawing.

4.7 Electricals, Controls and Instrumentation

a. O2 Analyser, SO2 Analyser, NOx analyser at inlet and outlet of SCR as per P&ID. NH3 Analyser at outlet of SCR, any other analyser connected to SCR System. Local enclosures/ cabinets to house the analysers.
b. pH measurement for as applicable.
c. Ammonia Leak Detector System as indicated in the detailed specification
d. Local Controls Panels, Field Junction boxes, Local instrument enclosures
e. Pneumatic & electric actuators for regulating & Open/close applications

f. Instrumentation & Control cables from field equipment / instruments to Local JB/ Local Control panels
g. Instrument installation materials including pipings, fittings, root valves etc., for vendor supplied instruments.
h. Erection materials for vendor supplied equipment
i. Equipment and skid mounted instruments shall be in Vendor's scope. Vendor shall terminate the instruments up to Local junction boxes. Line mounted instruments will be in Purchaser's scope.
j. The minimum quantity of instruments shall be as indicated in the P&ID. Vendor shall include the additional measurements if any to meet the process requirement. Vendor to refer Annexure U for Specification of Measuring Instruments
k. Equipments & instrument enclosures shall be suitable for the Hazardous area of Classification.
l. Electrical motors for the drives. Vendor to refer Annexure S for Specification of Motors
m. All Electrical actuators shall be provided with Integral starters. Vendor to refer Annexure R for Specification of Electrical Actuators
n. Vendor to refer Annexure Q for Electrical Power supply details.
o. Vendor to refer Annexure P for Terminal Points for Electrical C&I Equipment.

4.8 Other Requirements

a. Utility piping, fittings, hangers and supports from a tie-in point at the Vendor's battery limit to service the SCR system steam, water and air requirements.
b. Primer, finish painting of all uninsulated steel and piping surfaces shall be provided. Purchaser shall confirm if the Vendor's paint is acceptable.
c. One (1) year spare parts (excluding catalyst) for maintaining the availability of the Vendor's supplied equipment shall be supplied along with main equipment.
d. Mandatory spares as per the list enclosed separately shall be offered. Pricing of the spares will be considered for commercial evaluation.
e. Erection material for vendor supplied equipment.
f. Supervisory services for the erection, start-up, testing and commissioning of the Vendor's equipment. Breakup price for the above services shall be quoted separately.
g. Instruction manuals, performance test procedures and testing plan for the equipment supplied by the Vendor for purchasers review and acceptance.
h. Performance testing and commissioning is Vendor's responsibility.
i. Trouble shooting of equipment engineered or supplied by vendor before handing over of SCR system to end customer shall be in Vendor scope.
j. Onsite SCR training program with instruction manuals for preparing the Purchaser's personnel to operate and maintain the equipment supplied by the Vendor.
k. Vendor quality plan shall be submitted for Purchaser's review and approval.
l. The Vendor shall provide the Purchaser with reasonable advance notice of all factory tests associated with the equipment/items under Vendor scope of supply. The Purchaser shall be entitled to witness all factory tests. The Purchaser shall also be allowed to specify a third party representative to witness these tests.

In general, all components, features and design parameters specified herein are minimum requirements. If the Vendor's design dictates that these requirements be exceeded to meet specified performance guarantees and to provide a safe, reliable operating unit, he shall include all equipment above and beyond the equipment required to meet these minimum requirements. The Vendor shall provide all accessories and appurtenances which are required for a complete, reliable and safe SCR operating unit whether or not the specific equipment which is customarily a part of such a system has been specified herein.

Note: For project specific scope of supply refer Division of Work.

5.0 EXCLUSION

The following items shall be provided by others and are not a part of this specification:

a. Supply of anhydrous ammonia
b. Site permitting
c. Water for the ammonia system
d. Site utilities for construction and SCR operation - including instrument air, electrical power, water, steam, outdoor lighting, etc.
e. All earthwork, foundations, base plates, anchor bolts and site remediation for accommodating the SCR system
f. Complete Electricals including MCC, Switchgears, Distribution boards, Power & Control Cables, Cable trays, Earthing, Grounding, Lighting & Illumination, Lightning protection system.
g. Instrumentation cables beyond Local JB (for Vendor supplied instruments)
h. Instruments other than those specifically included under scope of supply
i. UPS & its distribution
j. Steam, water, air, oil, nitrogen and drain piping, valves, traps outside the Vendor's battery limit
k. Thermal insulation as required for associated piping not furnished by the Vendor
l. External structural steel for supporting ductwork, platforms and SCR reactor chamber. Access platforms, handrails, stairs, ladders, grating, and elevators.
m. SCR reactor bypass duct with insulation and lagging
n. Stack continuous emission monitoring system (CEMS) for regulatory compliance
o. Erection of all SCR equipment
p. Receiving and onsite storage of catalyst modules
q. Supply of duct works from Eco out to inlet of reactor chamber.
r. Supply of duct works from outlet of reactor chamber to APH inlet.
s. Lining and insulation of duct works from eco outlet to APH inlet including reactor chamber

PART II
Detail specification Requirements

1.0 SCR SYSTEM DESIGN REQUIREMENTS

1.1 The design of the SCR System shall be carried out taking following into consideration:

a) All operating conditions of steam generator (e.g. gas temperature, ash, start/stops, load cycling) from start-up to 40% TMCR without ammonia injection and from 40% TMCR to BMCR with ammonia injection for complete range of specified coal and specified ambient air condition.
b) Duct design for reduced gas stratification and effective gas-ammonia mixing for minimization of ammonia consumption and slip
c) Prevention of formation of ammonium bisulfate (ABS) and other ammonia components, which deactivate or plug up or mask the catalysts and other downstream components
d) Minimization of SO2 to SO3 conversion
f) Prevention of plugging of the catalyst by ash particles
g) Design life of 25 years (excluding catalyst).
h) Modular construction to enable catalyst management plan (CMP) and periodic maintenance / inspections.

1.2 The SCR system shall be of a hot-side, high dust design, located between the economizer and the gas inlet duct to the air preheater.

1.3 The SCR system shall be designed for continuous operation with any of the fuels specified in Part III. The SCR equipment performance shall meet outlet emission requirements as detailed in the Part III

1.4 Anhydrous ammonia with a minimum ammonia content of 99.5 % shall be used at this facility. Anhydrous ammonia is supplied and stored as a compressed liquid with moisture limited to 0.50% maximum.

1.5 Site Conditions
1.5.1 The basis for the SCR system design shall be according to the site conditions specified in Part III

1.6 The catalyst shall be selected to meet outlet emission requirements based on the design criteria and SCR performance shall be achieved for all combinations of fuels and operating boiler loads indicated in Part III.

2.0 SCR SYSTEM GUARANTEES
2.1 The SCR system shall be designed and guaranteed to limit the NOx emissions across all load range as specified in the Part III.

2.2 Unreacted ammonia exiting the SCR reactor shall not exceed the value specified in Part III for all operating conditions and fuels listed in Part III

2.3 The exit NOx and unreacted ammonia emission guarantees shall be maintained over a period of minimum operational hours as specified in Part III without replenishing the catalyst. In case of non-performance of the catalysts as per guarantee terms, then the vendor is liable to replace the catalysts/equipment to meet the performance requirements.

2.4 The SCR system including all ductwork, flow distribution devices, ammonia injection grid, and reactor flow straightening grid in the Vendor's design or supply scope shall be guaranteed not to exceed the draft loss as specified in Part III with all initial and future catalyst loaded.

2.5 The draft loss across the initial loaded catalyst shall be designed and guaranteed for the inlet operating conditions specified in Part III.

2.6 The oxidation rate of SO_2 to SO_3 shall be guaranteed as per Part III at all inlet operating conditions specified in Part III while firing any of the fuels specified in Part III. The guarantee should be based upon having all future catalyst layers loaded into the reactor.

2.7 The anhydrous ammonia consumption rate shall be guaranteed for each of the fuels/ operating conditions specified in Part III.

2.8 Protocol to be signed by Vendor with end customer after proving all guarantee parameters identified in this specification.

3.0 SCR REACTOR CHAMBER

3.1 The SCR reactor shall be a high dust, hot side arrangement located downstream of the economizer and upstream of the two air preheaters. Flue gas will flow vertically down through the catalyst layers.

3.2 There shall be one SCR reactor with two outlets located directly above the two air preheaters. Alternatively vendor to consider two SCR reactor with one outlet each as an option for purchasers review. The geometry of the reactor chamber shall be as specified by vendor. The Vendor must maintain support points, reactor chamber dimensions, etc. to enable steel arrangement and design at Purchasers end. In general refer the arrangement drawing furnished by the Purchaser in Part III.
The distance between module layers shall be a minimum as specified in Part III . This distance shall provide adequate clearance between catalyst layers to facilitate loading and unloading of modules as well as internal reactor inspections.
Multiple layers of catalyst shall be provided. No modules shall be stacked upon each other in the reactor. The maximum module height in any one layer shall not exceed 1500 mm (Vendor may specify any other dimension to optimise). This shall effectively allow soot blowing to dislodge any possible ash accumulation within catalyst surfaces.

3.3 The SCR reactor chamber and inlet ductwork shall be designed to maintain sufficient velocity to prevent fly-ash dropout over the entire boiler operating load range. Reactor inlet transition ductwork shall make gradual changes in cross-sectional area and contain an adequate number of vanes and/or baffles to minimize gas separation zones, prevent dust stratification, prevent fly-ash agglomeration and erosion, and minimize the propagation of wake regimes at the inlet of the reactor upstream of the flow straightening grid.
All ductwork designed by the Vendor shall contain adequate vanes, baffles, and mixing devices to ensure that gas velocity, temperature and ammonia distribution requirements are met. The vanes and mixing devices shall be designed to promote streamlined flow and prevent erosion and vibration.

3.4 The catalyst reactor shall be a self-supporting structure designed to allow for thermal expansion and contraction. Module support shall also be designed to allow thermal expansion and contraction without stressing the modules. Internal reactor steel shall be fabricated from A-36/ IS 2062 material with rolled members. The design of the internal structure shall conform to the seismic and wind requirements specified in Part III. The structural steel design shall also confirm to the latest edition of the AISC/BIS Specification for the Design, Fabrication and Erection of Structural Steel for Buildings.

3.5 Obstructions within the reactor chamber by beams, pipes, soot blowers, etc. shall be kept to a minimum. There shall be no areas where dust can accumulate. Ledges or flat areas shall be avoided. The reactor design shall also accommodate the installation of either a plate or honeycomb catalyst without requiring major structural modifications.

3.6 The SCR reactor shall contain a flow straightening grid upstream of the catalyst layers to provide uniform flow distribution and streamlines. The reactor shall be designed to avoid non-uniform gas flow and dust deposits on the catalyst bed. Reactor inlet flow distributions shall achieve a flue gas velocity uniformity of +/- 10 % from the average velocity when measured upstream of the first catalyst layer. The inlet and outlet gas flow around the straightening grid shall be as near normal (vertically downward) as possible.

3.6.1 A metal flow straightening grid shall be provided. The grid shall be provided in modules for ease of installation into the vertical flow reactor. The metal grid shall be bottom supported in the reactor.

3.6.2 The Vendor shall provide dimensional drawings of the metal grid assembled units. The drawings shall show adequate dimensions and clearances required for the proper installation and maintenance of the grid. The Vendor shall indicate the weights of each metal grid module component.

3.6.3 The metal grid modules shall be completely shop assembled and ready for installation into the reactor chamber. An optimized array of metal grid modules with lifting lugs shall be provided.

3.6.4 Module construction shall avoid flat surfaces which can potentially result in excessive ash deposition.

3.6.5 Structural tubing may be used to construct the grid. Module framework shall be constructed of carbon steel material or better. Provisions for expansion shall be inherent to the module construction. Exposure of the grid material to flue gas temperatures ranging from 200 to 400 C can be expected. All modules shall be completely welded. Other structural configurations may be proposed and considered by the Purchaser.

3.7 Reactor casing provided by the Vendor shall be welded steel plate construction fabricated from A-36 /IS 2062 material or better.

3.8 The catalyst reactor chamber shall be insulated and lagged. Adequate insulation shall be provided in order to ensure that the temperature of the catalyst surfaces does not go below the acid dew point during a shutdown. All insulation shall be applied against plate work, impaled on 10 gauge pins and secured with pin clips. All insulation shall be applied to prevent direct heat transfer through steel.

3.9 Catalyst and personnel access doors shall be independently insulated to allow convenient access or removal. Test ports and other flanged connections shall be insulated to the greatest extent possible.

3.10 Lagging shall be installed, sealed and flashed to provide a neat weatherproof protective covering. Lagging shall be a minimum of 0.81 mm on the reactor walls. Lagging on the reactor roof shall be a minimum of 1.27 mm.

3.11 The reactor shall accommodate sufficient catalyst to achieve guaranteed NOx reduction and ammonia slip requirements as specified. A spare layer accommodating the future addition of a minimum of one layer shall be provided. Design loads, including weight, pressure, seismic, draft losses across catalyst, etc., shall consider the addition of this future layer.

3.12 A permanent sealing system shall be provided between individual catalyst modules and support beams, reactor walls, and adjacent modules to prevent bypass of the flue gas around the catalyst. The system shall be designed to permit subsequent catalyst replacements without damaging the sealing mechanism. Baffles or shrouds (ash accumulation plates) shall be provided to prevent fly-ash accumulation between modules and along the perimeter of the reactor walls.

3.13 The SCR system shall include a reactor bypass (bypass ductwork supplied by the Purchaser) to be used during start-up, shutdown and emergency conditions. The reactor bypass shall include a tight shutoff damper to prevent flue gas slippage while the SCR is in operation. The Vendor shall assume 2 % flue gas bypassing the SCR reactor when selecting the proper catalyst volume for the design criteria specified in Clause 2 of Part II.

3.14 All access doors for inspection and catalyst loading shall be bolted construction. Square access doors shall be furnished with air tight gaskets suitable for the temperature and environment.

3.15 The Vendor shall furnish test ports on the reactor chamber to properly evaluate the performance of the catalyst. All test ports, except those used for permanent Analyzers and instrumentation connections, shall be a minimum of 101.6 mm diameter furnished with NPT thread on one end with screw cap. Pressure differential connections shall be provided between each catalyst layer. All test ports shall protrude outside the thermal insulation lagging a minimum of 101.6 mm. All other test ports not located in the Vendor's supplied ductwork and reactor shall be provided by the Purchaser. At a minimum, test ports shall be located upstream of the ammonia injection grid, upstream of the first catalyst layer and at a plane directly below the last catalyst layer (future layer). At a minimum, test ports used for portable probe traversing shall be located on 1 meter centres across any one plane.

3.16 Reactor start-up and shutdown thermal gradients shall not be limited by the internal reactor steel structure. Support beams, casings, and insulation shall be designed to allow the reactor to warm-up through the moisture and acid dew points as quickly as possible. The Vendor shall supply a start-up and shutdown sequence including a time line.

3.17 A hoist/monorail system shall be furnished by the Vendor to assist in the installation and removal of catalyst modules from the SCR reactor chamber. Internal monorail steel at each level of catalyst (including the future layer) shall be provided. An electric, slow speed hoist will be attached to the overhead monorail in order to facilitate the movement of individual catalyst modules from the ground to the proper level within the reactor. All monorail steel external to the reactor chamber shall be provided by the Purchaser. A hydraulic trolley provided with the catalyst modules shall be used to position each of the modules into the proper location within each layer.
The hoist requirements are as follows:
Number of hoists per SCR system: One (1)
Type : Lug mounted electric wire rope hoist
Load Capacity : As required to lift heaviest catalyst module
Vertical hook travel: To handle top most catalyst module level to ground level
Pendant assembly*: 1-Push-button pendant control station with conductor and support cables
Electrical requirements: Refer Part III.

**Note: The operator shall be capable of moving the load vertically 12.7 mm or less at a time by tapping the down button.*

4.0 CATALYST AND CATALYST MODULES

4.1 The catalyst supplied by the Vendor shall be plate or honeycomb type with a vanadium/titanium composition. Vendor to consider the maximum ash / dust concentration specified in Part III.

4.2 Sufficient catalyst volume shall be provided in order to meet the specified guarantees. The catalyst shall be designed in accordance with the criteria specified in Part III. Consideration shall be taken for 2 % gas flow bypass around the SCR reactor chamber. This leakage accounts for the slide gate shutoff damper located in the reactor bypass duct. The catalyst shall be capable of maintaining the performance with normal operating variations in gas temperature (+/- 10 deg. C from the average) and velocity (+/- 10% from the average) across the face of the catalyst surface.

4.3 Catalyst pitch shall be selected by the Vendor to provide an optimized design of geometric surface area versus volume and differential pressure. The pitch shall be such that the catalyst will not be prone to fly-ash pluggage. Vendor to consider the maximum ash / dust concentration specified in Part III

4.4 The Vendor shall submit a laboratory procedure for activity testing of the catalyst. Activity tests using samples from modules installed in the reactor shall be provided. These tests shall occur at mutually acceptable intervals during the service life guarantee period of the catalyst. The frequency of activity tests shall be at a minimum of once per year. The number of activity tests shall be consistent with achieving an optimum and cost effective catalytic management program. A final report shall describe laboratory test results and recommendations for future catalyst replacement. As part of the report, a plot of catalyst activity (K/K_o) versus operating hours shall be included.

4.5 The SCR system performance guarantees shall be based upon field measurements. Correction curves for off-design conditions shall be provided by the Vendor. At a minimum, these curves shall include the impact of flue gas volumetric flow, temperature, inlet NOx and O_2 upon the NOx removal efficiency. Also, a curve of SO_2 to SO_3 oxidation rate vs temperature and area velocity shall be provided.

4.6 The catalyst's chemically active constituents which are bonded to metallic substrates (plate type catalyst) shall not delaminate due to stresses induced by thermal or pressure forces for the life of the catalyst.

4.7 An option for the disposal of the initial charge of catalyst shall be provided. The Vendor shall adhere to all local regulations pertaining to handling, and disposing of the catalyst material. It should be noted that the catalyst will be exposed to coal fly-ash which contains heavy metals. Consequently, consideration for a hazardous waste disposal shall be assumed by the Vendor. This shall be indicated as an optional price.

4.8 The catalyst element baskets shall be shop assembled into modules for ease of installation and removal from the reactor. The module framework shall be constructed of carbon steel material. Grating protection shall be furnished on the upstream face of each module for ease of internal maintenance and inspection. Screening shall also be provided on the upstream face of each catalyst module to prevent large ash particles from becoming lodged within the catalyst plate material. Similar construction shall be provided if a honeycomb catalyst module is supplied.

4.9 Lifting lugs shall be provided on the catalyst modules for ease of installation into the reactor chamber. All special tools required for the proper installation of the modules shall be provided. This shall include a hydraulic trolley for individual module positioning within the SCR reactor chamber. A

spreader beam specially designed for lifting the modules from grade to each appropriate catalyst elevation shall be furnished. Any additional special tools required for the unloading of catalyst modules from either truck or rail delivery of the modules to the site shall be supplied.

4.10 All catalyst modules shall be packed in appropriate containers to prevent damage and/or exposure to moisture during shipment. The Vendor shall supply long and short term storage and handling procedures and recommendations for onsite storage of the modules.

4.11 The Vendor shall provide dimensional drawings of the catalyst modules, hydraulic trolley and spreader beam used for installation. The drawings shall show adequate dimensions and clearances required for proper installation and maintenance. The drawings shall show the weights of all major components. All Vendor drawings shall be submitted to the Purchaser for approval.

4.12 The Vendor shall provide the Purchaser with reasonable advance notice of all factory tests associated with the catalyst material and module fabrication. The Purchaser shall be entitled to witness all factory tests. The Purchaser shall also be allowed to specify a third party representative to witness these tests.

4.13 The Vendor shall provide Material Safety Data sheets for the catalyst material, as well as any information pertaining to applicable safety regulations for compliance with OSHA requirements (29 CFR 1710.111)and safety regulation standards applicable in India. In addition, all information required to support the Purchaser's safety regulations and site permitting shall be provided.

4.14 The Vendor shall supply operating and instruction manuals describing the procedures (including recommended hot, warm and cold start, shutdown for short and long term periods), as well as maintenance and other special instructions required for the proper care and safe and reliable operation of the catalyst. These instructions shall be specific to the Purchaser's ductwork arrangement, equipment and overall system design.

4.15 The catalyst Vendor shall specify the continuous recommended minimum allowable gas temperatures to the SCR for the full range of fuels/operating condition specified. The final method of flue gas temperature control shall be determined and supplied by the boiler supplier.

4.16 The following information shall be provided for the catalyst and module supplied by the Vendor:

a. Catalyst pitch, specific surface area (m^2/m^3), chemical composition, and selected volume (m^3)
b. Space velocity, area velocity, actual face velocity, linear velocity, SO_2 to SO_3 oxidation rate, draft loss across the initial installed catalyst, NOx removal efficiency and ammonia slip for a fresh catalyst as well as the NOx removal efficiency and ammonia slip for a catalyst after 8000 and 16000 hours of operation for all conditions specified in Part III.
c. Catalyst module width, module depth, module height, module weight, catalyst density, number of modules per layer, total number of modules per reactor. Arrangement and dimensions of modules shall accommodate the reactor dimensions.
d. For the full range of fuels specified in Part III, specify the minimum continuous allowable inlet operating temperature in order to avoid ammonium bisulphate formation on catalytic surfaces. Short term inlet temperatures, below those indicated above, and allowable maximum operating hours at these temperatures shall also be provided. Subsequent recovery temperatures and duration of operation shall be furnished.
e. A recommended, optimized schedule of catalyst module additions and replacements for a 10 year period. Provisions in the reactor chamber for a minimum one layer shall be provided for future.

f. A description of the module sealing method and sealing material.
g. The Vendor shall furnish the allowable conditions for the design of a superheated soot blowing system. Recommendations for steam temperature, pressure, and frequency of blowing shall be furnished. The vendor shall also recommend the distance between the top of the catalyst plate surface and soot blower nozzle. Utility requirements for sonic horns and air canons (if applicable) has to be furnished by the Vendor.
h. Typical laboratory procedures for activity testing of the catalyst shall be furnished. This shall include a list of all items tested and a summary of the type of report that can be expected.
i. The vendor shall provide recommended hot, warm, cold start-up and shutdown procedures. Permissible temperature ramp rates across the catalyst shall be furnished. An SCR reactor bypass has been furnished in order to provide operating flexibility during these conditions. A process control description functionally indicating the control logic, permissive, alarms, and control schemes as it affects catalytic reactive performance shall also be included.
j. The Vendor shall provide recommended jobsite handling and storage procedures for the catalyst modules.
k. The Vendor shall review the adequacy of the load/support requirements and access requirements for the SCR system and furnish the same for Purchasers engineering/BOM calculation at the time of document approval. Any additional access/supports not identified during document approval stage shall be in Vendors scope.
l. The Vendor shall provide the allowable continuous minimum operating temperatures to the catalyst for all fuels and inlet load conditions specified by the Purchaser.

5.0 Flue Gas Mixing Device and Flow Model

5.1 The Vendor shall construct a three-dimensional 1/10th scale (Plexiglas or equal) model of the proposed SCR equipment and boiler back-pass with associated ductwork, reactor transition pieces, and reactor internals. The model shall verify the size, configuration, and location of all necessary SCR installed equipment and final ductwork arrangement, guide vanes, and mixing devices necessary to provide uniform velocity, temperature and ammonia distribution across the catalyst.

5.2 The distribution of ammonia shall be simulated and the injection grid design verified.

5.3 The boundary limits of the physical flow model shall be from economiser outlet to the air preheater gas inlet flange. The Purchaser's boiler arrangement drawings shall be supplied to assist the Vendor in the construction of the model.

5.4 The model shall be arranged such that it simulates the aerodynamic effects on gas flow and distribution due to physical features such as internal ductwork bracing, guide vanes, mixing devices, injection grid, flow straightening grid, etc. The objective of the model is to verify the SCR system design for the following:
a. Gas velocity of +/- 10% from the average at the inlet to the ammonia injection grid and at the inlet to the first catalyst layer
b. Gas temperature within +/- 10 deg C at the inlet to the first catalyst layer
c. Ammonia distribution within +/- 5% of theoretical requirements at the entrance to the first catalyst layer. This distribution objective shall confirm the adequacy of the ammonia injection grid and flue gas mixing design and location.
d. Analysis of ash accumulation throughout the proposed SCR ductwork and reactor chamber.
e. Evaluation of pressure losses throughout the system including across inlet and outlet ductwork, catalyst layers, ammonia injection grid dampers, straightening grid, mixing devices and other

significant reactor/ductwork internals. A discussion of the device used to simulate gas draft loss across the catalyst shall be presented in the final report.

5.5 The Vendor shall submit the following to the Purchaser for review and approval before actual testing:
a. Drawings and description of the flow model showing all dimensions and details
b. Detailed description of the flow model test procedure
c. Tests to be performed
d. Data to be recorded
e. Testing results format
f. Limits, tolerances, and uncertainty in testing
g. Criteria for determining that the testing is complete and successful
h. Discussion of similitude between the flow model and the actual SCR system. The discussion shall include a comparison of the Reynolds, Prandtl, Schmidt, Grashof and Froude numbers for the model and the actual system.

5.6 The Purchaser and/or his representative shall have the right to inspect the flow model and to witness testing at any time. Adequate notice will be given by the Purchaser.

5.7 After completion of the successful model testing, the Vendor shall submit to the Purchaser the following:
a. Test report and results
b. Drawings showing design, dimensions and location of all required flue gas and ammonia mixing devices
c. Drawings showing design, dimensions and location of all duct turning vanes
d. Any changes that will be made to the ductwork, ammonia injection grid, reactor or other parts of the SCR system that are a result of the flow model test

5.8 Any changes in the SCR equipment design resulting from the flow model shall be retested to confirm the adequacy of the revisions. Close coordination of the flow model testing shall be achieved at all times with the Purchaser.
The Vendor shall submit to the Purchaser the proposed schedule for the complete model fabrication, testing and report submittals.

5.9 For the duct work in Purchaser's scope of supply, the arrangement of internals shall be based on mutual agreement

5.10 Final disposition of the model shall be the Purchaser's option.

5.11 **Flue Gas Mixing Devices**
5.11.1Flue gas mixing devices shall be provided, as required to ensure the uniformity of gas velocity, temperature and ammonia dispersion into the flue gas stream. The effectiveness of the mixer design and location shall be confirmed by physical flow model testing.
5.11.2 The mixing device material shall be compatible with the ductwork casing in the area.

6.0 De-Dusting System

6.1 Soot blowers are effective in keeping particulate matter entrained in the flue gas stream so as to avoid the possible formation of deposits on catalytic surfaces. Blowers shall be furnished upstream of each catalyst layer within the SCR reactor. Each soot blower shall use superheated steam supplied

at sufficient velocity and dynamic pressure to keep the catalyst modules clean. The steam source shall be from the steam generator with the tap-off point specified by the Purchaser. The Vendor shall recommend maximum acceptable steam conditions (steam temperature and pressure) for the catalyst. The Purchaser shall furnish steam piping up to a single point connection to interface with Vendor's steam piping supply. Vendor shall take care of the Inlet Dust Burden for designing the Soot blower.

6.2 Soot blowers shall be of the transverse arm, rake type design having nozzles or orifices spaced at regular intervals suitable for cleaning the catalyst without erosion. Location of the blowers shall ensure full cleaning coverage of the face area of the catalyst layer. The Vendor shall ensure that the nozzles are properly located on the blower arms above the catalyst in order to avoid structural damage to the catalyst material and provide effective cleaning.

6.3 Structural support and space provisions in the reactor chamber shall be furnished to accommodate the future installation of soot blowers above the spare catalyst layer.

6.4 Soot blowers shall be located on both sides of the reactor. The central pipe of the blowers shall be positioned in a zone of low flow intensity below reactor support beams. If internal soot blower pipes are exposed to the direct impact from flue gas, then flow deflector baffles shall be installed on the pipes to improve overall flow patterns.

6.5 The soot blower design shall avoid abrupt temperature changes to the catalyst surfaces to minimize the adverse effects of thermal shock. Maximum temperature differential between the soot blowing medium and the catalyst surface temperature shall not exceed 50 C.

6.6 The soot blower design shall minimize erosion of the catalyst caused by excessive medium velocity and water droplets.

6.7 The steam supply system provided by the Purchaser shall be designed assuming all soot blowers are installed and operational including those for the spare layer.

6.8 The blower equipment shall include all valves, piping, fittings, drains, wall boxes, rail assemblies, structural supports, hangers, motors, and controls for a complete system.

6.9 The Vendor shall state recommended soot blowing frequency, soot blower operational time, and mass steam flow per blower. Operation of the soot blower system shall be from top to bottom.

6.10 Commissioning services shall be provided for the soot blower system.

6.11 Vendor shall furnish takeout price for Soot blowing system supply.

6.12 Sonic Horn (if applicable)

a) Sonic horn shall be provided for cleaning all catalyst layers, including the future layer. Number of sonic horn shall be provided so that it should cover complete catalyst surface area. Sonic horns may be arranged on the single wall or opposite walls of the SCR reactor based on its cleaning intensity.

b) Sonic horns shall be provided to generate low frequency and high energy sound waves to resonate and dislodge ash deposits/fouling which develops on the catalyst modules/cassettes. The horns shall be driven using service air available at site sequentially at regular frequency. The horns shall be constructed of stainless steel having diaphragm of titanium alloy. Diaphragm shall have a minimum life of five (05) years. Each horn shall be provided with acoustic enclosures to reduce

ambient noise. The arrangement and type of sonic horns shall be as per standard practice of the contractor.
c) Each Sonic horn shall be provided with separate solenoid operated isolation valve along with associated piping. Adequate number of moisture traps shall be provided at each catalyst layer for removal of moisture from service air supply line.

6.13 Air Cannons (if applicable)
a) Air cannons shall be provided for cleaning all catalyst layers, including the future layer. Number of air cannons shall be provided so that it should cover complete catalyst surface area. Air Cannon may be arranged on the single wall or opposite walls of the SCR reactor based on its cleaning range.
b) Two (02) multiport air cannon system with fan jet nozzles shall be provided for each catalyst layer including the future layer.
c) Air Cannon shall be operated in combination with sonic horn. Initially air cannon shall discharge to break any adhered material loose and then acoustic cleaner shall continue to sound to keep ash deposits in suspension. Air Cannon discharge nozzle shall preferably be placed directly below the sonic horn.

6.14 Dry Cleaning System (if applicable) for in-situ cleaning shall include removal of the particulates and plug(s) on the catalyst using a blasting stream of a pressurized carrier gas having a particulate blasting medium (dry ice) directed at the SCR catalyst. Complete pressurization system for the carrier gas along with feeding/mixing of the blasting medium shall be provided along with necessary injection lances for in-situ cleaning of catalyst at each layer elevation.

6.15 For the de-dusting system, complete equipment and skid mounted instrumentation to be supplied by vendor.

7. Ammonia Unloading, Storage, Handling and Preparation System

A complete anhydrous ammonia unloading, storage, handling and dilution system shall be furnished. The equipment shall include an unloading compressor, ammonia storage tanks, vaporizers, associated piping, fittings, supports, valves, instrumentation, neutralization tank, dilution air blower skid and ammonia injection grid.

7.1 An unloading compressor shall be furnished to transfer liquid anhydrous ammonia from the delivery vessel to the main storage tanks. A compressor, local control panel incorporating all controls and monitoring, equipment and skid mounted instruments and unloading bulkhead shall be furnished near the vicinity of the tanks. The capacity of the compressor shall be properly sized to unload an ammonia shipment within a reasonable time period and at a maximum head of 18 kg/cm^2 gauge. The motor shall meet the requirements mentioned in Part III.

7.1.1 Two (02) oil free reciprocating type ammonia unloading compressors complete with motor drives and receivers shall be provided with all necessary fittings, monitoring and safety devices for unloading of ammonia from the truck to ammonia storage tank. The compressors shall be skid mounted. The compressor design shall have double and triple packing to obviate harmful gas leaks. Further, any leakage gas shall be returned to the suction line and no nitrogen purge and leak gas monitoring device with gland seal of the piston rod shall be required. Same compressor shall be used for liquid ammonia transfer and ammonia vapour recovery. The compressor shall be designed with the consideration of ammonia vapour recovery which may result in excessive temperature rise.

7.1.2 Each compressor shall be provided with gas filter and liquid trap with level control on its suction side. Liquid trap shall be designed for pressurized and vacuum operating condition. 4-way valve ball valve shall be provided for each unloading compressor for switching the direction of gas conveyance.

7.1.3 One (1) pressure relief valve shall be installed in the discharge line of each compressor and its connecting pipe shall be routed back to the storage tanks.

7.1.4 The design of compressor shall ensure the compliance with the following operational requirements:
i. Facilities for emergency shutdown of compressor at low suction pressure, high discharge pressure and high differential pressure across suction & discharge of the compressor.
ii. Facilities for emergency shutdown of compressor at high discharge temperature. Parallel operation and auto changeover of compressors shall not be envisaged. After completion of unloading of ammonia from the tank truck, the compressor must be switched off by means of a flow monitor and the unloading process completed.

7.1.5 Material of construction of compressor shall be suitable for handling anhydrous ammonia.

7.1.6 A clear space shall be provided around the compressor for inspection purpose.

7.2 Ammonia Storage Tank

7.2.1 The anhydrous ammonia storage tank shall be non-refrigerated, cylindrical, all-welded steel construction, complete with level, pressure, and temperature instrumentation, safety valves and vent/fill connections. The tank will be located outdoors at a location to be determined later.

7.2.2 The liquid capacity of the ammonia storage tank shall be as specified in Part III based upon an anhydrous ammonia flow. A margin of 20% shall be considered on the stoichiometric ammonia flow. A vapour space of approximately 15 % of the total tank capacity shall be provided at the top of the tank. An optimized, cost effective arrangement of the storage facility shall be achieved. If more than one tank is provided per SCR unit, they shall be interconnected so either tank can be utilized to furnish the required ammonia flow to the system. The ammonia storage facility shall have the flexibility of being an emergency backup for number of units specified in enquiry.

7.2.3 The ammonia storage tanks shall be designed as per ASME Boiler and Pressure Vessel Code Sec VIII. The tank shall be fully welded construction. All welds shall be 100 % radiographed and stressed relieved. All connections to the tank shall be welded. No threaded connections are acceptable. Tank plate material shall be ASTM A516-Gr 70 or better.

7.2.4 The storage tank shall have the flexibility of accepting ammonia delivery by truck. Each ammonia tank filling connection shall be provided with a combination of back pressure check and excess flow valve to prevent massive ammonia leakage in the event of a catastrophic line break.

7.2.5 The storage tank and handling facilities shall be designed to the following codes and standards:
a. IS 4544 latest edition
b. CGA G_2.1—2014 6th Edition (formerly ANSI K61.1), OSHA etc.
c. ASME Section VIll - Pressure Vessels
d SMPV, Static Mobile Pressure Vessel

In addition, the Vendor shall be responsible for meeting all the latest local codes and standards for the safe storage of anhydrous ammonia.

7.2.6 Each tank shall be equipped with the following equipment as a minimum:
a. One manhole shall be provided
b. Pressure gauge connections with isolation valves
c. Two (2) safety relief valves sized so that either valve can protect the tank
Note: The safety relief valve design shall permit maintenance and removal without draining the tank.
d. Level Indicator
e. An ammonia sensor and alarm located near the vicinity of the tanks.

Note: The permissible liquid anhydrous ammonia level shall not exceed 85% of the tank's total capacity. The level indicator shall be capable of actuating an alarm signal in the main control room when the storage level reaches a low or high level. The low level alarm shall allow the plant a reasonable amount of time to order an additional shipment of anhydrous ammonia while operating the plant at full load capacity.

7.2.7 All materials furnished for the ammonia storage and handling facility shall be compatible with anhydrous ammonia. Use of copper, brass, zinc, galvanized steel and copper containing alloys are not acceptable. Cast iron fittings shall not be used.

7.2.8 All piping, tubing and fittings shall be at least ASTM A-53, Grade B seamless or electric resistance welded (ERW) pipe. All piping joints shall be fully welded. No threaded connections anywhere in the ammonia equipment shall be acceptable. Hydrostatic relief valves shall be included where there is a possibility of liquid ammonia being trapped between two valves.

7.2.9 All necessary platforms, grating, handrails, ladders, etc. shall be provided to access all instrumentation, hose connections, safety relief valves, safety equipment and maintenance items.

7.2.10 Tank supports shall be designed to minimize settlement or lateral movement. In addition, the supports should be capable of withstanding exposure to fire, wind, earthquake, floods, etc.

7.2.11 A water spray system shall be provided for cooling the tank and hence, controlling the vapour pressure inside the storage tank. The actuation of the spray system shall be connected to the local control system to initiate spray when the vapour pressure rises above permissible level. Local control panel with required control logics and interlocks shall be supplied by vendor.

7.2.12 A covering or canopy shall be furnished to protect the tank from direct exposure to sunlight.

7.2.13 The ammonia storage tanks shall be protected by guard posts or other appropriate traffic barriers.

7.2.14 The Vendor shall supply an eyewash and safety shower station in close proximity to the storage tanks. Additional safety equipment such as a face masks and canisters, gloves, boots, etc. shall be provided. The safety equipment shall satisfy international and local code requirements.

7.2.15 All primers and finish paints furnished by the Vendor shall be compatible for outdoor ammonia applications.

7.3 Ammonia Vaporizers

7.3.1 The ammonia delivery system shall be designed for vapour withdrawal from the storage tank. Two (2)x100 %capacity, ammonia vaporizers (electric/ steam) capable of furnishing the maximum design anhydrous ammonia flow rate shall be supplied.

7.3.2 The steam vaporizer assembly shall be installed in a natural circulation loop, taking liquid ammonia from the bottom of the storage tank and returning the vaporized ammonia to the top of the tank. All piping welds in this loop shall be stressed relieved. All piping connections shall be fully welded. Threaded connections are not acceptable.

7.3.3 Vaporizer operation shall be controlled by an adjustable pressure switch or transmitter on the storage tank. The vaporizers shall operate whenever the vapour pressure in the storage tank drops below the set-point.
The Vendor is to recommend the set point pressure range for the pressure switch.

7.3.4 A thermostat controller shall be located within each vaporizer to prevent overheating. The vaporizers shall be designed so they cannot be activated unless liquid ammonia surrounds the heating elements.

7.3.5 The vaporizers shall be capable of being independently isolated for maintenance without draining the ammonia storage tank.

7.3.6 Electric heating elements (if applicable) shall not be in direct contact with the ammonia. The vaporizers shall be designed for an electric source as specified in Part III.

7.3.7 Vendor shall supply local control panel for implementing the complete control logics and interlocks.

7.4 Dilution Blower Skid

7.4.1 A separate dilution air skid located near the ammonia injection grid shall be provided. The skid shall include the following equipment:
a. Ammonia flow control and stop valves
b. Two 2 x100% dilution air blowers
c. Local skid piping and instrumentation
d. Inline ammonia - air mixer
A local control cabinet with complete control logics and interlocks separate from the skid shall be provided for manual start/stop operation of the blowers. The cabinet shall be supplied with the necessary instrumentation and controls capable of accepting a signal from the plant's gas analysis equipment (NOx and O_2) upstream and downstream of the SCR reactor. The local controls and panel shall be compatible with the plant's distributed control system.

7.4.2 The skid shall be furnished complete with piping, valves and fittings. Design shall be in accordance with the ASME Boiler Code and the Power Piping Code ANSI B31.1. ANSI Standards B1.1, B2.1, and B18.2 shall govern all material and workmanship. All piping connections shall be fully welded.

7.4.3 All materials furnished shall be compatible with anhydrous ammonia. All instrumentation required for the safe operation and maintenance of the skid shall be provided.

7.4.4 Two (2)x100% dilution air blowers shall be furnished. The blowers shall be installed on the same skid. The following specified conditions, shall be provided by the vendor for each blower.

a. Minimum air volume per blower
b. Minimum discharge pressure per blower
c. Maximum ambient air temperature

Operation of the blower shall be continuous even after the ammonia to the system has been terminated. The system shall also accept operation of two blowers at the same time.
Capability of starting the idle blower within ten (10) seconds shall be provided.

7.4.5 Each blower shall be furnished with the following accessories:
a. Flanged inlet and outlet connection with vibration isolators
b. Inlet air filter
c. Silencer to meet 85 d.BA at one (1) meter
d. Motor as specified as in Part III
e. Direct drive
f. Local cabinet for manual start/stop capability
g. Remote automatic start/stop capability
h. Discharge line check valve to ensure no air backup through the idle blower

7.4.6 Checks on operation of all fans and all rotating equipment to ascertain level of noise and vibration.

7.4.7 Characteristic curves of the performance of both single and dual blower operation shall be provided. The Vendor shall ensure that the ammonia requirements of the SCR system do not necessitate having the concentration of ammonia in air above 5% by volume over the entire operating range of the unit. The Vendor shall also include the predicted sound pressure levels at one meter from the source during blower operation.

7.4.8 Vendor may recommend any other alternate dilution air source for purchasers review and acceptance.

7.4.9 A mixing device (if applicable), located on the skid, shall be furnished in the dilution air piping to ensure a homogeneous ammonia-air mixture to the ammonia injection inlet manifold.

7.4.10 The Vendor shall be responsible for testing all piping, hose and tubing at a pressure not less than the normal operating pressure to ensure a completely leak free system.

7.5 An ammonia sensor and alarm (local and remote) shall be located in close proximity to the dilution air skid area.

7.6 The Vendor shall supply an eyewash and safety shower station in close proximity to the dilution air skid. Additional safety equipment such as face masks and canisters, gloves, boots, etc. shall also be provided in this area.
The equipment shall satisfy international and local safety codes.

7.7 Ammonia Connecting Piping

7.7.1 The Vendor shall supply all required interconnecting piping between the ammonia storage tank/vaporizer skid and the dilution air skid, and from the dilution air skid to the ammonia distribution inlet manifold. All piping shall be selected for the safe installation of an above ground system compatible with anhydrous ammonia. Final location of the ammonia tank and the dilution

air skid shall be specified by the Purchaser. The Purchaser shall review and approve all field run ammonia piping supplied by the Vendor.

7.7.2 All piping and fittings shall be at least ASTM A-53, Grade B seamless or electric resistance welded (ERW) pipe. All pipe joints shall be fully welded. Piping larger than NB 50mm shall be a minimum of schedule 40. All pipe sizes equal to or less than NB 50mm shall be a minimum of schedule 80. Hydrostatic relief valves shall be included where there is a possibility of liquefied ammonia being trapped between two valves.

7.7.3 Piping stress analysis, support details and locations shall be furnished by the Vendor.

7.7.4 All piping supplied by the Vendor shall be properly supported above ground.

7.8 Waste Ammonia Dilution Tank

7.8.1 The Vendor shall provide an ammonia dilution tank to thoroughly neutralize any ammonia gas and/or liquid discharge from the ammonia plant (various equipments). The dilution tank shall be sized to accommodate neutralizing the quantity of liquid ammonia resulting from the complete drainage of the ammonia storage tanks. An optimized arrangement using one (1) large tank to accommodate the number of SCR units specified in the enquiry.

7.8.2 The Vendor shall supply all required interconnecting piping from the ammonia equipment, relief valves, etc. to the dilution tank.

7.8.3 The dilution tank shall operate at atmospheric pressure via an atmospheric vent. Ammonia gas shall be prevented from escaping through the atmospheric vent. The vent line shall be extended beyond the canopy of the dilution tank along with rain cap.

7.8.4 Dilution tank shall be provided with a service water make-up line and a drain line along with control valve in each line. A motorized isolation valve shall be provided on the upstream of control valve and a manual isolation valve shall be provided on the downstream of control valve.

7.8.5 Complete equipment and skid mounted instrumentation, including level and overflow protection shall be furnished by the Vendor.

8. Ammonia Injection System

8.1 In general, the ammonia injection system shall consist of multiple flow control zones across the SCR inlet duct. Each zone shall be independently controlled by modulating flow control valves located on the piping exiting the ammonia distribution manifold. Individual injection pipes shall be configured with nozzles spaced uniformly across the inlet gas duct plane to enable thorough mixing of the ammonia/air mixture. Number of nozzles shall be suitably decided by the vendor and the supporting documents shall be furnished. Injection of ammonia shall be in the direction of the gas flow. Counter-current injection is not acceptable. All ammonia injection grid pipe openings shall be protected to avoid ash laden flue gas from plugging nozzles. The system shall be designed with external connections to allow a compressed air source to purge nozzles in any individual line.

8.2 The location of the ammonia injection grid in the ductwork shall ensure the uniform distribution of ammonia in the flue gas stream prior to entering the first catalyst layer. The ammonia injection grid shall maintain the ammonia to NOx molar ratio at the entrance to the first catalyst layer to

within +/-5% of theoretical requirements. The Vendor shall provide a test procedure for fine-tuning the grid and validating this criteria.

8.3 Ammonia injection grid piping NB 50 mm and larger shall be minimum ASTM A53, schedule 40 carbon steel pipe. Each branch shall have a manual flow regulating or throttling valve, flow orifice, and test connection with valve for a manometer. The ammonia inlet supply manifold shall be provided with temperature and pressure gauges.

8.4 All ammonia injection piping extending into the ductwork shall have carbon steel angle sections welded on the leading edge to minimize flue gas flow separation across the injection grid.

8.5 The ammonia injection grid shall be properly supported to prevent thermal distortion and damage due to vibration induced by the gas flow. The grid shall be designed for maximum thermal expansion, assuming no cooling is available from ammonia or dilution air. Flex hoses shall be furnished as required to connect the internal grid piping to external piping from the inlet manifold.

8.6 Detailed drawings of the Vendor's ammonia injection grid design shall be furnished to the Purchaser for review and approval.

8.7 The ammonia injection grid design shall be tested in a 1/10th physical flow model as in Clause No 5.0. Layout and number of ammonia injection nozzles, flue gas mixer design, and the location of the grid and gas mixer upstream of the catalytic layers shall be confirmed by flow model testing. Ammonia concentration uniformity shall meet the requirements specified in 8.2.

8.8 Alternatively, any other proven and successfully operating technology for ammonia injection into SCR system can be offered by vendor with sufficient technical back up documents subject to Purchaser’s approval.

9.0 INSTRUMENTATION AND CONTROLS

9.1 The SCR control system shall include all the required process instruments and control devices, local control panels and/or control stations as specified herein for the safe and efficient operation of the system. The control system logic shall be based upon inlet and outlet NOx monitoring integrated with boiler load and the ammonia to NOx molar ratio setting. The Vendor shall provide a detailed description of the instrumentation and control system logic. All analog inputs/outputs shall be 4-20mA (2 wire) signals. Individually pair shielded and overall shielded cables shall be used for analog signals. All digital input/output signals shall be dry contacts. Overall shielded cables shall be used for digital signals

9.2 In addition to the ammonia injection rate system, controls for all auxiliary equipment associated with the SCR system, i.e., ammonia unloading, storage and vaporizer system and dilution air supply system shall also be included. Instrumentation not only skid mounted, but also shall include inlet NO_X, O_2, SO_2 and outlet NO_X, O_2, SO_2, NH_3 Analyzers, catalyst pressure differential transmitter to measure draft loss across all catalyst layers, thermocouples with protection tubes for measuring gas temperatures upstream of the ammonia injection grid and before the first catalyst layer, catalyst surface thermocouples on the last active catalyst layer, ammonia flow orifice plates and removable manometers associated with the ammonia injection grid, and local pressure and temperature indicators on the ammonia injection inlet manifold .Local pressure indication shall also be provided to monitor draft loss across individual catalyst layers.

9.3 The control system logic shall be capable of fully controlling the ammonia storage and handling system. Interlocks shall ensure safe operation of the ammonia system and should prevent the fugitive escape of ammonia vapours.

9.4 The Vendor shall include a complete description of the SCR control system operation including cold, warm and hot start-up and shutdown procedures and normal operation. A process control description functionally describing the process, control logic, permissives, alarms and control schemes shall also be supplied.
At a minimum, the following items shall be included in the Vendor's control logic and alarmed and/or recorded in the Purchaser's control room:
a. SCR gas temperature "Low" Alarm
b. SCR gas temperature "High" Alarm
c. SCR differential gas draft loss "High" Alarm - monitored across SCR system and across each catalyst layer
d. Dilution air flow "Low" Alarm
e. Ammonia shutoff valve "Closed/Open" indication
f. Loss of power alarm for all electrical equipment
g. Ammonia storage level "Low" and "High" Alarm
h. Ammonia storage pressure "High" and "Low" Alarm
i. Indication of SCR inlet and outlet NOx-02 values
j. Indication of SCR system gas draft loss
k. Ammonia flow indication
l. Indication of SCR gas temperature (three locations)- upstream of ammonia injection grid upstream of the first catalyst layer and on the last layer of catalyst
m. Dilution air blower on/off indication - specified for each blower
n. Indication of ammonia liquid storage level in the tank
o. Indication of ammonia storage pressure
p. Indication of Ammonia slip
Note: Alarm set points shall be specified by the Vendor.

9.5 NOx analyzer shall be provided to continuously measure NOx emissions in the ductwork upstream of the ammonia injection grid and in the outlet duct directly below the SCR reactor chamber. An air conditioned cabinet shall house the two rack-mounted inlet and outlet Analyzers. All analog output signals shall be 4-20mA directed to the Purchaser's distributed control system.
The analyzer shall be micro-processor based capable of measuring NOx concentrations over the conditions mentioned under Part III.

9.6 The inlet and outlet NOx-02 analyzers shall comply with the following specifications:
Range: Selectable full scale ranges to cover the specified NOx concentration ranges
Sensitivity: 0.10 ppm
Linearity: +/- 1 % full scale
Precision: 0.50% full scale, all ranges
Zero Drift: 1 % of full scale per 24 hours
Span Drift: 1 % of full scale per 24 hours
Power Requirements: Suitable for 240V, 1 Phase,50 Hz operation (Refer Part-III also)
All direct readings from the analyzers shall be obtained based upon an uncorrected actual dry volume basis. Measurements transmitted from the analysers to the Purchaser's DCS shall be corrected to a 6 % dry volume O_2basis.
Gas analyzers shall be calibrated before and after each performance test with traceable calibration gases. Certification tests for relative accuracy and drift shall be passed before commencing performance testing.

9.7 Acceptable wet chemistry methods shall be used whenever measurements of ammonia at the outlet of the reactor chamber are required.

10.0 PAINTING AND FINISHING

10.1 Painting

The Vendor shall perform surface preparation, primary and finish painting in accordance with the manufacturer's standards for all exposed surfaces. Painting schedule shall be furnished for purchasers review and approval.

10.2 Marking

a) Stainless steel nameplates with following boldly engraved shall be firmly fixed to the body: Maker's name & production serial number and technical/process parameters.
b) Each spare shall be individually tagged with part name, makers name & spare code.

10.3 Packing

a) All opening shall be firmly capped against ingress of water or dust.
b) Shall be roadworthy/seaworthy packed in wooden boxes with water proof under cover.
c) Liberal packing material & struts shall be used to arrest rolling & to protect from transit damages.

11.0 SPARES AND SPECIAL TOOLS

11.1 Mandatory spares as per the list enclosed separately shall be offered. Pricing of the spares will be considered for commercial evaluation.

11.2 Vendor shall recommend one (1) year spare parts necessary for maintaining the SCR equipment.

11.3 The item wise price for the spares (recommended and mandatory) offered shall be mentioned.

11.4 Vendor shall supply the required commissioning spares at the time of commissioning at site.

11.5 Special tools or materials shall be furnished, as required, for the proper handling, storage, erection, start-up and maintenance of the Vendor's equipment.

12.0 INSPECTION AND TESTING

12.1 Access to the Vendor's or sub-contractor`s manufacturing facilities shall be provided for the purpose of inspecting the work and witnessing testing of the SCR equipment. At least two (2) weeks advance notice shall be given by the Vendor to the Purchaser or his representative.

12.2 Acceptance of the Vendor's equipment shall be based upon the successful completion of performance tests carried out by the Purchaser. The Vendor shall submit correction curves for gas temperature, oxygen content, flue gas volumetric flow and inlet NOx for determining performance for off- design field operating conditions. The Vendor shall provide a field representative to assist in tuning of the ammonia grid and advise the Purchaser during all performance testing.

12.3 The Vendor shall submit a performance test procedure as well as plans for tuning all furnished equipment for the Purchaser's review and approval.

12.4 All performance tests confirming SCR guarantee requirements shall be in accordance with acceptable EPRI testing methods or equivalent.

13.0 TRAINING

13.1 The Vendor shall provide a one (1) week training program for the Purchaser's personnel to operate and maintain the equipment supplied by the Vendor.

13.2 The training program shall include a description of the equipment, the proper operation of the system, the limits of the design, and the recommended maintenance (including module storage and disposal) and inspection procedures. Training manuals shall be submitted to all participants. Both classroom and field instruction shall be provided by the Vendor.

13.3 The Vendor shall submit a copy of the proposed training manual three (3) months prior to training for the Purchaser's review and approval.

14.0 DOCUMENT SUBMITTAL REQUIREMENTS

14.1 The following documents, drawings and information shall be furnished by the Vendor along with the offer:

Point-wise confirmation to the technical specification. Any deviation shall be clearly brought-out separately along with proper technical justification for Purchasers review.

14.1.1 General arrangement of SCR reactor & systems including but not limited to the following:

a) SCR housing and ductwork dimensions including terminal points
b) Catalyst module dimensions and arrangement within the reactor chamber
c) SCR housing and ductwork loadings
d) SCR catalyst and reactor chamber and loading plan – elevation wise
e) SCR catalyst handling load and location sketch
f) SCR catalyst loading intensity for floor design
g) Canopy requirements (if any) of reactor chamber and sketch
h) Sample and Recommended structural arrangement and cautions to be taken in steel design
i) No bracing and no beam zone marked in arrangement drawing (if applicable)
j) Cable, rack and any other loading requirements to be taken care by the steel design
k) Horizontal guide loads and location (Support and seismic/wind guide requirements)
l) Expansions required to interface with the Purchaser's ductwork and support steel
m) Structural steel support and access platform requirements. The Vendor must maintain support points, box dimensions, etc. to those shown on the SCR arrangement drawing.
n) Proposed monorail and hoist arrangement, handling procedure
o) Internal and external support steel requirements and loadings for the installation and removal of catalyst modules
p) Access door locations and dimensions in the SCR reactor housing and associated ductwork
q) Ammonia injection grid location, supports and access requirements. The support documents for number of nozzles and its arrangement

r) Flue gas mixing devices including location, dimensions, support details and access requirements (if applicable)
s) De-dusting equipment locations and internal/external support requirements and access requirements
t) Dilution air skid size and location
u) Piping layout and proposed support from dilution skid to ammonia injection distribution manifold

14.1.2 Other documents

a) Ammonia consumption calculation and storage tank sizing calculation
b) All essential Civil inputs for ammonia dyke area shall be furnished
c) Confirmation of the Purchaser's information shown on plant arrangement drawings
d) All P & I diagrams along with write up and applicable valve schedule for all related systems
e) Control logic diagrams including a list of all analog and digital inputs and outputs associated with the SCR control system
f) Proposed permanent sealing method with a detailed description of the sealer material and material safety data sheet for sealer
g) Proposed catalyst disposal requirements and procedures
h) Proposed module activity tests and recommended ten (10) year replacement schedule
i) Summary of predicted performance at all operating load conditions specified in Part III.
j) Utility consumption list (i.e., auxiliary steam, service air, instrument air, service water, etc.).
k) Summary of operating and installed power for all supplied equipment
l) Auxiliary Power Consumption
m) Recommended list of one (1) year spare parts
n) Instrument List clearly indicating the Scope of Instruments.
o) Drive List indicating type of drive (pneumatic, electric, LT motor, valve/damper etc.), Voltage, Type of power supply, rating, FLC, Speed
p) List of Analog and Digital I/Os
q) Electrical Load list indicating Voltage, Type of power supply, rating, location of load
r) List of Local control panels indicating the system which is controlled from the local panel
s) List specifying the systems which are controlled from purchaser’s DDCMIS.
t) List of all bought-out items with vendor details. The vendors are subject to Purchaser’s review and approval.
u) Filled in data sheets (Refer Part –III).
v) Terminal Point drawing/document with well-defined boundaries for scope.

14.2 The following documents, drawings and information shall be furnished by the Vendor on award of the contract:

a. Detail drawings of the hydraulic trolley and spreader beam for the catalyst installation.

b. Test port and instrument locations including number of proposed sampling probes and locations for permanent instrumentation

c. Structural steel drawings of reactor housing and internals including catalyst support steel and installation rails, monorail support steel, soot blower support steel, casing details, internal baffles, sealing plates, etc.

d. Ductwork drawings showing internal supports, sealing plates, vaning, baffles, access door locations, test port locations, instrumentation locations, etc.

e. Soot blower arrangement drawings including details of internal lances and supports, proposed supply piping layout to a common terminal point, piping support requirements, etc.

f. Detail drawing of ammonia storage tank including associated piping, instrumentation, support, etc.

g. Detail drawing of ammonia vaporizers.

h. Ammonia piping layout drawings including support details from the storage tanks to the vaporizer skid and from the vaporizer skid to the dilution air skid. Drawings shall also provide details of the ammonia accumulator.

i. Detail drawings of the neutralization tank including location, all instrumentation and interconnecting piping.

j. Module handling, storage, installation and removal procedures.

k. Operating instruction manuals (minimum 3manuals along with soft copy). The manuals shall contain complete operating and maintenance instructions for the care and operation of the Vendor's equipment.

l. List of all bought out items along with technical specification, datasheets and support documents.

m. Details of the Vendor's training program per the requirements listed in Clause 13.

n. Submittal of physical flow model test report.

o. Completely Filled in Data sheets

p. The Vendor's control philosophy shall be incorporated into the Purchaser's overall distributed control system. As a minimum the following information shall be provided by the Vendor in order to assist the Purchaser in the detailed design of the control system:

i. P&IDs with write up
ii. SCR digital logic diagrams & Write-up for SCR and all associated systems
iii. SCR analog logic diagrams & Write-up for SCR and all associated systems
iv. SCR graphic display diagrams
v. Interconnection drawings, Location of JBs, Local panels, cable lists
vi. Instrument List, Drive List, I/O List, Electrical Load list as per the purchaser’s format
vii. Signal exchange list between SCR control system and plant control system
viii. Alarm and SOE list
ix. Valve/dampers list
x. Equipment/Instrument grouping, LIE/LIR grouping list
xi. Instrument installation drawings/ Hook up drawings
xii. Instrument air requirement

xiii. Vendor datasheets and O&M manuals

xiv. Quality Plan, Inspection and Test Plan, Type test certificates

xv. Any other drawings/documents found applicable during contract stage

xvi. Vendor to clearly furnish the special requirements to be taken care by purchaser for equipment/instruments in Purchaser's scope.

Part-III
Contract specific Requirements

Project Name: DN109

List of Documents

S.No.	Description
1	Performance and Guarantee
2	SCR Selection sheet
3	Fuel Analysis
4	Site Condition
5	Terminal Points for Electrical C&I Equipment- Annexure P
6	Electrical Power supply Details – Annexure Q
7	Specification for Electric Actuators – Annexure R
8	Specification for Motors – Annexure S
9	Specification for Field Instruments and Analysers – Annexure U
10	Specification for Cables, Cable Trays and Cable Glands – Annexure V
11	Specification for Panels Erection Installation Material – Annexure W
12	Data Sheets
13	Process and Instrumentation Diagrams
13.1	Scheme of De-NOx system – Key Diagram (1-SR-DNX-00010)
13.2	Scheme of De-NOx system – Ammonia Unloading and Storage system (1-SR-DNX-00011)
13.3	Scheme of De-NOx system – Ammonia Vaporizer and Accumulator (1-SR-DNX-00012)
13.4	Scheme of De-NOx system – Boiler Island (1-SR-DNX-00013)
13.5	Scheme of De-NOx system – Water ammonia handling, Safety system (1-SR-DNX-00005)
14	SCR Arrangement drawing (0-SK-SCR-00009)

PERFORMANCE AND GUARANTEE

The Supplier shall Guarantee that the equipment/materials furnished hereunder will be entirely suitable for the service specified, conform to all conditions of performance and design, be free from manufacturing and material defects.

The Supplier shall guarantee the following based on all operation conditions for any coal specified, during the guarantee of catalyst life, unless otherwise specified:

A) Overall NOx removal efficiency (%)	
B) NOx content of the flue gas as measured downstream of the SCR system (ppm vol dry. as O2 6%)	
C) Ammonia slip as measured downstream of the SCR reactor (ppm vol dry as O2 6%)	
D) Conversion rate of SO2 to SO3 (%)	
E) Catalyst life (after Commercial Operation Declaration) to meet the NOx removal efficiency and ammonia slip (From the point of boiler flue gas passing through SCR De-NOx system initially) - with the initial charge of catalyst (Operating Hours)	
F) SCR De-NOx system gas side draft loss (mmH2O) - With all catalyst including future layer at BMCR (max. pressure drop) - With the initial fresh/dirty catalyst at TMCR	
G) Ammonia consumption at TMCR (kg/h unit)	
H) Molar ratio of NH3 to NOx	
I) Auxiliary Power consumption at TMCR-Design coal	

Project Name:DN109

SCR selection sheet

Annexure-1

Sno	Description	Units	Load							
			BMCR-DC	BMCR-BC	BMCR-WC	TMCR-DC	TMCR WC	80%TMCR-DC	60%TMCR-DC	HPH-DC
1	Flue gas flow at Economiser Outlet *	kg/hr	1257000	1259000	1178000	1157000	1093000	950000	742000	1195000
2	Flue gas temperature entering SCR	deg C	343	348	335	338	331	320	300	297
3	Total Volumetric Gas Flow at Actual Temperature	m3/hr	2240642	2264388	2063047	2036972	1891003	1615646	1216393	1971947
4	Total Volumetric Gas Flow	Nm3/hr	993012	995456	926335	910136	854709	743797	579538	944459
5	Flue gas pressure at SCR inlet	mmwc	-108	-110	-99	-97	-97	-75	-59	-94
6	Flue gas constituents, Wet Basis - % By Weight									
i	CO_2	%	21.936	21.884	22.052	21.936	22.052	21.936	21.936	21.936
ii	N_2	%	68.288	68.447	67.986	68.288	67.986	68.288	68.288	68.288
iii	O_2	%	3.431	3.439	3.417	3.431	3.417	3.431	3.431	3.431
iv	SO_2	%	0.181	0.115	0.301	0.181	0.301	0.181	0.181	0.181
v	H_2O	%	6.164	6.115	6.244	6.164	6.244	6.164	6.164	6.164
7	SO3 in Flue gas at SCR Inlet @ 6% O2 (Considering 1.0 % Conversion)	ppm	6.87	4.36	11.48	6.90	11.55	6.93	7.54	7.45
8	Inlet Particle Dust Concentration	gm/Nm3	36.6	8.5	95.6	36.8	96.2	37.0	37.0	36.7
9	Permissible SO2 to SO3 conversion in SCR **at 6% O2 dry volume basis**	%	Less than 1 %							
10	NOx concentration to SCR Inlet **at 6% O2 dry volume basis**	mg/Nm3	750	750	750	750	750	750	750	750
11	NOx required at SCR Outlet **at 6% O2 dry volume basis**	mg/Nm3	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100
11	Heat input to SCR (Q fired in boiler)	GJ/hr	2756	2777	2716	2537	2520	2083	1627	2622
12	Maximum Permissible slip **at 6% O2 dry volume basis.**	ppm	3							

Note:

1) A variation of +/- 5% may be considered on the flue gas volume for design

2) Maximum pressure drop allowed – 100mmWC (From Eco Outlet to SCR Outlet including duct losses)

3) Required Catalyst life: Minimum 16000 hrs (both mechanical and Chemical Life)

4) Reagent Used : Anhydrous Ammonia (99.5%)

5) Min distance between Catalyst modules = 1300mm

6) Liquid capacity of ammonia storage tank should be for 14 days

7) Ammonia tank to be located 1.2 km from boiler area

* For DC and BC, Flue gas flow includes 6% of Gas recirculation.

DC-Design coal

WC-Worst coal

BC-Best coal(Imported coal)

FUEL ANALYSIS – COAL

DESCRIPTION (Source / Type)	UNIT	Design Coal* (Blended coal) 60 Coal : 40 Rejs	Indian coal (WC)	Imported coal
PROXIMATE ANALYSIS (as recd basis)				
Fixed Carbon	%	35.00	25.31	44.70
Volatile matter	%	25.56	16.40	34.82
Moisture (Tbm)	%	11.00	15.00	12.00
Ash	%	28.44	43.29	8.48
Tpbl	%	100	100	100
HHV	kcal / kg	4375	3065	5710
LHV	kcal / kg			
Ash	kg / 10⁶ kcal			
ULTIMATE ANALYSIS				
Carbon	%	46.38	32.99	60.36
Hydrogen	%	3.02	1.84	3.48
Sulphur	%	0.70	0.81	0.58
Nitrogen	%	1.07	0.97	1.47
Oxygen (difference)	%	9.89	5.39	13.42
Moisture	%	11.00	15.30	12.00
Ash	%	28.44	43.29	8.48
Carbonates	%	-	-	-
Phosphorous	%	-	-	-
HARD GROVE INDEX		49	60	49
IT - Initial deformation temp	°C	>1450	> 1450	1234
ST - Softening temp. H = W	°C	> 1450		1270
HT - Hemispherical temp. H = W / 2	°C			1321
FT - Fusion temp. Flow Temperature	°C			1368
ASH CONSTITUENTS				
A - SiO_2	%	53.22	59.72	48.74
A - Al_2O_3	%	25.53	26.6	24.48
B - Fe_2O_3	%	8.96	9.17	8.77
B - CaO	%	4.25	0.42	8.08
B - MgO	%	2.29	1.05	3.53
B - $Na_2O + K_2O$	%	1.28	1.18	1.36
A - TiO_2	%	1.50	1.55	1.45
P_2O_5	%	0.89	0.14	1.63
SO_3	%	2.08	0.17	3.96
Basic / Acid Ratio		-		
Fe_2O_3 / CaO Ratio		-		

SITE CONDITIONS

1. **Ambient temperature** (For Design & Perf. Guarantee)	:	34.4 Deg.C
2. **Relative humidity** (For Design & Perf. Guarantee)	:	60.0 %
3. **Height above M.S.L**	:	111.0 m
4. **Type of Soil**	:	Shall be furnished upon receipt from the customer
5. **Seismic load***	:	Zone-III
6. **Wind speed***	:	44 m/sec

Terminal Points for Electrical C&I Equipments

a)	Remote pressure, level, flow measurements	-	Up to field junction boxes for vendor supplied equipment mounted instruments For other instruments, up to root valves for pressure, level and flow measurements
b)	Remote temperature measurements	-	Up to input terminals of local mounted purchaser's junction box, for vendor supplied equipment mounted instruments For other instruments, up to tapping point stub with M33x2 (F) Thread
c)	Test temperature tappings Pressure & Flow Test pockets	-	Thermowell with caps Up to root valves
d)	Electric drives (LT Motors and servomotors)	-	Terminal box with cable glands
e)	UPS, 220 V DC, 240VAC	-	At individual equipment's input terminal
f)	Signals from/to motorized actuators to/from DDCMIS	-	At actuator terminal box.
g)	Signals from/to local control panels	-	At the terminals of local control panels
h)	Pneumatic Control valves and regulating actuators	-	Integral terminal box. All signals of valves shall be internally wired & terminated in the Integral Junction Box for external connection to DDCMIS
i)	Instrument air distribution	-	Equipment end
j)	Earthing	-	Equipment terminals

Annexure Q

Electrical Power supply Details:

1. The voltage level for motors shall be as follows:
a) Motors above 200 kW: 6900 V AC, 3 phase, 50 Hz
b) Motors up to 200 KW: 415V AC, 3 phase, 50 Hz

2. DC System Voltage: 220 V DC

3. UPS Power supply: 240 V AC, 1 Phase, 50 Hz

4. Utility Power supply (Space Heating, Lighting): 240 V AC, 1 phase, 50 Hz

ANNEXURE-R
Electrical actuator
(Open/Close duty& Inching duty applications)

Sl. No.	Details	Technical Requirements
1	Actuator Application	Open/Close or Inching or Regulating duty, suitable for Valve/damper applications. Suitable gearboxes shall be coupled (if required) to achieve the torque requirements of the load. Actuator mounting shall be suitable to the load requirement.
2	Actuator type	Electrical Actuator with integral starter for Open/Close and inching duty applications.
3	Actuator Duty	The actuator shall be of Open/Close or Inching or Regulating duty as per the application requirement.
4	Actuator Construction	Totally enclosed weatherproof construction meeting IP-65 protection class requirements. All the gears available in the actuator shall be of metal (Fiber gears are not acceptable). Actuator shall have self-locking facility.
5	Manual operation through Hand-wheel	Shall have a lever and hand wheel mechanism for manual operation. The hand wheel mechanism shall be designed such that it is declutched automatically when the power supply to the motor, is restored.
6	Torque requirement	Shall be designed to meet with the required torque at the output shaft as per the load requirement. The adjustable range of run torque and starting torque of actuator shall be indicated (in kgm) for the actuator offered.
7	Operating time	The operating time of the actuator required for the complete travel has to match with the load requirement.
8	Supply voltage	415 V, 3 phase AC supply, 50Hz.

Sl. No.	Details	Technical Requirements
9	Power supply variation	The actuator shall operate without any trouble under power supply voltage variation of ± 10% of the rated value, power supply frequency variation of ± 5% of the rated value, combined voltage and frequency variation of 10% of the rated value.
10	Motor type &construction	Motor type shall be of Squirrel Cage induction type (or) Permanent Magnet Synchronous motor (or) BLDC. Shall be of Totally Enclosed, Self-Ventilated construction with weather proof enclosure conforming to IP-65. Shall have double shielded, grease lubricated anti-friction bearings.
11	Motor Insulation	Shall have class F insulation with temperature rise of the motor winding limited to Class B. Motor winding shall be tropicalized, suitable for the site conditions. Temperature rise over ambient temperature of 50 °C shall be 70 °C.
12	Motor duty cycle	The duty cycle of the motor shall be short time S2 duty cycle rated for the period of operation of 15 minutes or rated for 3 successive open-close operations whichever is longer. For inching duty, motor shall be suitable for 150 starts/hour. For regulating duty, motor shall be S4 duty with Cyclic Duration Factor of 60% and suitable for 1200 starts/hour.
13	Motor Starting	Motor shall be suitable for direct on-line starting. Starting current shall be limited to 6 times the full load current exclusive of tolerance.

Sl. No.	Details	Technical Requirements
		Shall be capable of starting at 85% of rated voltage and Running at 80% of rate voltage for a period of 5 minutes.
14	Standards	Actuator shall be conforming to IS-9334 or any other equivalent international standard for all requirements. Motor shall be conforming to IEC-60034, IS-325 or any other equivalent international standard for all requirements.
15	Motor Thermostat	Motor winding shall be provided with inbuilt thermostat connected in series (one thermostat in each phase) and shall be wired to terminal box.
16	Space heater	Shall have a space-heater with suitable rating and the power supply shall be derived internally from the main power supply.
17	Earth terminals	2 Nos. of earth terminals shall be provided on the body of the motor.
18	Torque & position limit switches	2 numbers of adjustable torque limit switches (one for open and one for close), each with 2 NO and 2 NC potential free contacts. The torque limit switches shall have calibration in Kg-m (for whole actuator including gear box if supplied), so that the switches could be easily set to any desired value, within the range specified for each actuator. Torque switches shall be bypassed in both the end positions using the position Limit switches available at the other end of the travel. Actuators shall have provision for bypassing the torque switch during initial 5% opening of valves. 4 numbers of position limit switches, rotary drum type capable of being set at any position(2 nos. for open and 2 nos. for close) each with 2 NO & 2 NC potential free contacts.

Sl. No.	Details	Technical Requirements
		All Gear train mechanism shall be made of suitable metal only. Shall be enclosed in a dust & weather proof compartment and the compartment shall have enough space suitable for calibration. Contacts of limit and torque switches shall be Silver plated having high conductivity and non -corrosive type. Contact rating of all the above limit switches shall be 5 A at 240 V AC and 0.5 A at 220 V DC.
19	Local position indicator	Shall be provided to indicate 0 to 100% travel.
20	Positioner Controls (Applicable only for regulating duty applications)	Actuator shall be provided with an electronic positioner and related electronic controls required for positioning the actuator, accepting 4-20 mA command signal. Shall have following standard, adjustable control features in the actuator. SPAN :- To calibrate the position feedback signal with the travel of the actuator for 100% range of position demand signal. ZERO :- To calibrate the position feedback signal with the travel of the actuator for minimum value of demand signal. DEAD BAND :- The actuator should meet the process requirements. STAYPUT :- The positioner shall have STAYPUT characteristics on loss of the demand signal.

Sl. No.	Details	Technical Requirements
		Solid State reversing circuit shall be provided for forward and reverse operation of the actuator.
21	Position Feedback transmitter	For inching duty and regulating duty applications, position feedback transmitter has to be supplied. Shall be 2 wire, non-contact type (LVDT) electronic position transmitter with an output of 4-20 mA DC and shall be loop powered from external power supply. The output shall also be capable of driving minimum 500 ohms load in the control circuits.
22	Internal wiring	Shall be done with 1.5 sq.mm PVC insulated, stranded copper wire of 650V grade for control signals. For Power circuits, internal wiring shall be done using suitable size of stranded cables, taking care of the motor current rating. Ferrules should be used for easy identification. Internal wiring and the terminal block drawing shall be neatly pasted on the internal side of the terminal box.
23	Terminal box	All terminals of the position limit switches, torque limit switches, space heaters shall be terminated in the terminal box. The terminals shall be of cage clamp type suitable for the cables of size 2.5sq.mm. Minimum 6 numbers of spare terminals shall be made available in the terminal board. Terminal box of actuator shall be weatherproof conforming to IP-65 and shall have enough space for connecting cable glands/plug and sockets. Terminal box shall be fitted with a removal front cover-plate.
24	Cable Termination philosophy	Termination of Power Cable :- Double compression type, Brass with Nickel plated cable glands shall be provided for the termination of power cable. Motor terminals shall be of stud type. Cable gland along with blanking washers shall be selected suitable for the power cable sizes as indicated below.

Sl. No.	Details	Technical Requirements
		• Up to 3 KW – 3C x 2.5 sq.mm. Copper, OD – 17 mm ± 2 mm. • > 3 KW & up to 7 KW - 3C x 6 sq.mm, Aluminium, OD – 19 mm ± 2 mm.
		Termination of Control Cable:- 3 Nos. of Double Compression type, Brass with Nickel plated cable glands have to be supplied for the termination of the control/instrumentation cables suitable for a cable OD of 18mm.
25	Fasteners	All fasteners used in the equipment shall be of a corrosion resistant material.
26	Paint & finish	All external Parts shall be finished and painted to produce a neat and durable surface which would prevent Corrosion & Rusting.
27	Lubricant	The gear box of the actuator shall be either oil filled or grease filled.
28	Inspection & Testing	For the purpose of inspection & testing of electrical actuator, Quality Plan Ref. QA:CI:STD:QP:13 has to be referred.

Technical Description of the Electronic Integral Starter

Sl. No.	Details	Technical Requirements
1	Integral starter	Control logic of the starter shall be designed using suitable electronic control circuit. The starter shall have the following minimum features : Power supply isolation switch & fuses of suitable rating. • Thermal Over load relay. • Lockable Local- Off -Remote selector switch.

		• Push buttons for Local Operation (OPEN, CLOSE, STOP) • Indication lamps (OPEN, CLOSE, TRIP) • Remote Signal interface • Output Contacts • Status/Fault annunciation
2	Open/Close Command	Interposing relays of coil burden <=2.5VA shall be provided to initiate opening and closing using 24V DC signal from the external control system. Actuator shall also be suitable for remote operation by potential free contacts for Open/Close & Stop, the necessary 24V DC power supply shall be derived internally. Open/Close command termination logic with position and torque limit switches shall be suitably built inside the starter Electrically & mechanically interlocked contactors shall be provided for forward and reverse operation. Contactor rating shall be sufficient to withstand the extreme conditions like valve jamming and instantaneous reversal of motor.
3	Protection Features in Starter	Shall have various protection features such as Single Phasing prevention, Wrong phase sequence protection, Overheating protection through thermostat, Short Circuit protection, Overload, Supply Under Voltage, over and above other standard protection features as per manufacturer's design.
4	Control Supply	Control supply voltage of the starter shall be 24V DC. If other control voltage rating is used, then the same shall be derived internally by the manufacturer. Necessary primary and secondary fuses shall be provided. Opto isolation circuit shall be provided with suitable coupling relays for 24V DC commands from external control system.
5	Local Operation	Provision shall be available to operate the actuator locally. Lockable local/remote selection shall be provided on the front panel of the actuator.

6	Status indication	The following status indication signals shall be provided in the actuator over and above the standard signals available in the actuator as per the manufacturer's standard • Actuator Open • Actuator Close • Actuator in travel
7	Output Contacts	A Common potential free contact for collective fault annunciation of following faults such as Thermal Overload trip, Motor Thermostat trip, Control supply failure, Power Supply Failure/Single Phasing, Local/Remote switch in LOCAL/OFF, Torque Switch acted along with Other protections acted shall be provided for customer use. Potential free contacts shall be provided for Local/Remote/Off positions of the selector switch.
8	Fault Annunciation	The following fault annunciation signals shall be provided in the actuator over and above the standard signals available in the actuator as per the manufacturer's standard Open Torque Switch/Close Torque Switch acted Motor thermostat trip Motor Overload relay acted Actuator shall have necessary provision for diagnosing the fault locally.
9	General features to be provided in the actuator	Open Torque Switch shall be bypassed initially for 3 seconds or 5% of the valve travel. It should be possible to reverse the direction of travel for inching duty application. Automatic phase correction facility and single phasing prevention shall be provided.
10	Details to be furnished	The ratings of the various components of the starter, various signal exchanges to/from the starter and the wiring interconnections shall be clearly indicated in the wiring drawing of the actuator.

Pneumatic Actuator-Regulating type

Sl. No.	Details	Technical Requirements	
1	General :		
	This technical specification covers the requirements of Regulating Duty, pneumatic actuators, SMART positioner and accessories, to be used for control damper applications.		
2	Actuator :		
a.	Actuator type	Double or Single acting type, to suit the application. Piston operated type. The actuator shall be sized to meet the requirements of the load.	
b.	Actuator Duty	Regulating duty	
c.	Actuator mounting type	The actuator mounting shall be of any one of the following types. Stand mount type with output shaft and output lever. The actuator shall be connected to the load through linkage rod mechanism. (Or) Direct Mount type: The actuator (piston rod) shall be directly connected to the load. The actuator shall have trunnion base.	
d.	Actuator assembly	The actuator base shall be suitable for mounting the cylinder and for fixing the foundation bolts. The entire arrangement should be able to withstand the load and torque requirements.	
3	Air Supply	Power Air	Minimum : 3 Kg/sq. cm (g)
			Maximum : 7 Kg/sq. cm(g)
4	Stroking time	To suit the process requirement.	
5	Action on Loss of Power Air Supply.	To suit the process requirement.	
6	Action on Loss of Command Signal.	To suit the process requirement.	
7	Position indicator	1 No. local mechanical position indicator is required.	

Sl. No.	Details	Technical Requirements
8	Provision for reversal of action	Actuator assembly to be configured in Direct acting. Provision to change to reverse action shall be provided
9	Material :	
a.	Piston rod	Hard chrome plated high strength steel. Leather bellows / Gaiters shall be provided to prevent actuator inner parts from rusting.
b.	Piston	High Strength Steel.
c.	Actuator body/Cylinder barrel	Honed & hard chrome plated seamless Carbon steel.
d.	Actuator seals	Viton.
e.	General	Necessary surface treatment shall be provided for all the components (as applicable) to prevent rust and corrosion.
10	Limit Switch :	
a.	Quantity	One for open and one for close.
b.	Number of contacts	In case of SMART positioner, 1 NO + 1 NC
c.	Type	Snap action
d.	Limit Switch Enclosure	Dust & Weather Proof, IP-65
e.	Contact Rating	5A at 240 V AC / 0.2A at 220 V DC.
f.	Make	Shall be as per the manufacturer's standard.
11	Air Lock Device :	
a.	Type	Set point has to be adjustable. Self-Reset.
12	Air filter cum regulator :	
a.	Supply air pressure	7 Kg / sq.cm
b.	Type	Diaphragm
c.	Pressure rating	15 Kg / sq.cm
d.	Filter Material	Phosphor Bronze
e.	Body	Die-cast aluminum
f.	Inner valve, seating and spring	Stainless steel
g.	Enclosure protection	IP-65
h.	Output pressure	0 – 7 Kg / sq.cm
i.	Filter Element	Phosphor Bronze
j.	Filter size	5 microns
k.	Drain	Auto Drain feature shall be provided
l.	Accessories	Blow down valve shall be provided

Sl. No.	Details	Technical Requirements
13	Pressure gauge :	
a.	Dial	50 mm Diameter
b.	Type	Bourdon
c.	Material of sensing element (Bourdon)	Phosphor bronze
d.	Range	0 – 10 Kg / sq. cm
e.	Accuracy	± 5%
f.	Make	Shall be as per manufacturer's standard
g.	Air connection inlet	Air connection inlet shall be suitable to accept ¼" OD PVC sheathed copper tube
h.	Hand wheel / Lever	To be provided along with actuator for manual operation.
14	Integral Junction Box	
a.	Junction Box	All the electrical connections from the accessories, shall be wired suitably as per the wiring drawing to the junction box. Protection Class: IP-65. Terminal blocks shall be of Cage-Clamp type, suitable for 2.5 sq.mm. Cable.
b.	Termination of external cable to the Junction box.	3 nos. of double compression type brass with nickel plated weather proof cable glands suitable for cable OD of 18 mm.
c.	Linkage rods for Stand mount type pneumatic actuators.	The Linkage rods shall be supplied as per the drawings referred in the purchase enquiry. The application names & tag nos. have to be painted on the linkage rods for easy identification.
d.	Inspection & testing	As per quality plan CI:QAC:STD:QP:42 (latest revision) or project specific quality plan. The applicable quality plan will be indicated in the purchase enquiry.
15	Painting/Finish for both Power Cylinder & Linkage rods	
a.	Paint Shade	Shall be as per manufacturer's standard
b.	Finish	Corrosion resistant, Epoxy based resin.
16	Packing	Shall be as per manufacturer's standard practice. The packing shall be suitable for safe transport, safe delivery at site and shall be suitable to avoid damages due to water entry and shall withstand the environmental conditions during storage at site.

SMART positioner (For Control Valve and Damper applications)

Sl. No.	Technical Requirement	
1	Make of the SMART positioner	Vendor to specify.
2	Type of Input	4-20 mA, 24 V DC, 2 wire system (Loop powered from DCS)
3	Operational signal range	3.6 mA - 21 mA (4-20 mA). Split range operation shall also be possible.
4	Voltage	12 to 36 V DC
5	Input impedance	Vendor to specify
6	Supply Air pressure	3 – 7 Kg/cm2
7	Air Capacity	Vendor to match with the requirement of the actuator.
8	Sensitivity, Accuracy, Repeatability, Hysteresis	Vendor to match with the requirement of application requirement.
9	Type of Acting (Direct/Reverse)	Vendor to match with the requirement of the actuator.
10	Flow Characterization	SMART positioner shall be compatible to fit valve characteristic curves, Linear/Equal percentage etc.
11	Stroke time	Vendor to match with the requirement of the actuator.
12	No. of pneumatic outputs (Single/Double)	Vendor to match with the requirement of the actuator.
13	Pneumatic Process Connection	To suit the impulse line as per the process P & ID.
14	Communication by Hart Protocol	SMART positioner shall be compatible for Remote calibration & Diagnostics using Hart Management System.
15	Calibration	SMART positioner shall be compatible for Auto Start with self-calibration, Remote calibration from Hart Management System & manual calibration using push buttons available on the positioner.
16	Position sensing & feed back	Output: 4-20mA position feedback signal shall be provided.
17	Electrical Cable entry	Side or bottom entry to avoid water ingress.

Sl. No.	Technical Requirement	
18	Protection Class	IP-65
19	Action required during 4 to 20 mA control signal failure.	SMART positioner shall be compatible for achieving Fail Open, Fail Close & Stay put (Fail freeze) functions to be configured at site.
20	Accessories	For Supply & output pressure, pressure gauges shall be provided on the positioner.
21	EMC Compliance	SMART positioner shall conform to EMC Compliance as per international standards IEC/EN. 61000-4-2/3/6/12
22	Diagnostic Features	Soft Open / Close limit switch output. Alarm on loss of demand signal. Fault. Manual/Auto operation indication. Alarm on Power air failure. Travel/ Stroke counter. Diagnosis of leakage in actuator. On line partial closure test (as per requirement of valve) Valve signature analysis Valve friction/jamming detection Step Response Test
23	In built Operator panel	The positioner shall have a display with push buttons for configuration and for read out. The same shall be Password protected/Hardware lock
24	Mounting Assembly	Required mounting accessories & fasteners for mounting the positioner on valve actuators shall be provided.

ANNEXURE - S

LT AC Motor

Sl. No.	Description	Requirement
1	General Description	Squirrel cage type induction motor, suitable for direct on line starting.
2	Applicable Standards	IS-325, IS-1231, IS-6362, IS-2253, IS-5572, IS-12065, IS-12075, IS/IEC-60079,IS-12615, IS/IEC-60529 &IEC-60034. (Latest version of relevant standards shall be referred)
3	Type of enclosure	Totally Enclosed Fan Cooled (TEFC), IP-55 as per IS/IEC-60529. Motors located in hazardous area shall have flame proof enclosure as per IS/IEC -60079. Vendor to provide flame proof enclosure as per the area of classification, meeting the requirements of type of fuel being.
4	Duty Cycle	Continuous, S1
5	Energy Efficiency Class	IE-2 as per IS-12615/IEC 60034-30. The requirement of a particular project will be indicated in the project specific annexure.
6	Rated Voltage & Tolerance	415 V, AC, 3 Phase, ± 10 %.
7	Rated Frequency & Tolerance	50 Hz, ± 5 %
8	Combined voltage & frequency tolerance	10 % (absolute sum)
9	General Requirements	a. All motors shall be so designed that maximum inrush currents, locked rotor and pull out torque developed at extreme voltage and frequency variations do not endanger the motor and driven equipment. b. Motor shall be designed to keep torsional and rotational natural frequencies of vibration at least 25 percent above the motor rated speed ranges to avoid resonant vibration over the operating speed range of the motor and driven equipment. c. Maximum continuous rating (MCR) of the motor shall have at least 15 % margin over the maximum load

Sl. No.	Description	Requirement
		demand of the driven equipment including voltage and frequency variation. (Applicable only if vendor supplies motor along with the driven equipment or load). d. Requirements during running :- The motor shall be capable of operating satisfactorily at full load for 5 minutes without injurious heating with 75 % rated voltage at motor terminals. The motor shall be designed to withstand momentary over-load of 60% of full load torque for 15 seconds without any damage. The motor shall be designed to withstand 120 % of rated speed for 2 minutes without any mechanical damage. e. Requirements during starting :- Motor shall start with rated load and accelerate to full speed with 80 % rated voltage at motor terminals The motor shall be capable of withstanding the stresses imposed if started at 110 % rated voltage. f. Torque requirements :- Accelerating torque at any speed with the lowest permissible starting voltage shall be at least 10% of motor full load torque. Pull Out torque at rated voltage shall not be less than 205 % of full load torque
10	Class of Insulation	Class-F insulation with temperature rise limited to Class-B. Temperature rise of the motor shall be limited to 70°C (by resistance method) over an ambient temperature of 50°C
11	Stress withstanding capability during Bus Transfer	The motor may be subjected to sudden application of 150% rated voltage during bus transfer, due to the phase difference between the incoming voltage and motor residual voltage.

Sl. No.	Description	Requirement
12	Capacity to restart for rated voltage	a. Two successive starts from cold condition b. Three equally spread starts per hour c. Two hot starts in succession, with motor initially running at normal temperature.
13	Locked Rotor Condition	The ratio of Locked Rotor KVA at rated voltage to rated KW shall not exceed as indicated below, including tolerance ✓ For Motor rating <110KW : 10 ✓ For Motorrating ≥110KW : 9
14	Locked Rotor with-stand time	For motor with starting time up to 20 seconds at minimum permissible voltage during starting, the locked rotor withstand time under hot condition at highest voltage limit shall be at least 2.5 seconds more than starting time.
		For motor with starting time more than 20 seconds but not exceeding 45 seconds at minimum permissible voltage during starting, the locked rotor withstand time under hot condition at highest voltage limit shall be at least 5 seconds more than the starting time.
		For motor with starting time more than 45 seconds at minimum permissible voltage during starting, the locked rotor withstand time under hot condition at highest voltage limit shall be 10% more than the starting time
		Vendor to provide Speed switches mounted on the motor shaft in case the above requirement is not met with.
15	Type of balancing of rotor	Dynamic balancing
16	Method of cooling	IC-0411 as per IS-6362
17	Direction of cooling air flow	NDE side to DE Side
18	Winding wire	Enameled Copper Wire, Grade-2, as per IS-13730, Part-3. Windings shall be non-hygroscopic, oil resistant and flame resistant.
19	Treatment on Winding Insulation	Winding Insulation shall be given tropical and fungicidal treatment for operation of motor in hot, humid & tropical climate.

Sl. No.	Description	Requirement
20	Starting Current	The starting current (% of FLC) shall be limitedto 600%, subject to tolerances as per the standard.
21	Noise level	Noise level shall be limited to 85dBat 1.5 meter distance from the outer surface of the motor.
22	Vibration level	The peak amplitude of vibration shall be as per IS-12075(Limits of Severity-Normal grade shall be followed).
23	Shaft extension	Motor shall be provided with key slotted bare shaft extension, with key at the drive end.
24	Terminal box	Flame proof as per IS/IEC-60079, capable of being turned through 360° in steps of 180°. Terminal box shall have adequate space to terminate the Power cable applicable to the motor by using suitable lugs. Minimum Distance between center of the terminal stud & the gland plate and Minimum inter-phase/phase-earth air clearance shall be provided as per the details indicated in the annexure (project specific requirement). 1 No. Earth terminal shall be provided inside the terminal box. Connection diagram shall be marked inside the terminal box. The motor terminal box shall be suitable for withstanding the system fault current of 50 KA for a duration of at least 0.25 seconds, without any rupture.
25	Cable Entries, Cable Glands &Lugs	Cable entries, Cable glands and Lugs shall be provided suitable for the power cable size as indicated in the annexure(project specific requirement). Double Compression type, brass with nickel plated flame proof cable glands shall be supplied – Quantity to be matched with the number of entries. 3Nos. of Tinned Copper Lugs shall be provided.

Sl. No.	Description	Requirement
26	Terminals	Separate Terminals for Space heaters and Windings with suitable connecting links shall be supplied.
27	Body Earth	Shall have 2 Nos. of earthpoints (Threaded hole with suitable GI Bolt) at appropriate location (in motor base frame).
28	Space heater for motors rated 30 KW and above	Separate space heater suitable for 240 V AC, Single Phase supply shall be provided.
29	Lifting provision	Eye bolt.
30	Project specific requirements	• Motor bearing shall be insulated wherever required. • All LT motors 15 KW and above shall be provided with external greasing arrangement • All motors for outdoor duty shall have detachable metal canopy.
31	Bearing	Bearings shall be of ball or roller type effectively sealed against ingress of dust. The bearing shall be so constructed that the loss of lubricating grease is kept to minimum. Bearing shall be rated for a minimum standard life of 40000 hours.
32	Tests	• Measurement of resistance of windings of stator and wound rotor. • Reduced voltage running up test at no load (for squirrel cage motors). • No load test. • Full load test to determine efficiency, power factor and slip. • Insulation resistance test. • High voltage test • Test for vibration severity of motor. • Test for noise levels of motor. • Test for degree of protection by enclosure. • Temperature rise test at limiting values of voltage and frequency variations. • Over speed test. • Locked rotor readings of voltage, current and power input at a suitable reduced voltage.
33	Name Plates	Motor shall have name plate as per relevant IS and in addition, Manufacture's name, frame size, Energy

Sl. No.	Description	Requirement
		Efficiency class, Insulation class designation shall also be indicated.
34	Documents to be submitted by the vendor for approval by BHEL/Customer, after placement of purchase order.	3 Sets of the following :- a. Final technical Data sheet as per the format submitted by BHEL. b. Motor GA drawing indicating foundation, shaft details and terminal box arrangement with complete dimensions. c. Motor Characteristic curves (Torque Vs. Speed, Current Vs. Speed, Speed Vs. time, Current Vs. time, Efficiency and PF Vs. load, Thermal withstand characteristic)
35	Packing	Shall be as per manufacturer's standard practice. The packing shall be suitable for safe transport, safe delivery at site and shall avoid damages due to environmental conditions during storage at site.

POWER CABLE SIZE:

Vendor to provide the cable entry, glands and lugs as per the specification requirement suitable for the power cable sizes as indicated below. However, the sizes indicated herein are tentative and shall be finalised during detailed engineering.

Sl. No.	From (KW)	To (KW)	Power Cable size in sq. mm.
1.	0.01	1	3C-2.5mm^2(CU)
2.	1.01	2	3C-2.5mm^2(CU)
3.	2.01	3.7	3C-10mm^2(AL)
4.	3.71	5.5	3C-10mm^2(AL)
5.	5.51	7.5	3C-25mm^2(AL)

6.	7.51	9.3	3C-25mm^2(AL)
7.	9.31	11	3C-25mm^2(AL)
8.	11.1	15	3C-50mm^2(AL)
9.	15.1	18.5	3C-50mm^2(AL)
10	18.51	22.0	3C-50mm^2(AL)
11	22.0	27.0	3C-50mm^2(AL)
12	27.1	30.0	3C-70mm^2(AL)
13	30.1	37.0	3C-70mm^2(AL)
14	37.1	45.0	3C-95mm^2(AL)
15	45.1	55.0	3C-150mm^2(AL)
16	55.1	75.0	3C-150mm^2(AL)
17	75.1	90.0	3C-185mm^2(AL)
18	90.1	110.0	3C-240mm^2(AL)
19	110.1	125.0	2-3C-240mm^2(AL)
20	125.1	132.0	2-3C-240mm^2(AL)
21	132.1	160.0	2-3C-240mm^2(AL)
22	160.1	174.0	2-3C-240mm^2(AL)

DIMENSIONS OF TERMINAL BOXES (For Flame proof motors)

Sl. No.	Motor MCR in KW	Minimum Distance between centre of stud and the gland plate (in mm)
1	Up to 3 KW	As per manufacturers' practice
2	Above 3 KW – Up to 7 KW	85

3	Above 7 KW – Up to 13 KW	115
4	Above 13 KW – Up to 24 KW	167
5	Above 24 KW – Up to 37 KW	196
6	Above 37 KW – Up to 55 KW	249
7	Above 55 KW – Up to 90 KW	277
8	Above 90 KW – Up to 125 KW	331
9	Above 125 KW – Up to 200 KW	403

ANNEXURE-U

FIELD INSTRUMENTS & ANALYSERS

FIELD INSTRUMENT REDUNDANCY

Redundant instruments shall be provided for all control applications. For all closed loop controls (CLCS) triple redundant sensors shall be provided. This will include sensors provided for compensation also. Similarly for critical protection logic requirements triple redundant sensors for 2 out of 3 logic shall also be provided to avoid spurious tripping. For all other control application dual redundant sensors shall be provided.

Two out of three measurements philosophy shall be adopted for all CLCS and Protection for reliability of operation. The control system shall select the median value for the normal control purpose. In case of deviation of one transmitter output from the other two, the same shall be automatically isolated and average output of the remaining transmitters shall be fed to the control and measurement system and the control loop in this case shall be maintained on auto, with an alarm. In case of failure of the two remaining transmitters in circuit, deviation of one transmitter output is more than the preset limit compared to the other transmitter, there shall be automatic bump less transfer to manual and changeovers shall have suitable alarms. For signal compensations, separate signals from separate transmitters other than used for measurement & control shall be used.

For open loop controls (OLCS), all sensors used for the protection shall be triple redundant. All sensors for permissive and interlock shall be dual redundant.

1.00.00 SPECIFICATION FOR ELECTRONIC TRANSMITTERS

1.01.00 PRESSURE TRANSMITTER

1. Working Principle	: Smart (HART 5/7 protocol Compatible)
2. Type	: Microprocessor based, 2 – Wire
3. Output Signal	: 4-20 mA DC along with superimposed Digital signal
4. Measuring Element	: Capsule / Diaphragm
5. Element material	: SS-316 (Stainless Steel) or better – Shall be decided by the vendor to suit the process medium

6. Static Pressure	: 150 % of maximum span continuously, without affecting the calibration
7. Turn-down ratio	: 10:1 – For low pressure application 30:1 – For high pressure application
8. Span and Zero	: Continuous, tamper proof, remote as well locally adjustable with zero elevation and suppression by 100% of span
9. Enclosure Class	: IP-65 (Explosion proof for NEC Class-1, Division area)
10. Output Indicator	: LCD (Integral indicator of 5 digit display)
11. Nameplate	: Tag number, service engraved in SS tag plate
12. Body	: SS
13. Operating Voltage	: 24V DC
14. Load	: 500 Ohms (min.) at 24 Volts D.C.
15. Ambient Temperature	: 0 - 50 °C
16. Performance:	
i. Accuracy	:±0.1% of calibrated span (minimum)
17. Sealing/Isolation	: Extended diaphragm (Silicon oil/ Flurolub filled) with 5 meters SS armoured capillary for corrosive/viscous/solid bearing or slurry type fluid applications - Shall be decided by the vendor to suit the process medium

18. Accessories :

a. Universal mounting bracket suitable for 2" pipe mounting
b. High tensile carbon steel Ubolts
c. Siphon for steam and hot water services
d. ½" NPT 2-valve stainless steel manifold, constructed from SS316 bar stock
e. Companion flange with nuts, bolts and gaskets
f. ½" NPT cable gland
g. Handheld calibrator
h. All accessories shall be suitable to handle the process medium

19. Adjustment/Calibration/ Maintenance	: From handheld calibrator/ HART management system

Notes: For primary air/ secondary air/ flue gas applications, DP type transmitters shall be provided for pressure measurement. LVDT type is not acceptable.

1.02.00 DIFFERENTIAL PRESSURE TRANSMITTER / FLOW TRANSMITTER

1. Working Principle	: Smart (HART 5/7 protocol Compatible)
2. Type	: Microprocessor based, 2 – Wire
3. Output Signal	: 4-20 mA DC along with superimposed digital signal
4. Measuring Element	: Capsule / Diaphragm
5. Element material	: SS-316 (Stainless Steel) or better - Shall be decided by the vendor to suit the process medium
6. Static Pressure	: 150 % of maximum span continuously, without affecting the calibration
7. Turn-down ratio	: 10:1 – For low pressure application 30:1 – For high pressure application
8. Span and Zero	: Continuous, tamper proof, remote as well locally adjustable with zero elevation and suppression by 100% of span
9. Enclosure Class	: IP-65 (Explosion proof for NEC Class-1, Division 1 area)
10. Output Indicator	: LCD (Integral indicator of 5 digit display)
11. Nameplate	: Tag number, service engraved in SS tag plate
12. Body	: SS
13. Operating Voltage	: 24V DC
14. Load	: 500 Ohms (min.) at 24 Volts D.C.

15. Ambient Temperature : 0 - 50 °C

16. Performance:
    i. Accuracy : ± 0.1% of Span or better

17. Sealing/Isolation : Extended diaphragm (Silicon oil/Flurolub filled) with 5 meters SS armoured capillary for corrosive/viscous/solid bearing or slurry type fluid applications - Shall be decided by the vendor to suit the process medium

18. Accessories :
    a. Universal mounting bracket suitable for 2" pipe mounting
    b. High tensile carbon steel U-bolts
    c. Siphon for steam and hot water services
    d. ½" NPT 5-valve stainless steel manifold, constructed from SS316 bar stock
    e. Companion flange with nuts, bolts and gaskets
    f. ½" NPT cable gland
    g. Handheld calibrator
    h. All accessories shall be suitable to handle the process medium

19. Adjustment/Calibration/Maintenance : From handheld calibrator/ HART management system

1.03.00 ULTRASONIC LEVEL TRANSMITTER

1. Type : Microprocessor based, 2-wire, Smart (HART 5/7 protocol Compatible)

2. Operating Principle : Detection of reflected ultrasonic pulse

3. Output Signal : 4-20 mA DC along with superimposed digital signal

5. Display : LCD

6. Temperature Compensation : Built in –Programmable

7. Power supply : 24 V DC

8. Enclosure : SS, IP-65 (Explosion proof for NEC Class-1, Division 1 area)

9. Zero & Span : Continuous, tamper proof, remote as well locally adjustable. It shall be possible to calibrate the instrument without any level in the sump/ tank

10. Accuracy &Repeatability: 0.15 % of span or better

11. Resolution : 0.1 % of span

12. Operating temp. : Transmitter- 500 °C and Sensor - 800 °C

13. MOC Sensor : SS-316/Body- PVC and Face –Polyurethane - - Shall be decided by the vendor to suit the process medium

14. Mounting : 4" Flanged/ 2" NPT for sensor and Transmitter on panel

15. Accessories :

a. Handheld calibrator
b. Weather canopy for protection from direct sunlight and direct rain
c. ½"NPT cable gland
d. All mounting hardware (SS- 316), Prefab cable
e. SS Nameplate

16. Diagnosis : On-line

17. Status Indication : Power On, High, V. High, Low, V. Low, Fault

19. Adjustment/Calibration/ Maintenance: From handheld calibrator/ HART management system

20. Applications : Coal Bunker, Water Service etc.

1.04.00 ULTRASONIC FLOW TRANSMITTER

1. Type : Ultrasonic – Clamp On

2. Accuracy : +/- 1 % of reading

3. Repeatability : +/- 0.3 % of reading

4. Rangeability : 400: 1

5. Output Signal : 4-20 mA DC with HART

6. Measured Parameter : Volumetric flow, Totalized flow and flow Velocity

7. Display : LCD with internal Key Pad (Flow rate &totalization)

8. Power Supply : 24 V DC (2 Wire)

9. Enclosure : SS (IP- 68 – Submersible)

10. Mounting : SS Chain or Strap

11. Accessories
    a. Handheld calibrator
    b. ½"NPT cable gland
    c. Transducer cable
    d. All mounting hardware (SS-316)
    e. SS Nameplate

12. Adjustment/Calibration/ Maintenance : From handheld calibrator/ HART management system

13. Applications : Plant water service

Note: Multi-path insertion type (minimum 4 path) Ultrasonic Flow meter shall be provided for raw water/ Cooling Water flow measurements.

1.05.00 MASS FLOW METER

1.05.01 SENSOR

1. Measuring Principle : Coriolis Mass flow
2. Primary Element : Flow Tube of 316SS or better
3. Heating Arrangement : Integral
4. Process Connection : Flanged of rating as per process requirement
5. Drain : Self-draining facility
6. Enclosure : Stainless steel
7. Accessories : Counter flanges, Mounting nuts, bolts, gaskets etc.

1.05.02 TRANSMITTER

1. Measured quantities : Mass Flow rate, Total Mass Flow, Density
2. Input Signal Processing : Smart (HART compatible)
3. Display : LCD

4. Output	: 2 nos. isolated output of 4-20mA DC selectable from four measured quantities
5. Load	: < 750 ohms
6. Power supply	: 240V AC, 50 Hz

2.00.00 HART HAND HELD CALIBRATOR

Universal type Hand held calibrators shall be provided for adjustment/ calibration/maintenance of the HART compatible transmitters. The hand held calibrator shall be suitable for all types of transmitters supplied in the package. If one type of hand held type calibrator is not suitable for communicating with all types of transmitters then separate hand held calibrator shall be provided.

3.00.00 PROCESS ACTUATED SWITCHES

3.01.00 PRESSURE SWITCH

1. Type :
   a. Piston for high pressure application
   b. Bellow / Diaphragm for low pressure application

2. Sensing element material : SS-316 or better - shall be decided by the vendor to suit the process medium

3. Case Material : SS or better - shall be decided by the vendor to suit the process medium

4. Setter Scale : Black graduation on white linear scale. Graduation 0-100% with red pointer for set points

5. Over range : 150 % of maximum pressure

6. Adjustments :
   a. Internal Set Point
   b. Adjustable Dead band

7. End Connection : 1/2" NPT (F) bottom connected

8. Switch configuration : Two SPDT (240V, 5A AC/220V, 0.5A DC)

9. Switch Type : Snap acting, shock & vibration proof

10. Terminal Block : Suitable for full ring lugs

11. Enclosure Class : IP-65 (Explosion proof for NEC Class-1, Division 1 area)

12. Performance :
    a. Repeat accuracy ± 1.0%
    b. Accuracy of Setting Indication of+ 1.5%

13. Ambient temperature : 0 – 50 °C

14. Nameplate : Tag number, service engraved in SS tag plate

15. Accessories :
    a. Silicon oil/ Flurolub filled Remote diaphragm seal with SS-316 capillary for corrosive/ viscous/ solid bearing or slurry type fluid applications
    b. Snubbers for pulsating fluid applications
    c. Siphons for steam and hot water services
    d. Retention ring and screws for surface mounting
    e. 1/2" NPT 2 Valve SS-316barstock manifold
    f. ½" NPT cable gland
    g. All accessories shall be suitable to handle the process medium

16. Applications : During Detail Engineering on Owner's approval

3.02.00 DIFFERENTIAL PRESSURE SWITCH

1. Type :
    a. Piston for high pressure application
    b. Bellow / Diaphragm for low pressure application

2. Sensing element material : SS-316 or better - Shall be decided by the vendor to suit the process medium

3. Case Material : SS

4. Setter Scale : Black graduation on white linear scale. Graduation 0-100% with red pointer for set points

5. Over range : 150 % of maximum pressure

6. Adjustments :
    a. Internal Set Point

b. Adjustable Dead band

7. End Connection : 1/2" NPT (F) bottom/ back connected

8. Switch configuration : Two SPDT (240V, 5A AC/220V, 0.5A DC)

9. Switch Type : Snap acting, shock & vibration proof

10. Terminal Block : Suitable for full ring lugs

11. Enclosure Class : IP-65 (Explosion proof for NEC Class-1,Division 1 area)

12. Performance :
    a. Repeat accuracy ± 1.0%
    b. Accuracy of Setting Indication of+ 1.5%

13. Ambient temperature : 0 – 50 °C

14. Nameplate : Tag number, service engraved in SS tag plate

15. Accessories :
    a. Silicon oil/ Flurolub filled Remote diaphragm seal with SS-316 capillary Diaphragm seals for corrosive/ viscous/ solid bearing or slurry type fluid applications
    b. Snubbers for pulsating fluid applications
    c. Siphons for steam and hot water services
    d. Retention ring and screws for surface mounting
    e. 1/2" NPT 5 Valve SS-316 bar stock manifold
    f. ½" NPT cable gland
    g. All accessories shall be suitable to handle the process medium

16. Applications : During Detail Engineering on Owner's approval

3.03.00 LEVEL SWITCH

3.03.01 FLOAT OPERATED

1. Float material : SS-316 or better - shall be decided by the vendor to suit the process medium

2. Wetted parts : SS-316 or better - shall be decided by the vendor to suit the process medium

3. Float chamber : Stainless steel/Carbon steel, construction welded - to suit the process medium

4. Float chamber mounting : Side mounted

5. Fluid connection : Side – Side

6. Fluid connection size : 1" ANSI RF Flange (rubber line, if required)

7. Drain : ½ inch NPT with Plug

8. Pressure rating of chamber: Minimum 1.5 times of design pressure

9. Repeatability : ±1.5 mm or better

10. Switch housing : Stainless Steel

11. Switch housing type : IP- 65

12. Type of switch : Snap acting magnetically operated hermetically sealed

13. Switch configuration : 2 SPDT (5A, 240 V AC, 0.5A, 220V DC)

14. Accessories :
    a. Counter flange, nuts & bolts, suitable gasket etc.
    b. Steel globe type drain valve
    c. ½"NPT cable gland
    d. Stainless steel nameplate with alpha-numeric engraved for service and tag
    e. All accessories shall be suitable to handle the process medium

15. Application : During Detail Engineering on Owner's approval

3.04.00 FLOW SWITCH

1. Type : Paddle /Piston/Disk

2. Wetted part material : Stainless steel or Hastelloy for acidic application - shall be decided by the vendor to suit the process medium

3. End connection :
   a. Threaded up to 1" line size with integral Tee
   b. Flanged for line size > 1 ½"

4. Enclosure material : Stainless Steel

5. Enclosure class : IP 65

6. Switch configuration : 2 SPDT (5A, 240 V AC, 0.5A, 220V DC)

7. Repeatability : 2%

8. Cable connection : ½"NPTF

9. Accessories :
   a. Tee, Counter flange, nuts & bolts, suitable gasket etc.
   b. ½"NPT cable gland
   c. Stainless steel nameplate with alpha-numeric engraved for service and tag
   d. All accessories shall be suitable to handle the process medium

3.05.00 RF LEVEL SWITCH

1. Type : RADIO FREQUENCY Sensing probe

2. Material : SS-316

3. Mounting application : Threaded

4. Temperature : 250°C (Max.)
   Electronic Controller

5. Input Supply Voltage : 240V AC ±10%, 50 Hz.

6. Relay Output : 2 SPDT (240V AC, 5A)

7. Ambient Temperature : 50 °C

8. Enclosure Protection : IP-66

9. Enclosure Housing : SS

10. Local LED Indication :

a. Normal Level
b. Power On
c. Alarm Level
d. Probe Healthy

11. Switching Repeatability : ±0.5%

12. Accessories : Co-axial cable for probe connection to controller SS Tag plate ½" NPT Cable Glands

13. Application : Solid level

3.06.00 CONDUCTIVITY TYPE LEVEL SWITCH

1. Type : Conductivity discrimination

2. Probe MOC : SS-316

3. Mounting Application : Flanged on external cage

4. Temperature : 250°C (Max.)

5. Test Pressure : Two times rated pressure

6. Input Supply Voltage : 240V AC ±10%, 50 Hz.

7. Input : Four independent channel with selectable switching threshold for water conductivity

8. Relay Output : 2 SPDT (240V AC, 5A)

9. Ambient Temperature : 50 °C

10. Enclosure Protection : IP-65 (Explosion proof for NEC Class-1, Division-1 area)

11. Enclosure Housing : SS
12. Local LED Indication : High, Low, Very High, Very Low, Power Fault

13. Accessories :
a. Interconnecting cable from probe to electronics
b. Mounting accessories
c. External cage
d. Washer & Gasket

e. ½" NPT Cable Glands
f. SS Tag Plate

14. Application : During Detail Engineering on Owner's approval

3.07.00 TEMPERATURE SWITCH

1. Type : Bimetallic or gas filled or liquid filled

2. Sensing Element Material : SS-316 – to suit the process medium

3. Bulb Material : SS-316

4. Capillary : Stainless Steel armoured

5. Movement Material : Stainless Steel

6. Case material : Stainless Steel with neoprene gasket and clear glass where applicable cover conforming to IP-65. (Explosion proof for NEC Class-1, Division 1 area).

7. Scale : Black graduation on white linear scale. Graduation 0-100% with red pointer for set points

8. Over range Protection : 120 %

9. Instrument connection : Bottom

10. Switch configuration : Two SPDT (240V, 5A AC/220V, 0.5A DC)

11. Switch type : Snap acting, shock and vibration-proof

12. Adjustability : Internal Set point adjustable over span range

13. Compensation :
    a. Capillary compensation with invar wire throughout the capillary length
    b. Case compensation

14. Performance
    a. Scale Accuracy: ±1.0 % of full scale

b. Repeatability :< 0.5 % of full range
c. Response time : Less than 40 seconds with thermowell

15. Capillary length	: 5 meters (minimum) for local mounting/15 meters for local panel mounting
16. Nameplate	: Tag number, service engraved in stainless steel tag plate
17. Accessories	: Mounting accessories, ½" NPT cable gland
18. Applications	: During Detail Engineering on Owner's approval

4.00.00 LOCAL INSTRUMENTS

4.01.00 PRESSURE GAUGE AND DIFFERENTIAL PRESSURE GAUGE

1. Type	: Bourdon/Bellows/Diaphragm
2. Applicable Standard	: EN-837/ANSI B 40.1
3. Sensing & Socket	: SS-316 or better – To suit the process medium
4. Movement Material	: SS-316 or better – To suit the process medium
5. Case Material	: Stainless steel. IP-65 (Explosion proof for NEC Class-1, Division 1 area)
6. Dial Size	: Generally 150 mm
7. Scale	: Black lettering on white back-ground.
8. Window	: Shatterproof glass
9. Range Selection	: Normal process pressure: 50~70 % of range – Shall be finalised during detailed engineering with owner's approval.
10. Over-range Protection	: 125% of maximum range by internal stop. External stop at zero
11. Adjustment	: For Zero adjustment (Micrometre screw external)

12. Element Connection : Argon welding

13. Process Connection : 1/2" NPT (M) Bottom for local, back for panel mounting

14. Performance : Accuracy of ± 1.0 % of span or better

15. Operating ambient : 0 - 50 °C

16. Safety Feature : Blow out disc /diaphragm at the back

17. Accessories :

a. Snubbers for pulsating fluid application.
b. Stainless steel Diaphragm seals for corrosive/ viscous/ solid bearing or slurry type fluid applications
c. 3-Way SS316 Gauge cock for pressure gauges
d. 5-valve SS316 manifold from barstock for differential pressure gauge
e. Siphons for steam and hot water services
f. All accessories shall be suitable to handle the process medium

18. Nameplate : Tag number, service engraved in stainless steel tag plate

4.02.00 LEVEL INDICATOR (FLOAT & BOARD TYPE)

1. Type : Float and Board

2. Float Material : SS-316 or better -Shall be decided by the vendor to suit the process medium

3. Float Cable : SS-316

4. Indicator Assembly : Epoxy painted Aluminium

5. Guide wire spring assembly : SS-316 (2 Nos.)

6. Guide Wire Anchor : SS-316

7. Scale Board : Anodized Aluminium with engraved marking (Minimum graduation 10mm), mounting brackets and suitable hardware required as per tank height

8. Elbow Assembly	: Anodized Aluminium
9. Flanges	: RF, ANSI 150, SS (3 Nos.)
10. Accuracy	: + 10 mm or better
11. Accessories	: All mounting accessories including counter flange, nuts & bolts, suitable gasket etc. as applicable, SS Tag plate

4.03.00 ROTAMETER WITH DP REGULATOR

1. Type	: ON-LINE for line up to and including 50 mm NB. Borosilicate BY-PASS for line size above 50 NB
2. Metering tube	: Toughened Borosilicate - to suit the process medium
3. Float	: SS-316
4. End fittings	: SS-316
5. Packing material	: Teflon / PTFE
6. Casing	: Stainless Steel
7. Gland Rings/Followers/ Other wetted parts	: Stainless Steel
8. Orifice Plate	: Stainless Steel (for bypass type)
9. Operating Temperature	: 0-50 °C
10. Test Pressure	: 200% of maximum operating pressure
11. Scale	: 250 mm nominal length
12. Graduation	: Direct reading
13. Process Connection	: Flanged (RF) to line size as per ANSI standards
14. Tapping	: D & D/2
15. Accuracy	: ± 2% of full scale reading

16. Reproducibility : Within 0.5% of instantaneous reading

17. Accessories : SS Tag Plate, orifice plate

5.00.00 TEMPERATURE ELEMENTS & ACCESSORIES

5.01.00 RESISTANCE TEMPERATURE DETECTOR

1.Element Type : PT100,Ungrounded

2. Wiring : 3 Wire

3. Protecting Tube
   a. O.D. : 8mm
   b. Material : Seamless, SS-316 or better - Shall be decided by the vendor to suit the process medium
   c. Filling : Magnesium oxide (Purity above 99.4%).

4. Response time :
   a. Less than 15 sec. (bare).
   b. Less than 50 sec. (with thermowell)

5. Calibration : DIN 43760

6. Accuracy : ± 0.5%

7. Head
   a. Type : IP-65 universal screwed type
   b. Material : Stainless Steel
   c. Terminal blocks : Nickel plated Brass-screw type / silver plated
   d. Cable connection : ½" NPT gland and grommet
   e. Others : Terminal head cover with SS chain and suitable gasket. Head of TE to be provided with sufficient space and arrangement to mount head mounted temperature transmitter (as applicable).

10. Accessories :
   a. Adjustable nipple-union-nipple [1/2" Sch 80 X ½" NPT] with thermowell connection
   b. Compression fittings/unions
   c. Flanges etc. (for flanged connections only)
   d. Thermowell (As specified below)

11. Thermowell connection : ½" NPT (M) or 150 RF Flanged - shall be finalised during detailed engineering based on stub connection

12. Nameplate : Tag number, service engraved in stainless steel tag plate

Note: The specifications for RTDs of winding/ bearing of motor/pump, can be as per their manufacturer standards. The manufacturer shall submit the adequate supporting documents for establishing their standard practice. However, the type of RTD shall be Pt-100.

5.02.00 THERMOCOUPLES

1. Type :
   a. 16 SWG wire of Chromel-Alumel) (Type-K)or Platinum Rhodium(Type-R)
   b. Duplex
   c. Ungrounded

2. Protecting Tube
   a. O.D. : 8mm
   b. Material : Seamless, SS-316 or better Shall be decided by the vendor to suit the process medium
   c. Filling : Magnesium oxide (Purity above 99.4%).

3. Response time
   a. Less than 15 sec. (bare).
   b. Less than 50 sec. (with thermowell)

4. Accuracy As per standard ANSI MC 96.1

5. Head
   a. Type :IP-65 universal screwed type
   b. Material : Stainless Steel
   c. Terminal blocks : Nickel plated Brass-screw type / silver plated
   d. Cable connection : ½" NPT gland and grommet
   e. Others : Terminal head cover with SS chain and suitable gasket. Head of TE to be provided with sufficient space and arrangement to mount head mounted temperature transmitter (as applicable).

6. Accessories :

a. Adjustable nipple-union-nipple [1/2" SCH 80 X ½" NPT] with thermowell connection
b. Compression fittings/unions
c. Flanges etc. (for flanged connections only)
d. Thermowell (As specified below)

7. Thermowell connection : ½" NPT (M) or 150 RF Flanged -shall be finalised during detailed engineering based on stub connection

8. Nameplate : Tag number, service engraved in stainless steel tag plate

5.03.00 TEMPERATURE GAUGE

1. Type : Expansion type (Liquid/Gas filled system/Bimetallic)

2. Applicable Standard : EN-13190

3. Sensing Element Material : Bourdon – SS-316 or better - shall be decided by the vendor to suit the process medium

4. Bulb & Capillary Material : SS-316

5. Capillary Tubing : SS316 capillary with SS304 armouring. Shall be decided by the vendor to suit the process medium

6. Movement Materials : Stainless Steel / Direct Bourdon tip connection to pointer spindle

7. Case Material : Stainless Steel stove enamelled, black finish, threaded bezel ring, clear glass cover conforming to IP 65.

8. Dial size : 150 mm

9. Scale : Black lettering on white back-ground

10. Over range protection : 125 percent of FSD

11. Instrument Connection : Bottom connection for local mounting, back connection for panel mounting

12. Process Connection : ½" NPT (M) or RF Flanged - Shall be finalised during detailed engineering based on stub connection

13. Extension Neck Length : 50 mm

14. Compensation :
    a. Capillary compensation
    b. Case compensation

15. Performance
    a. Accuracy : ±1.0 percent of full scale Deflection
    b. Repeatability : Less than 0.5 percent of full range
    c. Response time : 15 seconds (max.).

16. Capillary length : 5 metres (local) / 15 metres (local panel)

17. Other features : Shatter proof glass

18. Nameplate : Tag number, service engraved in stainless steel tag plate

19. Accessories : SS316 thermowell or better - shall be decided by the vendor to suit the process medium

5.04.00 THERMOWELL

1. Material : SS-316 or better - shall be decided by the vendor to suit the process medium

2. Manufacture : Drilled from bar stock, Hex Head, Tapered design (As per ASME PTC 19.3-2016)

3. Process connection : M33x2

4. IBR Certification : Applicable for process pressure above 3.5 kg/sq.cm.

5. Bore concentricity : +5% of wall thickness

6. Identification mark : Tag number punched on head

7. Surface treatment : Polish after machining

8. Element connection : ½" NPT (M) or 150 RF Flanged

9. Head : Hexagonal

10. Length of the hex head : 31.75 mm (min.) - Shall be finalised during detailed engineering

11. Accessories : SS Plug and chain for test thermo wells SS Nameplate, Flange with companion flange & all required accessories for flanged connections.

Note: Bidder shall provide calculation for thermo well as per ASME – PTC-19.3 2016 for approval. IBR form III C or Equivalent certificate and detailed drawings shall be furnished for all thermowells.

6.00.00 ANALYSERS

6.01.00 OXYGEN ANALYZER

1. Operating Principle : Zirconium Oxide (ZrO_2)
2. Sampling/Non-sampling : In-Situ
3. Type : Microprocessor based
4. Range : 0.1-10% / 0.25-25%
5. Accuracy : ±1% of Full Scale
6. Response time (up to 90 % of full scale) : Less than 5 seconds
7. Linearity : ±1% of Full Scale
8. Repeatability : ≤0.5% of Span
9. Calibration : Automatic & Manual (Zero & Span)
10. Power Supply : 240 V AC
11. Output signal : 4-20 mA DC (with superimposed HART signal) into 500 ohms
12. Alarm annunciation : Four relay contacts, Dual Alarm set points (240V AC, 5A)
13. Enclosure : Stainless Steel (IP-65)
14. Material for gas carrying Components : SS-316
15. Reference : Instrument Air
16. Probe Length : 1800 mm or as applicable
17. Indication : LCD display
18. Operating Temperature Range : Min.1600 °C
19. Accessories :
    a. Interconnection cable (as required) in flexible conduits

b. Tubes/Fittings, mounting brackets as required
c. Bolts, Nuts, Gaskets
d. Automatic calibration kit for one year continuous operation(complete with all accessories and standard Gas Cylinders)
e. Surge Arrester

6.02.00 GAS (SOX/NOX) ANALYZER

1. Operating Principle : NDIR
2. Sampling/Non-sampling : Dilution
3. Type : Microprocessor based
4. Range :
   a. SO_2 : 0-450 ppm
   b. NOx : 0-500 ppm
   c. CO/CO_2 : 0-500 ppm
5. Accuracy : 1% F.S.
6. Response time (up to 90% of full scale) : Less than 5 (five) seconds
7. Linearity : ±1% of Full Scale
8. Repeatability : ≤1% of Span
9. Calibration : Automatic & Manual (Zero & Span)
10. Power Supply : 240 V AC
11. Output signal : 4-20 mA DC each channel (with superimposed HART signal) into 600ohms
12. Alarm annunciation : Four relay contacts, Dual Alarm set points(240V AC, 5A)
13. Enclosure : Stainless Steel
14. Indication : LCD display
15. Operating Temp. Range :0-300 °C
16. Accessories :
    a. Interconnection cable (as required) in flexible conduits
    b. Tubes/Fittings, mounting brackets/pads as required
    c. Purge system for cleaning
    d. Surge Arrester
    e. Standard gas for calibration.

ANNEXURE - V

SPECIFICATION FOR CABLES, CABLE TRAYS AND CABLE GLANDS

1.0 GENERAL TECHNICAL REQUIREMENTS

1.0.01 All cable and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) and IEC except where modified and/or supplemented by this specification.

1.0.02 Cable and material conforming to any other standard which ensures equal or better quality, may be accepted. In such case, copies of the English version of the standard adopted shall be submitted along with the bid.

1.0.03 The electrical installation shall meet the requirements of Indian Electricity Rules as amended up to date and relevant IS Code of Practice. In addition, rules and regulations applicable to the work shall be followed.

1.0.04 Cables shall be flame retardant low smoke (FRLS) type. In hazardous areas cables of suitable R/L ratio shall be provided for intrinsic safety. Repaired cables are not acceptable.

1.0.05 FRLS marking shall be provided on the surface of the cable at intervals not exceeding 5 m Durable marking at intervals not exceeding 625mm shall include Manufacturer's name, Year of manufacture, Voltage grade, Type of cables (Conductor size & number of pairs / type of compensating /extension cable),Insulation material, FRLS etc.

1.0.06 Progressive sequential length marking shall also be provided at every meter interval on outer sheath of cable.

1.0.07 Non-returnable standard seasoned wooden drum containing minimum 500/1000 m ±5% length. Drum shall be anti-rodent, anti-termite and smooth finish. Both end of cable shall be capped by means of non-hygroscopic sealing material.

1.0.08 For continuous operation at specified rating, maximum conductor temperature shall be limited to the permissible value as per relevant standard and/or this specification which one is more stringent.

1.0.09 The insulation and sheath materials shall be resistant to oil, acid and alkali and shall be tough enough to withstand mechanical stresses during handling.

1.0.10 Armouring shall be single round wire of galvanized steel for multicore cables and aluminum for single core cable for power and control cables. For fire survival control cable, the armouring over inner sheath shall consist of single layer of wire / round galvanized steel wire as per IS-3975 amended up to date.

1.0.11 The outer sheath shall have flame retardant low smoke halogen evolution (FRLSH) characteristics or fire survival characteristics as applicable and shall meet the requirements of additional tests specified for the purpose.

1.0.12 Core identification for multicore cable shall be provided by colour coding.

1.0.13 All control cables shall be 2.5 Sq. mm copper cable.

1.0.14 Multicore control cables will generally have spare conductor(s) in accordance with the following chart :

	Conductors	**Required Cables**
i.	1 or 2	1-3/C
ii.	3 or 4	1-5/C
iii.	5 or 6	1-7/C
iv.	7 or 8	1-9/C
v.	9 or 10	1-12/C
vi.	Above 10	Two or more of above cables

1.0.15 **Cable** Identification

Cable identification shall be provided by embossing on the outer sheath the following:

a. Manufacturer's name or trade mark
b. Manufacturer's name or trade mark
c. Voltage grade
d. Year of manufacture
e. Type of insulation, e.g. XLPE, HRPVC & IE2 etc.
f. No. of core & size of cables
g. Type of outer sheath e.g. FRLSH, FS etc.

1.1 Thermocouple Extension & Compensating Cable

01. Conductor	: Solid conductor
02. Conductor size	: 16 AWG (1.31 Sq. mm)
03. Type	: KX (Compensating) (Chromel Alumel) RX (Compensating) (Copper-Copper alloy) JX (Compensating) (Iron-Constantan)
04. Conductor Insulation	: HR PVC Type-C (IS-5831, 1984) 0.6mm thick
05. Operating Voltage	: 650V
06. Twisting	: Pair twisted with lay of 60 mm (max)
07. Twisting Direction	: All pairs in the same direction. Lapped to form bunch with Mylar tape.
08. Screen (Pair & Overall)	: Aluminium Mylar tape with a thickness of28 µm (min.) for individual pair screen and 60 µm (min.) for overall screen with100% coverage and 25% over lapped edges. Over the individual pair screening tape two laps of 0.05 mm thick (min.) polyester tape shall be applied with Minimum overlap of 25%. Metallic side of the screen shall be in contact with drain wire.
09. Drain wire	: Annealed tinned copper wire, stranded. Size 0.5 Sq. mm. (No. of strands / size: -7 / 0.3mm) (For both individual and overall screen)
10. Inner Sheath	: Extruded FRLS PVC (anti-rodent, anti-termite& moisture resistant properties) HR PVC Type ST2 of IS-5831, 1984 Thickness as per IS-1554Part-I 1976
11. Rip Cord	: Nonmetallic under sheath

12. Armouring : GI wire / strip as per IS 3975

13. Outer Sheath : Extruded FRLS PVC (anti-rodent, anti-termite &moisture resistant properties)
HR PVC Type ST2 of IS-5831, 1984
Thickness 1.8 mm (Min)

14. Filler : Non hygroscopic with FRLS property

15. Temperature Range : Up to 85 °C

16. Insulation at 200 C : 100 MΩ/Km [Min]

17. Capacitance at 800 Hz : 200 nf/km

18. Cross talk : 60 dB

19. Attenuation : 1.2 dB/Km

20. Codes & Standards :

a. IEC 332-1
b. ANSI MC 96.1
c. IS-8784-1987

21. Tests :

a. Oxygen Index : Min.29 at room temp. (ASTM-D-2863)
b. Acid Gas Gen. : Max.20% by weight as per IEC 754 Part-I
c. Temp Index : Min 250 °C at21Oxy. Ind. (ASTM-D-2863)
d. Smoke Density Rating : Max.60 %(ASTM-D-2843).
e. Flammability Test : as per IEC 332Part-I /IEEE-383
f. Swedish Chimney Test - SS-424-1475 F3
g. High voltage test
   Core to core- 2.0 KV for 1 min.
   Core to screen- 2.0 KV for 1 min.
h. Insulation Resistance 100 MΩ /Km Min
i. Rodent & Termite repulsion test(Presence of lead shall be confirmed)

22. Conductor material & sheath color for thermocouple cable as per ANSI MC96.1

Cable Type	Colour of Outer sheath	Wire	Colour of Insulation	Conductor material
KX	Yellow	Positive	Yellow	Nickel / Chromium
		Negative	Red	Nickel / Aluminum
JX	Black	Positive	White	Iron
		Negative	Red	Constantan
RX	Green	Positive	Black	Copper
		Negative	Red	Copper Nickel

23. Durable printed or embossed numbering at regular interval of 50mm shall be provided for identification of pairs. Each core printed with number or numbered binder tape shall be provided on each pair.

1.2 Instrumentation multi Paired Signal Cable

01. Conductor type : Stranded (7) annealed tinned copper

02. Conductor size : 0.5

03. Conductor resistance : 39 Ω

04. Conductor Insulation : HR PVC Type-C (IS-5831, 1984) 0.6 mm thick

05. Operating Voltage : 650V

06. Twisting : Twin twisted with lay of 60 mm

07. Twisting Direction : All pairs in the same direction. Lapped to form bunch with Mylar tape.

08. Screen (Pair & Overall) : Aluminium Mylar tape with a thickness of 28µm. (min.) for individual pair screen and 60µm. (min.) for overall screen with 100%coverage and 25% overlapped edges. Over the individual pair screening tape two laps of0.05 mm thick (min.) polyester tape shall be applied with minimum overlap of

25%.Metallic side of the screen shall be in contact with drain wire.

- Analog signals- Individual pair & over all shield to be considered.
- Binary signals- overall shield to be considered.

09. Drain wire : Annealed tinned copper wire, stranded. Size 0.5 Sq. mm. (No. of strands / size: - 7 /0.3mm)

10. Inner Sheath : Extruded FRLS PVC (anti-rodent, anti-termite & moisture resistant properties) HR PVC Type ST2 of IS-5831, 1984 Thickness as per IS-1554, Part-I 1976

11. Rip Cord : Nonmetallic under sheath

12. Armouring : GI wire / strip as per IS 3975

13. Outer Sheath : Extruded FRLS PVC (anti-rodent, anti-termite & moisture resistant properties) HR PVC Type ST2 of IS-5831, 1984 Thickness 1.8mm (Min)

14. Filler : Non hygroscopic with FRLS property.

15. Temperature Range : 85 OC

16. Insulation at 20 Deg.C : 100 MΩ/Km [Min]

17. Capacitance at 800 Hz : 120 nf/km

18. Cross talk : 60 dB

19. Attenuation : 1.2 dB/Km

20. Codes & Standards :

a. IPCEA-S-61-402
b. BS 5308
c. IEC 332-1

d. ASTM-B-33
e. IS-8130-1984
f. IS 1554 Part-1
g. IS 10810

21. Sheath color : Inner- Black and Outer- Gray

22. Tests :
    a. Oxygen Index : Min.29 at room temp.(ASTM-D-2863)
    b. Acid Gas Gen. : Max.20% by weight as per IEC 754 Part-I
    c. Temp Index : Min 250 °C at 21Oxy.Ind. (ASTM-D-2863)
    d. Smoke Density Rating : Max.60 %(ASTM-D-2843).
    e. Flammability Test : as per IEC 332Part-I
    f. Swedish Chimney Test-SS-424-1475F3
    g. Insulation Resistance 100 MΩ / Km Min
    h. High voltage test
        Core to core- 2.0 KV for 1 min.
        Core to screen- 2.0 KV for 1 min.
    i. Rodent & Termite repulsion test(Presence of lead shall be confirmed)

23. Color of pair/core for Instrumentation Cable (As per IS-9938)

1st Pair	Blue, Red
2nd Pair	Gray, Yellow
3rd Pair	Green, Brown
4th Pair	White, Black

Above 4 Pairs, 4 Pairs making a unit shall have indelible printed color coded bands like Pink for 1st unit, Orange for 2nd unit and Violet for 3rd unit and soon. In addition band marking, for example single band for 1st. unit, double band for 2nd. Unit and so on, shall be provided on each conductor for identification of unit. Band marking on individual core shall be provided at regular intervals not exceeding 50 mm.

Cables near high temperature zone shall be capable of withstanding high temperature and terminated in junction box / panel in normal temperature zone. Teflon insulated and sheathed thermocouple extension cables and copper conductor cables shall be used in high temperature zone. Conductor and sheath shall be extruded FEP (Teflon)

as per VDE 0207 Part 6 and ASTMD2116. These cables shall be pair, multipair, and twisted & shielded.

1.3 CONTROL CABLES

1100 V grade 85ºC continuous rating under normal condition and 160°Cunder short circuit condition rating HRPVC Control cable (YWY) conforming to following requirement and in line with IS:1554, IS:8130, IS:5831 andIS:3975.

1. Conductor : Stranded, non-compacted & circular, High conductivity annealed plain copper, generally conforming to IS: 8130.

2. Insulation : Extruded HRPVC type-C compound conforming to IS: 5831. The minimum volume resistivity of insulation shall be 1 x 10^{14} ohm-cm at 27^{0}Cand 1 x 10^{11}Ω cm at 85^{0}C.

3. Core Identification : By color coding and numbering at interval of100mm or less

4. Inner sheath : Extruded HRPVC compound conforming to typeST2 FRLS of IS: 5831 for multicore cables. Single core cables shall have no inner sheath. Filler shall be of same material as of inner sheath i.e. ST2.

5. Armour : Galvanized single round steel wire for twin and multicore cables.

6. Overall sheath : Extruded FRLSH HRPVC compound conforming to type ST2 of IS: 5831.

7. Drum : Conforming to IS: 10418 (Wooden drum)

1.4 LV POWER CABLES [1.1KV (XLPE TYPE)]

1100 V grade, 90 °C continuous rating under normal condition and 250°Cunder short circuit condition rating, XLPE heavy duty, power cable conforming to following requirement and in line with IS 7098 Part-I. IS 8130 &IS 5831 and IS 3975.

1. Conductor : Stranded and compacted plain aluminium of grade H2 and class 2 stranded, high conductivity annealed plain copper for cable sizes up to 2.5 mm^2 conforming to IS:8130.
2. Insulation :Extruded cross-linked polyethylene (XLPE) conforming to IS: 7098 (Part-1)
3. Core Identification : By color coding
4. Inner Sheath : Extruded HRPVC FRLS compound conforming to type ST2 of IS: 5831 for multicore cable. Single core cables shall have no inner sheath. Filler shall be of same material as of inner sheath i.e. ST2
5. Armour : Galvanized single round steel wire armour for twin and multicore cables. Non-magnetic hard drawn aluminum single round wire conforming to H4 of IS-8130 latest for single core cables
6. Overall Sheath : Extruded FRLSH HRPVC compound conforming to type ST2 of IS: 5831.
7. Drum : Conforming to IS-10418 (Wooden drum)

1.5 Cable Tray

Pre-fabricated perforated & covered cable trays of average 3 meters length and of minimum dimension 100X35X3 mm shall be used. The tray shall be of minimum100 mm wide, fabricated from not less than 2 mm thick sheet steel and of vertical edge of height not less than 35 mm on both sides. Cable trays shall be hot dip galvanized after fabrication. Minimum value of average mass of zinc coating shall be 460 gm/sq.mt. as per IS: 4759. Supporting galvanized brackets shall be provided at regular intervals for fixing the trays.

1. Material : Mild steel, slotted
2. Thickness : not less than 2.0 mm
3. Finish : Hot dip galvanized
4. Perforation : As per MFR standard
5. Cover : Suitable for tray

1.6 Cable Gland

1. Type : Double compression
2. Entry Thread : NPT / ET
3. Material : Brass
4. Finish : Cadmium / Nickel Plated.
5. Protection : IP 54 or better
6. Accessories : Neoprene gasket, locknuts, reducers etc.

ANNEXURE-W

1.0 LOCAL CONTROL PANELS/CABINETS

1.0.01 Local Control panels (PLC/Relay based) shall be as specified below.

1.0.02 The cabinet mounted equipment's shall be fully assembled, installed in mounting racks, wired and fully tested as per specification requirements and Owner approved drawings prior to shipment to the project site.

1.0.03 The vendor shall ensure that the cabinets are complete & ready for installation before dispatch from manufacturing works. The installation work at project site for these cabinets shall only involve connections through multi-pair cables from marshalling cabinets (wherever provided) to system cabinets and inter cabinet/cabinet to Control Desk/ Back up Panel.

1.0.04 All electronic cards, network components, power supply modules etc. located shall be suitably housed in cabinets and shall be neatly arranged in sub-racks. Network components shall be visible in door closed condition (e.g. Glass doors etc.) as approved by Purchaser.

1.0.05 Vendor shall design the cabinet internal arrangement and cable gland plate such that all the cables entering or leaving the cabinet can be properly glanded in the gland plate.

1.0.06 The packaging density of panels shall be such that the temperature rise within the panels shall never exceed 10°C above ambient even under worst operating conditions. Cooling Fans shall be provided wherever required and this shall be of industrial grade.

1.1 TECHNICAL PARTICULARS

1. Material of Construction : Cold Rolled Coal Annealed (CRCA) steel sheet

2. Thickness of Sheet :
   a. 2.0 mm for faces supporting instruments / terminals
   b. 1.6 mm for other sides and top

3. Construction : Welded throughout as per approved National Standards

4. Post welding operation :
   a. Grounding of all welds to smoothness
   b. Rounding of corners

5. Panel height : 2300 mm (approx)

6. Corners : 7 mm inner radius

7. Dimensional Tolerances :
   a. In height & length - 3 mm
   b. In height between adjacent sections - 2 mm
   c. Total for a group - 6 mm

8. Doors : Double, recessed, turned back edges, full height front & rear
   a. Thickness of Sheet : 2 mm
   b. Hinges : Stainless steel
   c. Door latches : Three point type
   d. Door gaskets :Neoprene rubber on fixed frame to result dust
   e. Proof/weatherproof enclosure
   f. Opening of the doors : Outward
   g. Louvers : With removable wire mesh to ensure dust and vermin proof

9. Gland plates : Removable in sections - 4 mm thick (bottom)

10. Cable entry : Bottom

11. Hardware :
   a. Anti-vibration pad- 15 mm
   b. Predrilled base channel ISMC –100 or equivalent for all sides
   c. Stainless steel buff- finished 2 mm thick kick plate for all sides
   d. Stainless steel scratch strips along desk edges fixed with pan-head recessed screws
   e. Rubber strips to ensure air tightness between kick plate and finished floor
   f. Lifting hook / Eye bolt
   g. Drawing pocket
   h. Door switch, lamps, thermostat, heaters and industrial grade cooling fans, illumination fixtures.

12. Name Plate : Both at front and back surface of the panel

13. Fixing of name plate : Stainless steel pan head screws

14. Name plate material : Laminated phenolic (3 layers)

15. Lettering : Black with white engraved

16. Mounting of terminal blocks : Vertical angle support bracket tack welded on sheet steel plate, screwed on internal wall of enclosure

1.2 LOCAL INSTRUMENT RACK (LIR) / LOCAL INSTRUMENT ENCLOSURE(LIE)

1.2.01 Devices (Transmitters/ Switches) located in the field shall be suitably grouped together to the extent possible and installed in the LIE (Closed Rack).

1.2.02 Enclosure shall be factory prefabricated & painted and shall complete with internal piping, tubing, manifold, isolation valves, blow down valves, integral junction box, illumination etc. No more than six instruments shall be grouped in a single rack / enclosure.

1.2.03 Enclosures shall be installed above the tapping points for air, flue gas and coal air mixture application whereas for applications such as for water and steam, racks to be installed below the source point.

1.2.04 Attention shall be paid in the layout to avoid air traps in liquid piping and water accumulation in air /gas piping.

1.2.05 Enclosures used for furnace, flue gas and air application shall be provided with intermittent & continuous air purging.

1.2.06 Welding of impulse lines shall comply with the provisions of the latest applicable ANSI Code for Pressure Piping. Earth stud shall be furnished at rack for safety grounding.

1.3 LOCAL INSTRUMENT ENCLOSURE (LIE)

1.3.01 Enclosure shall be free standing type. Racks shall be adequately reinforced to ensure true surfaces and to provide support. Major load - bearing posts shall be suitably supported by gusset plates or moment members.

1.3.02 Enclosure outer shall be constructed from at least 3 mm thick steel plate and epoxy painted to shade gray. Base frame shall be made of ISMC- 100 and black colour finish.

1.3.03 2" NB galvanized pipes shall be laid horizontally and supported at two end channels to mount transmitters at accessible height. Center posts or any member, which would reduce access, shall be avoided.

1.3.04 Double leaf interlocking front opening doors with three point locking shall be provided and shall be arranged for maximum possible access to the interior. Key shall be of identical for all enclosures.

1.3.05 Doors shall have concealed quick removal type pinned stainless steel hinges and locking handles. Gaskets shall be used between all mating sections to achieve dust and

weather proof enclosure rated for IP-65 including the internal junction box. All enclosures shall have access doors on front side.

1.3.06 Removable type bulkhead plates of thickness not less than 6 mm shall be mounted at the racks with suitable high temperature gasket. Impulse lines within the enclosures shall be properly clamped.

1.3.07 All internal wirings between the instruments and junction box shall run through flexible conduits. No exposed wirings within transmitter racks both open and closed type, is admissible.

1.3.08 Racks shall have a common blow down drain header, which will connect individual instrument blow down line after suitable pressure breaking through regulating globe type blow down valves. Covered funnels shall be used for saturated liquid and steam service, whereas, open funnels may be used for cold liquid services. Header (2" NB ASTM A 106, Sch-80 Gr. C) shall be suitably sloped and shall have one end flanged and extending beyond the rack for connection to plant drain header.

1.3.09 Each rack shall be provided with one receptacle, light fixtures with wire guard and one lighting switch each at instrument & Junction box compartments with wire guard. Lighting switches may be door actuated & mounted inside the panel. Outlet box, switch box and device covers shall be of galvanized stamped steel. Light switches and receptacles shall be installed inside the enclosure on the wall near the latch side of the enclosure door. Light fixtures shall be installed on the ceilings of the enclosures.

1.3.10 Power supplies for miscellaneous devices shall be provided with MCB located within the enclosures. MCB shall be mounted in fuse blocks. Name plates shall be furnished above the MCB blocks, identifying the devices being served.

1.3.11 Vibration dampeners shall be installed for supporting each enclosure. The loading at each corner of the enclosure shall be determined by actual test weighting when construction is complete to determine the correct length of each dampener for proper loading of the dampener in accordance with manufacturer's recommendations.

2.0 JUNCTION BOX

1. Type of Enclosure : Dust tight & weatherproof conforming to IP 65

2. Material : 3 mm fiberglass reinforced polyester (UV stabilized)

3. Type of Cover : Solid unhinged with retention chain /Screwed at all four corners

4. Paint :
   a. Exterior : Opaline green shade 275 of IS: 5

b. Interior - Brilliant Glossy White. Surface / Two (2) inch Pipe stanchion

5. Mounting : (At a dry compartment at one side of the enclosure / rack with front opening type door)

6. Cable Entry : 3 mm (min) Bottom / side Gland plate

7. Gasket : Neoprene

8. Grounding : Brass earth lug with green screw headExternal-2 nos, Internal-1no. (M6)

9. Number of Drain Holes : Two at bottom capped

10. Identification : Label for JB and Tags for cable

11. Accessories :

a. Rail mounted cage clamp types crew less terminals (suitable for conductor size up to 2.5sq.mm of suitable voltage grade) with markers and 20% spare terminals.
b. Cable gland (Brass) & raceways.
c. Ferrules & lugs (Brass).
d. Aluminum back panel.
e. Canopy at top.
f. Mounting brackets.
g. Bolts and nuts made of brass etc.

3.0 ERECTION MATERIALS

3.0.01 General Technical Requirements

This section provides the general technical guidelines for the erection materials for instruments. All erection materials shall be of good quality and conform to the operating environment of the corresponding instrument. However, any item required for erection of vendor supplied system but not categorically indicated in this section, shall be supplied by the vendor and all these items shall conform to International / National standards / codes.

3.0.02 Process Hook Up Accessories & specification

Material and rating of the hook up items shall suit the piping and fluid condition. Hook up materials shall be IBR certified for applicable cases. Vendor shall furnish hook up drawings and the drawings for open racks &closed racks for purchaser's approval.

I. Seamless Stainless Steel Pipe

a. Reference : ASTM A-312 TP 316
b. Material Grade : TP 316

c. Type : Seamless /Plain end
d. Size : As applicable (e.g.½" NB etc.)
e. Schedule : 40
f. Standard Length : 5 meter

II. Stainless Steel Pipe Fittings

a. Reference : ASTM A-182 F 316 / ANSI B16.11
b. Type : Forged
c. Rating : 3000 lbs / 6000 lbs / 9000 lbs
d. Size : To suit related SS pipe.
e. End connection : Generally socket weld
f. Type of Fittings : Reducing coupling, male-female reducer, straight coupling, equal tee, three piece union, elbow, cap etc.

III. Seamless Stainless Steel Tube

a. Reference : ASTM A-213 , ASTM A-249 or ASTM A-269
b. Material Grade : TP 316
c. Size : As applicable (e.g.½" OD X 0.083" wall thickness / ¼" OD X 0.049" wall thickness etc.)
d. Type : Cold drawn annealed, pickled, passivated, descaled, Hydraulically cleaned seamless tube.
e. Properties : The tube shall be free from scratches and suitable for Bending and capable of being flared by hardened and tapered steel pin. The expanded tube shall show no crack or rupture. Hardness shall be RB 80.
f. Test Pressure : 400 Kg/Sq. cm (minimum)
g. Tolerance thickness : ± 0.13 mm for outside diameter ± 15 % for wall
h. Standard Length : 5 meter
i. Test : Flare, Hardness, Ball and Bubble Test

IV. Stainless Steel Tube Fittings

a. Reference : ASTM-A-182
b. Type : Double ferrule double compression
c. Material : 316 Stainless steel forged
d. Ferrule : 316 Stainless Steel
e. Type of Fittings : Male / female connector, elbow, cross /equal tee, straight connector, bulkhead union, ferrule etc. as required to suit installation.
f. Size : To suit SS tubing and NPT end connection

V. CS Pipe

a. Reference : ASTM-A 106 Gr. C
b. Material : Cold drawn seamless black C.S.
c. Type : Seamless / Plain ends
d. Size : As applicable (e.g. ½" NB etc.)
e. Schedule : 80, 160, XXS as required

f. Standard Length : 5 meter

VI. CS Pipe Fittings

a. Reference : ASTM-A 105 / ANSI B16.11
b. Type : Forged
c. Rating : 3000 lbs / 6000 lbs / 9000 lbs
d. Size : Suitable to related C.S.Pipe
e. End connection : Generally socket weld
f. Type of Fittings :Reducing coupling, male-female reducer, straight coupling, equal tee, three piece union, elbow, cap etc.

VII. AS Pipe

a. Reference : ASTM-A 335 P22 AS PER ANSI B 36.10
b. Material : Cold drawn seamless A.S.
c. Type : Seamless / Plain ends
d. Size : As applicable (e.g. ½" NB etc.)
e. Schedule : XXS
f. Standard Length : 5 meter

VIII. AS Pipe Fittings

a. Reference : ASTM-A 182 F22 AS PER ANSI B 16.11
b. Type : Forged
c. Rating : 9000 lbs
d. Size : Suitable to related ASPipe
e. End connection : Generally socket weld
f. Type of Fittings : Reducing coupling, male-female reducer, straight coupling, equal tee, three piece union, elbow, cap etc.

IX. GIPipe

a. Reference : IS-1239, Part-I
b. Type : Medium grade, threaded at both ends protected with end caps
c. Material : Continuous ERW galvanized MS pipe
d. General : Pipe shall be galvanized both inside and outside
e. Size : As applicable (e.g. 1/2"/3/4"/1" etc.)

X. GIPipe Fittings

a. Reference : IS-1239, Part-II for material, dimension, thread etc.
b. Style : Threaded
c. Type of Fittings : Equal tee, three piece union, unequal tee, straight socket, 90 Deg. elbow, reducing socket cap. Etc. to suit installation.
d. Size : Suitable to related GIPipe.

XI. Carbon Steel Globe Valve

a. Reference : ASTM A-105
b. Type : Globe

c. Construction : Forged Body Cadmium Plated
d. End Connection : As applicable (e.g. ½" Socket Weld etc.)
e. Rating : Cl. 800 / CL. 2500
f. Material :
- Body - Carbon steel
- Stem - Hardened Steel
- Plug - AISI 316 SS
- Seat- Stainless steel stellited

g. Packing : Teflon / Grafoil as required
h. Yoke : ASTM A105
i. Hand wheel : Carbon steel
j. Design standard : As per ANSI B 16.34

XII. Stainless Steel Globe Valve

a. Reference : ASTM A-182 F316
b. Type : Globe
c. Construction : Forged Body
d. End Connection : As applicable (e.g. ½" Socket Weld etc.)
e. Proof Pressure : 400 Kg/Cm2
f. Material :
- Body - Stainless steel
- Stem - Hardened Steel
- Plug - AISI 316 SS
- Seat- Stainless steel stellited

g. Packing : Teflon as required
h. Yoke : ASTM A182 F316
i. Hand wheel : Carbon steel
j. Design standard : As per ANSI B 16.34

XIII. Alloy Steel Globe Valve

a. Reference : ASTM A-182 F22
b. Type : Globe
c. Construction : Forged Body
d. End Connection : As applicable (e.g. ½" Socket Weld etc.)
e. Rating : CL. 2500
f. Material :
- Body - Alloy steel
- Stem - Hardened Steel
- Plug - AISI 316 SS
- Seat- Stainless steel stellited

g. Packing : Grafoil as required
h. Yoke : ASTM A182 F22
i. Hand wheel : Carbon steel
j. Design standard : As per ANSI B 16.34

XIV. Instrument Valve Manifold

a. Type :
   - Two valve manifold
   - Five valve manifold

b. Mounting : Remote 2” Pipe Mounting / Transmitter Rack
c. Construction : Single block (bar stock)
d. Material : Forged body and bonnet AISI 316 stainless steel
e. Ports : Manufacturer’s standard(e.g. 1/2 " NPT (F) etc.)
f. Rating : 420 Kg/Sq. cm at ambient
g. Operating temperature : (-)30 to (+)170 Deg C
h. Packing : PTFE Wafer
i. Seat & Stem : AISI 316 SS
j. Plug : AISI 316 SS free to turn on stem / 17-4 PH
k. Handle Bar : AISI 316 SS
l. Connection : Straight
m. Accessories : Plugs for all ports, Mounting Bracket , bolts ,nuts

C&I Inputs for Selection of Mechanical Equipments

(I) SOLENOID VALVES

1. Coil voltage rating: 240 V AC /24 V DC
2. Type: Single coil (Fail-safe design)

(II) All Control valves to be provided with SMART positioner as per the requirements indicated in the Annexure R

Data Sheets

PERFORMANCE DATA - SCR REACTOR			
S.No	**Description**	**Unit**	**Data to be filled**
1.1	General		
1	Unit load range for NOx guarantee		
2	De-NOx efficiency with newly installed catalyst	(%)	
3	De-NOx efficiency at the end of catalyst life	(%)	
4	Activity of newly installed catalyst		
5	Catalyst Activity at the end of catalyst life		
6	Catalyst Pluggage at the end of catalyst life	(%)	
7	Loss of catalyst material at the end of catalyst life	(%)	
1.2	**Temperature (deg. C)**		
1	Gas temperature at SCR reactor inlet	deg. C	
2	Gas temperature at SCR reactor outlet	deg. C	
3	Temperature of ash collected in SCR reactor ash hopper (if applicable)	deg. C	
4	Temperature of ash collected in duct ash hopper (if applicable)	deg. C	
5	Temperature of ammonia-air mixture at ammonia injection grid inlet	deg. C	
6	Maximum catalyst heating up rate (deg C/min)	deg. C	
7	Maximum catalyst cooling down rate (deg C/min)	deg. C	
8	Minimum flue gas temperature for continuous SCR operation with ammonia injection	deg. C	
1.3	**Pressure (mmwc)**		
1	Gas pressure at SCR reactor inlet	mmwc	
2	Gas pressure at SCR reactor outlet	mmwc	
1.4	**Differential pressure (mmwc)**		
1	Gas pressure drop across SCR reactor with new catalyst	mmwc	
2	Gas pressure drop across SCR reactor at end of catalyst life	mmwc	
3	Gas pressure drop from economizer outlet to APH inlet with new catalyst	mmwc	
4	Gas pressure drop from economizer outlet to APH inlet at end of catalyst life	mmwc	

1.5	**Flow rate (Nm3/s)**		
	Gas flow rate at SCR reactor inlet	Nm3/s	
	Gas flow rate at SCR outlet	Nm3/s	
1.6	**Flue gas constituents**		
1	NOx concentration at SCR reactor outlet	mg/Nm3 @ 6% O2 dry basis	
2	Ammonia Slip at reactor outlet with new catalyst	ppm	
3	Ammonia Slip (ppm) at reactor outlet at end of catalyst life	ppm	
4	SO2 to SO3 conversion rate in SCR with new catalyst (%)	%	
5	SO2 to SO3 conversion rate in SCR at end of catalyst life(%)	%	
6	Molar ratio NH3/NOx at reactor inlet		
7	NH3/Air ratio at Ammonia Injection grid inlet		
8	Conversion of elemental mercury to oxidized mercury (%) (if measured	%	
1.7	**Velocity (m/s)**		
1	Gas velocity in SCR reactor inlet duct	m/s	
2	Gas velocity through SCR reactor	m/s	
3	Gas velocity in SCR reactor outlet duct	m/s	
1.8	**Supplementary Data for SCR System**		
1	Water requirement i) DM water ii) Service Water iii) Potable water		
2	Service air		
3	Instrument air		
4	Super-heated steam		
5	Number and electrical rating of AC power supply feeders for each control instrumentation system in Bidder's scope		
6	Schedule of power consumption		

PERFORMANCE DATA - AMMONIA SYSTEM

S.No	Description	Unit	100% TMCR Design Coal	BMCR Design Coal	HP Out Design Coal	60 TMCR Design Coal	BMCR Worst Coal	TMCR Worst Coal
	Ammonia Handling System							
1.1	**Temperature (deg. C)**	deg. C						
1	Ammonia forwarding pump suction temperature at minimum ambient temperature	deg. C						
2	Ammonia forwarding pump discharge temperature at minimum ambient temperature	deg. C						
3	Temperature of ammonia at vapouriser inlet	deg. C						
4	Temperature of ammonia at vapouriser outlet	deg. C						
5	Temperature of steam to ammonia vapouriser	deg. C						
6	Temperature of ammonia at air-ammonia mixer inlet	deg. C						
7	Temperature of dilution air at air-ammonia mixer inlet	deg. C						
1.2	**Pressure (mmwc)**							
1	Ammonia storage tank pressure at minimum ambient temperature	mmwc						
2	Ammonia forwarding pump suction pressure at minimum ambient temperature	mmwc						
3	Ammonia forwarding pump discharge pressure at minimum ambient temperature	mmwc						
4	Pressure of ammonia at vapouriser inlet	mmwc						
5	Pressure of ammonia at vapouriser outlet	mmwc						
6	Pressure of ammonia at air-ammonia mixer inlet	mmwc						
7	Pressure of dilution air at air-ammonia mixer inlet	mmwc						
8	Pressure of ammonia-air mixture at ammonia injection grid inlet	mmwc						
9	Ammonia pressure drop from vapouriser outlet to air-ammonia mixer inlet	mmwc						
1.3	**Flow rate (Kg/hr)**							
1	Ammonia flow rate at vapouriser outlet	Kg/hr						
2	Ammonia flow rate at air-ammonia mixer inlet with new catalyst	Kg/hr						
3	Ammonia flow rate at air-ammonia mixer inlet at end of catalyst life	Kg/hr						
4	Dilution air flow rate at air-ammonia mixer inlet	Kg/hr						
5	Ammonia-air flow rate through ammonia injection grid	Kg/hr						
1.4	**Ammonia Piping**							
1	Pipe size							
2	Material							
3	Length							
1.5	**Foundation details of Ammonia tanks**							

EQUIPMENT DETAILS FOR SELECTIVE CATALYTIC REDUCTION

S.No	Description	Unit	Data to be filled
1.1	**General**		
1	Manufacturer of SCR System		
2	Manufacturer's model number		
3	No. of SCR reactors per steam generator		
4	Capacity of each SCR reactor (% of BMCR FG flow)		
5	Reactor Width (m)	m	
6	Reactor depth (m)	m	
7	Reactor height (m)	m	
8	Total no. of catalyst layers / reactor		
9	No. of catalyst layers / reactor in service		
10	Height between two adjacent catalyst support levels (m)	m	
11	Height between top edge of catalyst module and bottom edge of the immediately upper catalyst support level (m)	m	
12	Number of catalyst modules and elements per module for each layer		
13	Catalyst pluggage considered for catalyst volume determination		
14	Total Catalyst volume per reactor (m3)	m3	
15	Catalyst volume per reactor per layer (m3)	m3	
16	Total Catalyst surface area per reactor (m2)	m2	
17	Catalyst weight per layer / per reactor (MT)	MT	
18	Percentage of Catalyst pluggage (filled with ash) considered for support structure design (MT)	MT	
19	Space Velocity (m3/s/m3)	m3/s/m3	
20	Area Velocity (m3/s/m2)	m3/s/m2	
21	Type of Static mixer for ammonia and flue gas mixing		
22	No. of nozzles in ammonia Injection Grid		
23	Type and material of nozzle		
24	No. of catalyst de-dusting levels/reactor		
25	Type and number of catalyst de-dusting devices/layer/reactor		
26	Medium and its consumption rate for catalyst de-dusting		
27	Guaranteed power consumption of SCR system for one steam Generator at the guarantee point (KW)	KW	
28	Capacity of Economiser bypass system (if in Vendor scope)		
29	Capacity of SCR bypass system (if in Vendor scope)		
30	Proposed standard for conducting the performance tests		
31	Type of catalyst handling device		
32	Capacity of catalyst handling device (MT)	MT	
1.2	**SCR reactor casing**		
1	Material		
2	Casing wall thickness (mm)	mm	
3	Design pressure (mmwc) (+ve & -ve)	mmwc	
4	Design temperature (deg C)	deg C	
5	Max. pressure withstand capacity		
6	Max. temperature withstand capacity and duration		
7	No. of catalyst support levels		
8	Maximum load bearing capacity of each catalyst support layer(MT)	MT	
9	Number of inspection doors/layer		
10	Dimensions of access openings of inspection doors (mm x mm)	mm xmm	
1.3	**Catalyst**		
1	Supplier name		
2	Type of catalyst		
3	Catalyst material chemical composition		
4	Dimension of each catalyst module and element (L x W x H) (mm)	mm	
5	No. of catalyst element per module		
6	No. of plates in each element box for plate type catalyst		
7	No. of catalyst sub-layer per module		
8	Catalyst pitch (mm)	mm	
9	Catalyst plate thickness (mm)	mm	
10	Catalyst Substrate material		
11	Substrate thickness (mm)	mm	
12	Catalyst plate dimension for plate type catalyst (HXW) (mm)	mm	
13	Catalyst Porosity (%)	%	
14	Specific surface area (m2/m3)	m2/m3	
15	Specific Weight (Kg/m3)	Kg/m3	
16	Whether module contains a removable sample element		
17	Maximum Continuous Operating Temperature (deg C)	deg C	
18	Minimum Continuous Operating Temperature (deg C)	deg C	

19	Heating up rate (max.)(oC/min)	oC/min	
20	Cooling down rate (max.)(oC/min)	oC/min	
21	Type of catalyst erosion protection (if applicable)		
22	Minimum chemical life (months)	months	
23	Minimum mechanical life (months)	months	
24	Total Number of sample catalyst for two Reactor		
25	Space velocity (m3/h/m3)	m3/h/m3	
26	Area velocity (m3/h/m2)	m3/h/m2	
27	Physical properties of Catalyst		
	Geometry		
	Pitch		
	Plate thickness		
	Compressive Strength		
	Bend Strength		
	Bond Strength		
	Abrasion Resistance		
	Surface Area (m2/m3)	m2/m3	
	Pore Volume (m2/g)	m2/g	
1.4	**Ammonia Injection Grid**		
1	Type of Ammonia Injection grid		
2	Control of ammonia Injection (Zonal / overall)		
3	No. of nozzles		
4	Material of the nozzle		
5	Material of the ammonia pipes/manifold		
6	Nozzle size (mm)	mm	
7	Nozzle pitch (mm)	mm	
8	Nozzle spray direction		
9	Velocity at nozzle outlet (m/s)	m/s	
10	Size and weight of pipe frames (diameter and schedule) Vertical frames and Cross frames		
11	Drawing reference No		
1.5	**Catalyst De-dusting System**		
1	Type Sonic Horn/ Air Cannon/Soot Blower		
2	Manufacturer		
3	Location (Outdoor)		
4	Cleaning medium		
5	Parameters of cleaning medium		
	Pressure	(Kg/cm2) (abs)	
	Temperature (deg.C)	deg C	
	Flow rate (m3/s)	m3/s	
6	Source of cleaning medium		
7	De-dusting Frequency per day		
8	Number of De-dusting device/layer		
9	Total time required for one complete cycle of De-dusting operation (min)	min	
10	Depth of penetration (mm)	mm	
11	Cleaning radius/angle		
12	Effective area cleaned by one De-dusting device (m2)	m2	
13	Reduction in flue gas pressure drop across SCR reactor after each de-dusting cycle (mmwc)	mmwc	

1.6	**For Sonic Horn(if applicable)**		
1	Horn Material		
2	Diaphragm Material		
3	Diaphragm Life (yrs)	years	
4	Output power level (dB) and frequency (Hz)	Hz	
5	Maximum operating temperature (oC)	deg C	
6	Weight of each sonic horn (Kg)	kg	
1.7	**For Air Cannon(if applicable)**		
1	Nozzle Material		
2	Compressed air storage tank Material		
3	No. of ports		
4	No. of compressed air storage tanks/layer		
5	Capacity of each compressed air storage tank (Nm3)	Nm3	
1.8	**For Soot Blower**		
1	Type of Electric Drive Dual/Single Electric Drive		
2	Material		
	Lance / Swivel tube		
	Nozzle		
3	Motor rating (kW)	KW	
4	Location drawing of De-dusting devices		
5	Description of panels & system equipment offered		
6	Reference drawing Nos.		
1.8	**Dilution Air System**		
1.8	**Dilution Air Fan**		
1	Manufacturer		
2	Type Dual/Single Electric Drive		
3	Number and configuration of dilution air fan per steam generator		
4	Capacity Max Flow (m3/sec)Head (mmwc) Associated temp. (deg C) Density (Kg/m3)		
5	Source of air supply		
6	Max speed of fan (rpm)	rpm	
7	Fan efficiency at 100% TMCR	%	
8	Auxiliary power consumption at 100% TMCR (kW)	KW	
9	Overall dimensions		
10	Motor rating (KW)	KW	
11	Total weight of fan and motor (tonnes)	tonnes	
12	Method of lubrication		
	For fans		
	For motors		
13	Mode of air flow control adjustment		
14	Impeller diameter (mm)	mm	
15	Shaft diameter (mm)	mm	
16	Material of construction		
	Casing		
	Impeller blades		
	Shaft		
1.9	**Dilution Air Heater (if applicable)**		
1	Manufacturer		
2	Type		
3	Number and configuration per steam generator		
4	Auxiliary power consumption at 100% TMCR (kW)	KW	
5	Heater rating (KW)	KW	
6	Voltage level (V)	V	
7	Estimated life of heating element (years)	years	
1.10	**Ash Hoppers**		
	For SCR Reactor (if applicable)		
1	No. per SCR reactor		
2	Material		
3	Plate thickness (mm)	mm	
4	Side angle	degrees	
5	Valley angle	degrees	
6	Storage capacity of each hopper (hours)	hours	
7	Volumetric storage capacity of each hopper (m3)	m3	
8	No. of access doors per hopper		
9	Access door dimensions (mm x mm)	mmxmm	
10	Hopper dust level detectors		
	a) Number per hopper		
	b) Type		
11	Ash collection rate (Kg/hr)	kg/hr	

1.11	**Ammonia Unloading, Storage and Forwarding System**		
1	Name of overall system designer		
2	Design codes and standard		
1.12	**Truck Tank Unloading Station**		
1	Manufacturer		
2	Type of connections		
3	Hose Material		
1.13	**Ammonia storage Tank**		
1	Type of Ammonia storage tanks Horizontal		
2	No. and configuration of ammonia storage tanks		
3	Design code		
4	Storage capacity (days)	days	
5	Operating pressure	(Kg/cm2) (abs)	
6	Design pressure (Kg/cm2) (abs) (+ve & -ve) vii) Operating Temperature (deg. C)	deg C	
7	Design Temperature (deg. C)	deg C	
8	Tank Volume (m3)	deg C	
9	Maximum storage volume (m3)	m3	
10	Vapour space in tank (%)	%	
11	Hydraulic test pressure (if required)	(Kg/cm2) (abs)	
12	Shell thickness (mm)	mm	
13	Corrosion allowance		
14	Tank diameter (mm)	mm	
15	Tank length (mm)	mm	
16	Weight when empty (Kg)	kg	
17	Material		
	Shell and head		
	Nozzle necks		
	Nozzle flanges		
	Manhole nozzle		
	Manhole flange		
	Supports and structural attachments		
18	Reference drawing Nos		

1.14	**Ammonia Unloading Compressor**		
1	Manufacturer		
2	Type		
3	No. and configuration		
4	No. of stages		
5	No. of cylinders		
6	Cylinder bore (mm)	mm	
7	Stroke (mm)	mm	
8	Rated Capacity (Nm3/s)	Nm3/s	
9	Design temperature (oC)	deg C	
10	Design pressure	(Kg/cm2) (abs)	
11	Maximum Discharge pressure	(Kg/cm2) (abs)	
12	Maximum Compression ratio		
13	Speed of the compressor (rpm)	rpm	
14	Efficiency (%)	%	
15	Motor rating and speed	(KW, rpm)	
16	Construction features		
	Built in relief valve Yes/No	Yes/No	
	Relief valve set pressure adjustable Yes/No	Yes/No	
	Common base plate for compressor & motor Yes/No	Yes/No	
17	Material of construction		
	Cylinder		
	Piston		
	Piston Rod		
	Crank Shaft		
	Connecting rod		
	Bearing		
18	Noise Level (dB)	dB	
19	Dimension (LxWxH)(mm)	mm	
20	Reference drawing Nos.		
21	Codes and Standards applicable		
1.15	**Ammonia Forwarding Pump (if applicable)**		
1	Manufacturer		
2	Type		
3	No. and configuration		
4	No. of stages		
5	Rated Capacity (M3/hr)	m3/hr	
6	Design temperature (oC)	deg C	
7	Design pressure	(Kg/cm2) (abs)	
8	Minimum temperature ammonia pump can handle (oC)	deg C	
9	Specific gravity of ammonia at above temperature		
10	Maximum Discharge pressure	(Kg/cm2) (abs)	
11	Maximum differential pressure between suction and discharge pump can handle	(Kg/cm2) (abs)	
12	Speed of the pump (rpm)	rpm	
13	Efficiency (%)	%	
14	Maximum entrained vapour pump can handle (%)	%	
15	Motor rating and speed (kw, rpm)	kw, rpm	
16	Minimum allowable suction pressure (mmwc)	mmwc	
17	Construction features		
	Built in relief valve Yes/No	Yes/No	
	Relief valve set pressure adjustable Yes/No	Yes/No	
	Magnetic coupling drive Yes/No	Yes/No	
	Common base plate for pump & motor Yes/No	Yes/No	
18	Material of construction		
	Casing		
	Rotor		
	Shaft		
	Shaft sleeves		
	Base plate		
	Wearing rings (if required)		
	Bearing		
19	Dimension (LxWxH)(mm)	mm	
20	Reference drawing Nos.		
21	Codes and Standards applicable		

1.16	**Ammonia Vaporization system**		
1	Manufacturer		
2	Type		
3	No. and configuration		
4	Steam source		
1.17	**Ammonia Accumulator**		
1	Number		
2	Type of accumulator Cylindrical & Vertical		
3	Net capacity of each accumulator (m3)	m3	
4	Design temperature (oC)	deg C	
5	Design pressure (Kg/cm2) (abs)	abs	
6	Inner diameter of accumulator (mm)	mm	
7	Height of accumulator (mm)	mm	
8	Corrosion Allowance (mm)	mm	
9	Material/Thickness(mm)		
	Shell		
	Head		
	Nozzle		
	Codes and Standards applicable		
1.18	**Waste Ammonia Dilution Tank**		
1	No. and configuration		
2	Storage Capacity of each tank (m3)		
3	Diameter of each tank (m)	m3	
4	Height of each tank (m)	m	
5	Maximum storage volume (m3)	m	
6	Tank Material/Thickness(mm)	m3	
	a) Side Wall	mm	
	b) Bottom	mm	
	c) Roof	mm	
7	Design Pressure (Pa) / Temperature (oC)	deg C	
8	Codes and Standards applicable		
1.19	**Waste Water Collection System**		
1	Dimension of dyked area		
2	Storage capacity of dyked area (m3)	m3	
3	No. of waste water retaining basin		
4	Storage capacity of retaining basin (m3)	m3	
5	Dyke and retaining basin material		
6	No. and configuration of waste water disposal pump		
7	Design capacity of waste water disposal pump (m3/s)	m3/s	
8	Design pressure of waste water disposal pump (bar)	bar	
9	Design pressure of waste water disposal pump (oC)	deg C	
10	Pump material		
1.20	**Water Spray Devices**		
1	Location		
2	Type of spray device		
3	Material of nozzle		
4	Spray Water flow rate (m3/s)	m3/s	
5	Spray Water pressure (bar)	bar	

1.21	**Chemical dosing system for waste ammonia neutralization**		
1	Type of chemical for dosing		
2	Pump capacity		
1.22	**POWER CONSUMPTION (kW) FOR SCR SYSTEM OF ONE BOILER Normal Maximum**		
1	Ammonia unloading compressor	KW	
2	Ammonia forwarding pump (if applicable)	KW	
3	Ammonia vaporizer	KW	
4	Dilution air fan	KW	
5	Dilution air heater (if applicable)	KW	
6	Any other load	KW	
7	**Total**	KW	
1.23	**Thermal Insulation**		
1	Type of insulating material (s)		
2	Manufacturer's name		
3	Maximum hot face temp. (deg. C) the insulating material can withstand	deg C	
4	Bulk Density of insulating material (Kg./m3)	Kg./m3	
5	Area to be insulated and insulation thickness		
	SCR reactor Casing		
	SCR inlet duct		
	SCR outlet duct		
	SCR bypass duct		
	Economiser bypass duct		
6	Ash hopper		
	SCR Reactor (if applicable)		
	Duct (if applicable)		
7	Ammonia pipelines		
8	Ammonia Vapouriser		
9	Any other		
10	Total		
11	Insulation material standard		
1.24	**EQUIPMENT WEIGHT (TOTAL)**		
1	Structural Steel	ton	
2	SCR reactor including catalyst	ton	
3	SCR inlet duct including Ammonia injection grid, static mixer, Guide vanes, flow splitters etc	ton	
4	SCR outlet duct	ton	
5	SCR bypass duct	ton	
6	Economiser bypass duct(if in Vendor scope)	ton	
7	Platforms, Walkways stairways	ton	
8	Insulation and cladding	ton	
9	Control and Instrumentation	ton	
10	Others	ton	
11	Total estimated weight (Per Steam Generator)	ton	
	Excluding dust	ton	
	Including dust	ton	

GENERAL TECHNICAL INFORMATION / DRAWINGS FOR SELECTIVE CATALYTIC REDUCTION SYSTEM

(After Award of the Contract)

1.1	**Characteristic/Correction Curves for SCR System**
1	Gas flow rate vs DeNOx efficiency
2	Gas temperature vs DeNOx efficiency
3	Inlet NOx concentration vs DeNOx efficiency
4	Catalyst deactivation (Relative activity& Ammonia slip V/s operating time
5	Gas flow rate vs pressure drop across SCR reactor
6	Pressure drop vs Aux Power Consumption (KW)
7	Combined effect of gas flow rate and NOx concentration vs Ammonia consumption
8	Gas velocity vs catalyst life
9	Gas inlet dust concentration vs catalyst life
10	Nox/ ammonia molar ratio V/s outlet Nox concentration
11	Ammonia slip & SO3 concentration Vs Ammonium bi-sulphate formation Temperature
12	Ammonia slip & SO3 concentration Vs Ammonium bi-sulphate formation rate