



**NLC INDIA LIMITED
NLC TALABIRA THERMAL
POWER PROJECT- 3x800 MW
JHARSUGUDA, ODISHA**

**BIDDING DOCUMENT
FOR
SINGLE PACKAGE ENGINEERING, PROCUREMENT &
CONSTRUCTION**

SPECIFICATION NO : 18A03-SPC-G-001

SECTION-B

VOLUME: II-B

**TECHNICAL SPECIFICATIONS
FOR
STEAM GENERATOR AND AUXILIARIES**



**DEVELOPMENT CONSULTANTS PRIVATE LIMITED
CONSULTING ENGINEERS
BLOCK DG-4, SECTOR-II, SALT LAKE CITY
KOLKATA- 700 091, INDIA**

November, 2020

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DATED : NOVEMBER, 2020**

**NLC INDIA LIMITED
NLC TALABIRA THERMAL
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JHARSUGUDA, ODISHA****TENDER SPECIFICATION**

PACKAGE NAME : SINGLE PACKAGE ENGINEERING,
PROCUREMENT AND CONSTRUCTION

SPECIFICATION NUMBER : 18A03-SPC-G-001

JOB NUMBER : DCPL-18A03

CLIENT : NLC INDIA LIMITED

VOLUME : II-B**TECHNICAL SPECIFICATIONS
FOR
STEAM GENERATOR AND AUXILIARIES**

FINAL	14.11.2020	A. DEY	K. MUKHERJEE	B. LAHIRI
FINAL DRAFT	06.11.2020	A. DEY	K. MUKHERJEE	B. LAHIRI
DRAFT	30.08.2020	A. DEY	K. MUKHERJEE	B. LAHIRI
ISSUE	DATE	PREPARED	REVIEWED	APPROVED

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EPC Bidding Document

NLC India Limited
NLC Talabira Thermal
Power Project- 3x800 MW
Jharsuguda, Odisha

VOLUME: II-B

**TECHNICAL SPECIFICATIONS
FOR
STEAM GENERATOR AND AUXILIARIES**



Development Consultants Pvt. Ltd.

Vol. II-B
Steam Generator & Auxiliaries

SECTION-B



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EPC Bidding Document

**NLC India Limited
NLC Talabira Thermal
Power Project - 3x800 MW
Jharsuguda, Odisha**

VOLUME: II-B
SECTION-II
ELECTROSTATIC PRECIPITATOR



Development Consultants Pvt. Ltd.

**Vol. II-B/Section-II
Electrostatic Precipitator**

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NLC India Limited
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Power Project - 3x800 MW
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VOLUME: II-B

SECTION-II

ELECTROSTATIC PECIPITATOR

1.00.00 GENERAL INFORMATION

1.01.00 The Electrostatic Precipitators shall be of outdoor type and installed on the cold end side of regenerative air preheaters. The flue gas shall be drawn from air preheater outlets of the balanced draft, pulverized coal fired Steam Generator and guided through adequately sized duct work into the specified number of independent gas streams of ESP. Similarly, the flue gas after the Electrostatic Precipitators shall be led to the suction of the induced draft fans. The flue gas temperature may approach ESP from the economizer outlet temperature of about 300⁰C in case the regenerative air preheaters fail to operate. The Bidder shall take this aspect into account while designing the precipitator.

1.02.00 The ESP under this section of specification shall be designed on the basis of maximum continuous rating of the boiler and the worst coal specified / boiler exhaust flow conditions (worse fly ash resistivity). The adverse condition as is expected in normal operating conditions are also required to be taken care by the Bidder in design. Bidder should also consider effect of De-NOx system installed in its upstream. Specific design criteria of ESP, is given in the Annexure-I of this section.

1.03.00 Particle size distribution of dust and the amount of ash will be as estimated by the Bidder. Most adverse condition in these regards shall be considered in design.

1.04.00 The Bidder shall perform a mathematical model study (by computational Fluid Dynamic Analysis) of precipitator including the associated flues and shall finalize his design on the basis of results of the study. The study should check the gas distribution through ESP parallel sections for the type of inlet and outlet gas duct. Physical flow model study can also be conducted. The Bidder shall collect coal samples and carryout necessary coal testing to establish exact ash parameters for ESP design.

2.00.00 SCOPE OF SUPPLY

2.01.00 Bidder scope shall include supply of three (3) Nos. Electrostatic Precipitators complete in all respects with all components and accessories etc. for 3x800 MW units. The characteristics of the coal, ash and other relevant design data are specified in the technical specification.

- 2.01.01 Three (3) (one for each unit) nos. ESPs for Steam Generator of 3x800MW units complete in all respects including all components and accessories stated in this section.
- 2.01.02 Electrostatic Precipitator serving each steam generator, shall have at least six (6) numbers of independently operated passes (gas streams) housed in six (6) nos. of independent casings including outside shell, structural steel supports and frame work, access ladders, platforms, safety rails, stairways, walkways, access doors and weather proof pent house etc.
- 2.01.03 Flue gas inlet distribution system complete with perforated plates or aerodynamic distribution, turning vanes, deflector plates, flow splitters, guide vanes and all necessary gas flow control devices in the inlet and outlet cones and duct, warranted by the results of flow model test, complete duct stiffening devices, interior bracings, slide plates, access doors, brackets, supporting structures, hangers, sampling connections, etc.
- 2.01.04 Collecting and discharge electrode systems
- 2.01.05 Rapping system complete with structural supporting frame, drives, and automatic rapping control, etc.
- 2.01.06 Ash hoppers complete with panel type heater, level monitors and indicators, outlet flanges, jointing material, poke holes, access doors and walkways beneath the hoppers and provision for fixing Fluidizing pads.
- 2.01.07 Foundation base plates, bolts along with templates, nuts, anchor materials, packing shims, inserts & embedment along with lugs etc.
- 2.01.08 For assessment and design of appropriate flue gas flow distribution in the ESP and the duct work connected on the upstream and downstream sides of the ESP, the Bidder shall conduct comprehensive model testing by developing following models
- (a) Scale model by fabricating a three dimensional physical model of the Electrostatic Precipitator and it's ducting with a scale not less than 1:10. While modelling Bidder to ensure that for at least one pass (gas stream) especially the extreme left or extreme right pass having all the fields with collecting electrodes are included in the model. The duct work from outlet flange of air preheater outlet up to ID fan (s) inlet shall be considered in the physical modelling.
 - (b) Computer model based on Computational Fluid Dynamics (CFD) techniques, using "Star CD", or equivalent (User friendly) CFD modeling code.
 - (i) The Bidder shall develop three dimensional CFD model for the ESP along with its upstream and downstream side duct-work (from air preheater outlet to ESP and from ESP outlet to ID fan (s) inlet and from ID fan(s) outlet to chimney inlet transition duct outlet) using the

above CFD Modeling code / software. Owner's Engineers shall be fully associated at all stages of development of the above CFD model.

- (ii) Configured model for “**NTTP**” (3x800 MW) ESPs for NLC Talabira TPP) and duct work along with the results recommendation of the Computer modeling shall be supplied to the Owner on completion of the model testing.

- 2.01.09 Opacity monitors complete with all accessories at the outlet of each pass (gas stream) of ESP at upstream of the ID Fan.
- 2.01.10 High voltage transformer- rectifier sets complete with bus sections, grounding switches, controls, leveling wheels etc.
- 2.01.11 Insulators along with heating and ventilation system for insulator compartments complete with fans, heaters and necessary controls or adequately rated thermostatically controlled, panel type electrical heaters etc. to avoid moisture condensation.
- 2.01.12 Weather proof Penthouse covering the entire roof, Ash hopper fluidizers, provision for ESP and Hopper washing.
- 2.01.13 Complete microprocessor based ESP control system including the intermittent changing TR set controllers, rapping systems controllers, communication controllers etc. The system provided shall be capable for integrated operation from UCB and shall be provided with compatible PC, printer, keyboard, CRTs etc. for control of all other ESP auxiliaries.
- 2.01.14 Drive motors and actuators, couplings and coupling guards for all rotating auxiliaries.
- 2.01.15 Inspection and maintenance access doors, frames and safety locks.
- 2.01.16 Safety devices, safety barriers, etc.
- 2.01.17 Monorails with electrically operated hoists including monorail beams on the roof for handling transformer rectifiers.
- 2.01.18 Water washing system for the ESP and its hoppers along with all piping, valves and nozzles etc.
- 2.01.19 Thermal Insulation, Lagging, Cladding & Refractories
- Thermal Insulation along with aluminum cladding, lagging, reinforcement wire mesh, cleats and supports, shall be provided for all the equipment surfaces having skin temperature more than 60 degree Celsius. The insulation thickness shall be designed as specified in the specification.
- 2.01.20 Dressing of foundations, grouting of pockets and underpinning of base plates for structures equipment etc.

- 2.01.21 Corrosion protection painting for structures as described in the specification.
- 2.01.22 Rain water drainage arrangement from Roof / Penthouse of ESP.
- 2.01.23 Sheetting work for roof (pent house)/ canopy/ side cladding of ESP.
- 2.01.24 Arrangement/system for oil drainage from the ESP roof / Transformer rectifier floor up to nearest oil pit / oil drain.

3.00.00 DESIGN CRITERIA AND CONSTRUCTIONAL FEATURES

- 3.01.00 The Electrostatic Precipitators shall be designed to meet all the conditions as specified. Respective coal and ash analysis for the expected coal and oil are given in Technical Specification. The precipitator parameters that are required to be satisfied are given in specific design criteria of ESP sizing, Annexure-I of this section. The values indicated for ESP sizing shall be considered as minimum design criteria. These shall be modified to more conservative values if Bidder experience warrants the same. However, no credit shall be given to the Bidder for this during evaluation of the bids. Utilization of these values in no way relieves the Bidder of his responsibility to meet all the guarantee requirements. The Bidder shall also furnish along with his offer the detailed calculations and data along with his Bid to establish as to how he meets the efficiency requirements both at design point and guarantee point as specified in ESP sizing criteria.
 - 3.01.01 The Electrostatic Precipitator shall be arranged in at least six (6) independently operating gas streams viz. precipitator shall have six (6) independent casings.
 - 3.01.02 The Bidder shall also furnish along with his offer the detailed calculations for ESP collection efficiency, ESP power consumption and T-R set rating etc.
- 3.02.00 Casing
 - 3.02.01 Each of the ESP streams shall be housed in its own separate and independent casing.
 - 3.02.02 The precipitator elements shall be enclosed in gas tight, weather proof, all welded reinforced steel plates. Sway bracing, stiffener and other local members shall be incorporated into the shell construction. The precipitator casing shall be fabricated from all welded reinforced, 6 mm minimum thickness, carbon steel plates conforming to ASTM A36 / IS 2062. The exposed surfaces shall be self-draining and seal welded to prevent ingress of moisture during monsoon. Access door for each bus section shall be provided.
 - 3.02.03 The precipitator casing and its elements shall be designed to withstand a pressure $\pm 660\text{mmwc}$ at 67% of yield strength or maximum conceivable pressure of FD or ID fan system, whichever is higher and a temperature of 200°C . In case of any unscheduled outage of the air heater, the temperature

of flue gas at inlet to ESP may rise to about 300°C. This temperature excursion may persist for about thirty (30) minutes until preventive measures are taken. The precipitator and its elements shall be designed to withstand this temperature excursion without damage or increased maintenance. All the calculations shall be furnished to substantiate this. Adequate provision shall be made to accommodate thermal expansion and movements as required by the arrangement and operating conditions. The casing shall be gas tight. In order to prevent distortions, the structural design shall take care of unequal expansions. Care shall be exercised in the design and fabrication of the precipitators to reduce air in leakage to a minimum. All joints which do not require opening during maintenance and/ or inspection shall be seal welded.

- 3.02.04 The precipitator casing and hoppers shall form a common structure reinforced to withstand the wind load (in accordance with IS:875), load due to dust storage in the hoppers etc.
- 3.02.05 The inlet of the precipitators shall be provided with suitable flanged connections with the flue gas ducting which shall be completely seal welded inside and outside after assembly.
- 3.02.06 Access door of quick opening type, shall be provided to allow entry to all sections of the precipitators for maintenance and access, the size of these doors shall not be less than 600 mm diameter if circular or not less than 450 mm x 600 mm if rectangular. They shall be provided with safety chain and grounding strap. Doors shall be capable of being pad locked. Design shall be such as to eliminate air in leakage through the doors. All doors providing access to high voltage parts shall have warning signs permanently attached and marked "Danger High Voltage".
- 3.02.07 The precipitator shall be guided, anchored or supported by lubricated plates/roller bearings at such locations as may be required to limit precipitator, duct work or expansion joint forces or movement. Each casing shall be restrained to grow in a radial direction from the anchor point. In case lubricated plates are used these shall be covered under all conditions of precipitator movements by 1.6 mm, type 306 stainless steel plates.
- 3.02.08 The casing shall be gas tight. In order to prevent distortion, the structural design shall take care of unequal expansion.
- 3.03.00 Gas Distribution System
- 3.03.01 Gas distribution system shall be provided at the precipitator inlet as well as in the outlet nozzle to achieve uniform gas distribution throughout the unit with maximum utilization of collection areas at the inlet and outlet. It shall be designed to minimize local velocity regions and to avoid bypassing & re-entrainment of dust. To achieve the above, internal baffles, etc. shall be provided. The distribution screens shall be of modular design. The Bidder shall give full description of the gas distribution system, stating the means he proposes to keep the distribution screens clean.

3.03.02 Aerodynamic distribution system or perforated plates distribution screen is to be utilized to reduce RMS deviation over mean velocity below 15%. This system should be designed so that aerodynamic force (particles with high velocity hot spots) on the particles should not exceed Electro-Static force guaranteed by ESP to enable effective retention capability.

3.04.00 Dust Hoppers

3.04.01 Dust hoppers shall be of pyramidal type. The hopper shall be designed with proper valley angle and arrangement shall be such that the ash flows freely without any arching or clogging.

Hopper shall have storage capacity of minimum eight (8) hours for the first field corresponding to maximum ash collection rate. Subsequent fields will have storage capacity of 8 hours corresponding to maximum ash collection rate of that field under which the hopper is provided when two preceding fields are de-energized. The hopper capacity shall be based on the inlet dust burden, gas flow rate and gas temperature indicated in ESP sizing criteria (specific design criteria of ESP sizing, Annexure-I of this section) for the design point condition while firing the maximum ash coal. (Storage shall be up to a level which will not reduce the overall efficiency of the precipitator due to re-entrainment).

Ash storage capacity shall be at least 10% higher than the ash storage capacity theoretically required for each dust hopper. Specific weight of ash shall be assumed as 750 kg/m³ (maximum) for calculating storage capacity and 1600 kg/m³ (minimum) for structural design. Further for hopper strength and ESP structural calculations the level of ash in ESP shall be considered at least up to the top of hopper partition plane or the bottom of electrodes (whichever is more) along with additional ash build-up from the end of the third field up to the ESP flue gas inlet duct bottom level at a natural repose angle (not less than 30 degree to the horizontal in any case). In case a Bidder desires to adopt any level higher than that calculated as above, this higher level may be adopted. Necessary calculations supporting the same shall be furnished along with the bid. The number and arrangement of dust hoppers shall be such that there is at least one dust hopper per T/R set. Further, an arrangement with one hopper being shared by more than one T/ R set is not acceptable. The hoppers for all fields shall be identical in shape and size.

3.04.02 Hoppers shall be in welded steel plate construction and not less than 8 mm thick. The lower 1.5 meters of each hopper shall be lined with 16 gauge or heavier, type 304 stainless steel. All hopper internal sloping corners shall have 100 mm radius. Hopper valley angle to the horizontal shall not be less than sixty-five (65) degrees. Hopper outlet flanges shall be terminated at a height of 3.5 meters above the ground level to facilitate installation of fly ash removal system. Fluidizing pads are to be provided with necessary cut out in the stainless liner portion in the hopper by the Bidder for installation. Size of this cut out shall be finalized during detail engineering stage. SS liner cuttings for fluidizing pads shall be done at manufacturer's shop as per the final markings.

- 3.04.03 The dust hoppers shall be electrically heated upto a minimum of lower one third (1/3) of the dust hopper height but not less than 1.5 meter in height by thermostatically controlled panel type heating elements to prevent ash bridge formation. All heaters on each level shall have same wattage and be capable of maintaining internal hoppers temperature in excess of 140 deg .C and capacity selection of these heaters shall be as per Owner's approval. This temperature must be maintained even when there is no flow of flue gases through the precipitator. Maximum excursion of flue gas temperature upto 300°C, while the air heaters are out also shall be considered for heater mechanical design. They shall be arranged in at least three groups i.e. for the lower, middle and upper half of the heated height. The heating system shall be of low watt density (less than 3W/square Inch of heater area), panel type to avoid hot spots and to have more uniform distribution of heat. Hopper heater shall have a heating capacity not less than 10 KW per hopper where two nos. of hopper per TR set are provided and not less than 15 KW per hopper where one hopper per TR set is provided. The hopper heaters shall be complete with local junction box having, indicating lamps and test lamps. The Minimum heat input shall in no case be less than 500 watts/M2 of hopper surface area. These heaters shall have high reliability by connecting multiple parallel circuits (not less than six), thereby ensuring that burnout of one element does not affect the other heater element. Heating elements shall be of sturdy construction and made with Inconel 600 (punched type) or flat type Ni-chrome foil suitable for ESP application in power plants. These heaters shall have design life of 25 years and shall be able to withstand the thermal cycling as well as dynamic forces such as hopper poking, vibrations, sledge hammering to the hopper anvil or hopper itself. Each hopper shall be provided with separate thermostats. External surface of the hoppers shall be properly insulated. Provision for half heaters cutting and adjustment of temperature with indication for each hopper heater shall be provided. Facility for switching 50% heating capacity from local switch shall also be provided.
- 3.04.04 Each hopper shall be provided with two (2) nos. of hundred (100) mm diameter poke hole in mutually perpendicular directions, with threaded caps. The caps shall have flat iron bars suitable for striking with a hammer, to assist in breaking free any seized threads. The hoppers shall also be provided with suitably designed and located rapping anvils for loosening the fly ash by striking with sledge hammer.
- 3.04.05 Hopper baffles shall be designed to be capable of withstanding the unbalance of pressure created when one side of the hopper is filled with fly ash and the other side is empty. All bracing and stiffening shall be on the external side of the hoppers. Internal bracing, stiffening etc., shall not be accepted.
- 3.04.06 Each dust hopper shall be provided with a high level and a low level dust level monitor operating on proven Radiofrequency measurement principle. The level monitoring system shall incorporate all the necessary accessories including two nos. level switches per hopper (one for high and other for low level), each with 2 NO + 2 NC contacts, local and remote signaling lamps and high and low level alarms. The high level ash switch will provide contact closure and activate the alarm when the ash level reaches a level high enough to cause deterioration of ESP performance and possibility of damage

to ESP structure if not corrected. After a preset time elapses with the ash under high alarm activated, the logic shall have provisions to de-energize the TR set of the particular field of the affected ash hopper. The level control device shall be unaffected by ash build up, due to moisture or charged ash on either the hopper walls or on the probe itself.

- 3.04.07 Each hopper shall be provided with a quick opening access door of not less than 600 mm diameter (if round) and of not less than 450 mm x 600 mm (if rectangular). Access doors shall be hinged vertically and provided with a safety chain and grounding strap. Suitable access ladders shall be provided from the walkway beneath the hoppers to facilitate approach to the access doors.
- 3.04.08 The hopper outlet shall not be less than 400 mm x 400 mm. The hopper outlet flanges shall be terminated at a height of 3.5 m above ground level. Each ESP hopper shall be supported at four corners by providing four columns from the ground.
- 3.05.00 Collecting Electrodes
- 3.05.01 Collecting electrodes of mild steel construction shall be designed for dimensional stability and to maintain the collection efficiency at the specified level. The specific collecting plate area shall in no case be less than the value specified in specific design criteria of ESP sizing, Annexure-I of this section. The profile of the collecting plate shall be such as to minimize the re-entrainment of collected dust at the time of rapping. Minimum plate thickness shall be 18 BWG, for G profile collecting electrode minimum thickness shall be 1.20 mm. Each plate shall be shaped in one piece construction and shall be stiff enough to carry the rapping intensity. The swaying and warping tendencies shall be prevented by suitable means. These means shall be clearly brought out in the proposal.
- 3.05.02 The Bidder can offer 400 mm spacing for all fields (in the direction of gas flow), as per design requirements mentioned in ESP Sizing Criteria, 11.00.00 of this section.
- 3.06.00 Discharge Electrodes

The high tension stainless steel discharge electrodes shall be of rigid frame type design, located midway between the collecting electrodes. The electrodes shall be self-tensioned, or restrained in pipe frames. They shall be constructed from durable, corrosion and erosion resistant material. In case spiral type discharge electrodes are being offered, the material for the same shall be UHB 904 L or approved equivalent. Vertical and horizontal members shall be rigid enough to maintain the alignment of the system without warping or distortion even at elevated temperatures. Provisions made to maintain alignment of electrodes during normal operation, including rapping and thermal transients, shall be clearly brought out in the offer. However, no anti sway insulators shall be used at the bottom of the discharge electrodes frame to accomplish the above.

3.07.00 Rapping System

3.07.01 Independent rapping system shall be provided for discharge and collecting electrodes with control systems as per the requirement specified in Electrical Section. The rapping mechanism shall be of either electric impact type or tumbling hammer type. This shall be adjustable in frequency, intensity (for electric impact type only) and duration (for tumbling hammer type) to provide an efficient cleaning rate. Separate rapping equipment, shall be provided for the discharge and collecting electrodes served by one T/R set so that each mechanism can be suitably adjusted when required. It shall be so arranged that the rapping frequency can be independently set from the control room in accordance with the operating requirements. The rapping frequency range shall be adjustable in wide range, and this facility shall be such that it does not require any stop page of rapper operation. Sufficient number of rappers and rapper drives shall be provided so that minimum collection area and discharge electrode lengths are rapped at a time, which shall not be more than 6% of the total collection area for at least the last two fields/discharge electrode length of each field served by one T/R set. The Bidder shall provide necessary calculations in support of fulfilling the above requirements along with the offer. In case any special features are added to meet this stipulation the same should be clearly brought out in the offer. The rapping system shall be designed for continuous sequential rapping to prevent puffing under any conditions of precipitator operation.

3.07.02 A minimum rapping acceleration of 75 g measured normal to the plane of the plate shall be imparted on all parts of all the collecting electrode. These levels shall have been demonstrated in the Bidder's shop tests or field tests with comparable size collecting frames and rapping gear.

3.07.03 All internal parts of the rapping mechanism shall be accessible for inspection and they shall be placed on wide access passages and shall be easily accessible for operational and maintenance purposes. Major part of the rapping mechanism shall be located external to the precipitator. Necessary lubrication system shall be provided for the rapping mechanism. Lubrication system may not be required for Electric Single Impulse Rapping, which is a top mounted electromagnetic impulse based system,

3.07.04 The aerodynamic distribution system or perforated plates and/or guide vanes furnished for gas distribution system shall also be provided with rapping systems. The rapping mechanism shall produce sufficient force to keep the aerodynamic distribution system or perforated plates/guide vanes clean.

3.08.00 Supporting Steel Works

All structural steel works required for the precipitator shall be provided. The steel work shall include column, base plates, anchors, anchor bolts, sleeves, inserts, beams, girders, hangers and other steel necessary for installation and foundation of equipment. The steel structure shall be designed taking into account the weight of insulation, cladding, fly ash in the hoppers, load due to dust in pipes, live and dead loads and wind load conditions as specified in

Indian Standard No.: IS-875. The design shall also take into account a suitable seismic co-efficient as specified in IS-1893.

3.09.00 Location & Layout Requirements

3.09.01 The design of ESP shall permit the installation of the Ash Handling System. Ash extraction system will be installed at the bottom of the ESP hoppers. These equipment will take support from the ESP hoppers. Bidder to consider the above loads in the design of ESP.

3.09.02 Following minimum additional loads shall be considered in the design of ESP structure:

- a) Cantilever loads of not less than 2000 kg/m at a distance of 1200 mm from the external face of columns on both sides of the ESP for cable/ pipe trays and walkways.
- b) Ash handling system piping loads.

3.09.03 ESP control room located at grade elevation adjacent to ESP shall house the ESP switchgears, control cubicles. Man Machine Interface (MMI) to be provided to enable the operator to access the ESP controls for control, monitoring and data acquisition functions. The MMI shall be suitably extended to CCR for control, monitoring and data acquisition functions of ESPs from CCR.

3.10.00 Maintenance Requirements (Platform, Walkways and Stairs)

3.10.01 The design of the precipitators shall allow adequate space above and between the adjacent fields to carryout necessary inspection and maintenance. A permanent walkway shall be provided at each rapper level both for the discharge and collecting electrodes. Walkway is to be provided between the fields for inspection purposes at the casing inspection door level.

3.10.02 Minimum 2.0 M wide platforms shall be provided between the two casings of the ESP to facilitate maintenance work and minimum 1.5 M wide platforms shall be provided all around all ESP passes at intermediate and TR set elevation. Minimum 1.0 M wide platforms shall be provided all around the hoppers at hopper level. The protection for the rapping motors from exposure to rain shall also be provided. Protection of rapping motors from rain water exposure may be taken care by ESP pent house for all the rapping motors of all passes except extreme end passes. A canopy like arrangement will be provided over rapping motor for rain protection for extreme. Clear head room of at least 2.2 meters shall be maintained over platforms and walkways.

At least five (5) no's of staircases (one each between the two ESP casings, three located towards boiler side while the other two towards the chimney side in between ESPs) of minimum 1200 mm clear width shall be provided from ground to the roof of the ESPs with landings connected at all platforms. Further, the platforms between all the ESP casings shall be interconnected at least at one intermediate elevation.

There shall be at least one interconnection at the roof of each ESP stream with the adjacent stream.

3.10.03 Each one of the streams of Electrostatic Precipitator shall be provided with isolation dampers at inlet and outlet for carrying out maintenance work on one stream while the other streams are in service, by completely isolating it electrically and grounding it. For this purpose, double isolation Guillotine dampers with intermediate venting may be used. Suitable safety interlocks etc. for ESP shall be provided and elaborated in the offer by Bidder.

3.10.04 A monorail system with movable trolley and an electrically operated hoist mounted on the precipitators roof shall be provided for handling and maintenance of T-R sets, rapper motors, fans (if applicable) etc. By this arrangement, it shall also be possible to lower the T-R sets down to the ground level and/or onto a truck. Normal and special maintenance tools shall also be furnished for attending to different equipment.

3.10.05 Access for maintenance of each high and low level indicator shall be provided. For this purpose two (2) numbers portable aluminum ladders (light weight & easy to transfer) to be provided.

3.11.00 Thermal Insulation and Cladding

The equipment shall be furnished with thermal insulation and cladding. For details, Section-II of Volume: II-D1 of this specification shall be referred.

3.12.00 Insulators and Insulator Compartment

In the precipitator, each individual discharge electrode system shall be supported from the required number of high-tension insulators. These insulators shall be properly housed in insulator compartments so that they shall remain dry and clean.

The high voltage conductors shall be enclosed in weather-proof ducts. The insulator compartments shall be equipped with electrical heating by thermostatically controlled heating elements in order to keep the temperature above the dew point of flue gases.

3.13.00 Discharge Electrode Frame Work

The discharge electrode framework shall be designed to obtain a stable configuration. The entire framework shall be thoroughly braced to form a rigid structure. No parts of framework shall extend beyond the top and bottom edges of collecting plates. All sharp edges and the ends of the frame parts shall be rounded to avoid excessive flash over. The discharge system assembly shall ensure highly accurate spacing. Anti-sway devices shall be provided to prevent shifting and swinging of the frames. Framework shall be so designed that the clearance between electrodes is not disturbed during rapping.

3.14.00 Transformer Rectifier Unit

3.14.01 The transformer rectifier assemblies shall be free standing in steel housing, with HV disconnect and ground switch for each section of the ESP field. The core of the transformers shall be made of non-aging cold rolled grain oriented silicon sheet steel laminations and the winding shall be of electrolytic grade copper. The tank shall be of welded type construction and the bushings shall be made of porcelain.

3.14.02 The high voltage D.C. supply to the electrostatic precipitator shall be from adequate number of transformer-rectifier (TR) units. The transformer rectifier shall be suitably mounted on the top of precipitator. Each leg of the transformer rectifier shall not be connected to more than one bus section. The transformer-rectifier units shall be provided with protection against surge, excess temperature rise and under voltage. The transformer rectifier units shall be suitable for operation with maximum temperature rise of winding and oil, limited to 55°C and 50°C respectively above 50°C ambient temperature (design) having mineral insulated oil filled type class ONAN cooling. The transformer and its associated equipment shall conform to IS or other approved international standards (IEC/JIS etc.). Each field of each section will be provided with one TR set.

3.14.03 The transformer shall be provided with Buchholz relay, local oil level gauge, oil level indicator with low level alarm contact, dial type thermometer with alarm & trip contact, oil temperature monitor for remote control panel, pressure relief valve etc. and two nos. marshalling box, one for power and other for protection & control cable entry. The cable box and marshalling box shall have a degree of protection IP 54. The marshalling box shall be provided with thermostatically controlled space heater.

3.14.04 In HV side of Transformer clear indication should be provided whether it is ON or OFF. Otherwise dedicated key would be provided in each Rectifier panel and corresponding Transformer for maintenance purpose so that in no case running Transformer can be taken for maintenance. Remote "OFF" from control room for each TR set shall be provided.

3.14.05 The rectifiers shall be silicon diode type having proven service over five years and shall conform to relevant IS, or other approved international standards. The rectifier units shall be suitably arranged to give satisfactory operation at all loads with arrangement to take any one unit off the system without affecting operation of the precipitator.

Each TR set shall be placed on a metal tray to collect leakage/spillage oil. All such trays will be connected to common drainpipe, which shall be extended up to ground level with necessary valves.

3.14.06 The TR set shall be of reputed make, having adequate proven experience of use and subject to the approval of the Owner.

- 3.14.07 The HV Rectifier set shall preferably be located in a separate chamber, other than the transformer tank, in order to facilitate replacement/maintenance of the diodes.
- 3.14.08 Overcurrent protection shall be provided in case of failure of diodes.
- 3.14.09 Each TR panel shall have a provision of interfacing with ESP control room PC for ON/OFF, data logging, alarm & display etc. During running of TR panel if power fails, the system can be restarted from PC after revival of power.
- 3.14.10 The TR sets/ electrical equipment placed on ESP roof shall be adequately covered for weather protection with corrugated GI / Metapoly sheets.
- 3.15.00 ESP Control system

The control system shall be designed for automatic and manual local/ remote operation. ESPs serving the boiler shall be provided with a complete control system consisting of microprocessor based Electrostatic Precipitator Management System (EPMS), TR set controllers, rapper controllers, communication controllers, hopper heater controls, insulator heaters and pressurization system controls and all other controls required for safe, efficient and reliable operation.

- 3.15.01 Electrostatic Precipitator Management System (EPMS) : The EPMS shall be connected to the Transformer Rectifier Set Controllers (TRC) and Rapper Controllers (RPC) through duplicate data highway. However, any other standard, proven system of communication through balanced current loop is also acceptable. EPMS shall accept the feedback analog signals like Boiler Load index and output from opacity monitors, process these signals and issue control parameters to the TR Controllers and Rapper Controllers. It shall also control, monitor and display the status of each stream i.e. status of TR Controllers, Rapper Controllers, hopper heaters, hopper levels, insulator heaters/ pressurization air blowers etc.

The EPMS shall include, but not be limited to, the following features :

- a) A PC based master controller with non-volatile memory and report storage capabilities for a period of 6 months.
- b) TR set controllers and Rapper Controllers.
- c) High resolution 24" colour LED monitor.
- d) Communication ports and protocol for data transfer between EPMS Master control unit and the TRC/ RPC/ other controllers.
- e) Keyboard for operator interface.
- f) Facility for Auto operation of ESP with Energy Management
- g) Licensed software for the EPMS.

- h) Self surveillance and self diagnostic features.

3.15.02 The EPMS display unit shall display at least the following :

- a) A summary of the status of all the controllers.
- b) A summary of the readings of all the TR sets.
- c) A summary about each TRC i.e., settings, limits, voltage and current readings, alarms and the controller status.
- d) A summary of each RPC i.e. controller status, rapping frequency, alarms and indication of the rapper being operated.
- e) Status reading Energy Management System such as charge ratio of each field etc.
- f) Necessary alarms as decided during detail engineering stage.
- g) Status of hopper level, hopper heaters and insulator heater/blower
- h) ESP TR set power supply status and alarm
- i) Potential free contact for ESP trouble shooting etc. as required shall be provided.

The PC based master controller i.e. operating and monitoring station together with 24" colour LED monitor and keyboard shall be located in the unit control room.

3.15.03 TR set controllers : Each Transformer rectifier set shall be provided with a separate microprocessor based controller (TRC) for regulation and control of the electric power input to electrostatic precipitator fields. It shall be designed for minimum charge ratio of 1:159. It shall automatically optimize the charge ratio and maintain the spark rate at a suitable level for variations of gas temperature, dust composition, gas flow etc. It shall regulate the rectifier in such a way, that the current through the electrostatic precipitator is corrected as the conditions for sparking are changed. It shall be able to monitor filter functioning and shall give an alarm when values are lower or higher than preset values. It shall automatically regulate the charge ratio of each field/ TR set based on V-I characteristics of the respective electrical fields. It shall have alternative arrangement of optimizing the charge ratio based on Opacity Monitor signal also. The controller shall have proven noise immunity and shall be suitable for ESP application. It shall be capable of maintaining the optimum voltage and current in ESP under all regimes of boiler operation.

The system shall have the following minimum features :

- a) Display unit for :

- All the operating values like field DC voltages and currents
 - Spark rate
 - Semi pulse current limit
 - Voltage low limit
 - Charge ratio
 - All other adjustable parameters and limits
- b) Keys for operator interface and potentiometers local control and adjustments.
- c) Serial communication with protocol for communicating to EPMS.
- d) Local/ Remote selection.
- e) Spark counter.
- f) Alarms as mentioned below
- TR set oil level low.
 - TR set temperature high alarm.
 - TR set temperature very high trip.
 - AC current high.
 - Low DC voltage.
 - High DC voltage.
 - Back corona.
 - Management command failure.
 - TR set PRV trip
 - TR set bucholtz trip
 - TR set bucholtz alarm
 - Ash level high alarm.
 - Ash level high Trip.

3.15.04 Rapper Controller (RPC)

Each stream of ESP shall be provided with a separate, microprocessor based Rapper Controller (RPC). It shall have proven noise immunity and shall be suitable for ESP application. It shall control the sequence and frequency of operation of the rapping mechanisms of collecting and discharge electrodes of the different fields of the precipitator. The unit shall control and survey the operation of rappers in the ESP. It shall start and stop the rappers as programmed and shall give an alarm if a rapper fails. It shall be possible to start or stop manually each rapper, without interfering with the other rappers

from the controller. The operation status of each rapper shall be indicated with LEDs on the rapper controller panel.

It shall be possible to change the three timings (viz. start time, repetition time and run time), intensity (if applicable) and frequency of rapping independently for each rapper, without need for opening the panel or any alternation in programme. The range of rapping frequency available shall be upto 24 hrs. Additionally, the rapper controller shall have at least 50 no. pre-programming sequences of rapping stored in its memory so that the operator can select any of them according to his judgment or the controller itself can choose them based on feedback from boiler load. One rapper controller shall be provided for each stream in addition one standby working rapper controller shall also be provided for each stream so that in case of failure of any one of the working rapper controllers, the standby controller shall immediately and automatically take over the control functions of this rapping without affecting the operation of ESP.

The system shall have the following minimum features :

- a) Display of all adjustable parameters, rapping modes, time settings and intensity of rapper/ group and rapper status, rapper alarm and controller alarms.
- b) Key board for operator interface.
- c) Local/ remote selection: In local mode all commands and adjustments shall be from RPC. In remote mode all commands and adjustments shall be from EPMS.
- d) Communication port with protocol for communicating with EPMS.
- e) Remote on/ off capability from EPMS.
- f) The controller address (field programmable), logic programmes and other adjustable parameters shall be stored in non-volatile memory and shall not be affected by power loss.

3.15.05 Hopper Heater Control System

Any one of the following methodology for control and monitoring of the hopper heaters shall be adopted :

- a) The hopper heaters shall preferably be controlled and monitored from EPMS. The status of the each hopper heater / set of heaters meant for a hopper shall be displayed on the EPMS unit.
- b) Hopper heater control may be achieved through suitable thermostat. The status of the each hopper heater / set of heaters meant for a hopper shall be displayed on the EPMS unit.

3.16.00 Control Panels

The system shall be semi pulse control and microprocessor based. ESP LT PMCC Auxiliary control panels and rectifier control cubicles shall all be housed in a separate control room adjacent to the precipitators. In addition one electrical control panel for control, indication, metering, annunciation of incomers and bus couplers, transformer trouble shall be provided for each unit. On electrical control panel Audio Visual annunciation will be provided for circuit breaker trip/trip circuit unhealthy, incomer under voltage, various transformer trouble (both alarm & trip stage).

3.16.01 Auxiliary Control Panel

Each auxiliary control panel shall regulate the operation of rapping motors and heating elements pertaining to one pass of the system. Separate control panel shall be provided for each horizontal pass of the precipitator. Each auxiliary control panel shall consist of necessary relays, master-controllers, timers, switches, indicating lamps etc. necessary for the efficient operation and control of individual/group rapping mechanism and heating elements. Master controller and timer shall be designed to control the sequence and frequency of the operation of rapping mechanism of the collecting and discharge system of the different fields of the precipitators. Signal lamps shall indicate over-load tripping of the rapping motors.

3.16.02 Rectifier Control Cubicle

The control cubicles for the transformer rectifier unit shall incorporate protections for abnormal condition. It shall include devices like arc suppression unit, under-voltage protection and protection for excessive temperature rise and internal short circuit of the transformer winding. The panel shall be complete in all respects with DC and AC ammeters, voltmeters, circuit breaking devices, pulse rate controller, L.T. bus bar, control/ switches, indicators, visual and audio alarm overload and earth fault protection, current limiting relays, polarity switch (if applicable) and all necessary relays. The panel shall also provide all necessary interlocks, automatic regulator and other protective devices for safe and efficient operation of the precipitator and safety for operating personnel. DC voltage and current measurement must be directly from DC side.

3.17.00 Annunciation Provision

Annunciation in the unit control room shall include.

- a) ESP rectifier faulty.
- b) Electric supply to ESP fails.
- c) Rapping mechanism trip.
- d) Outlet dust emission level high.

e) Under voltage.

f) High Ash Level

3.18.00 415 V Power cum motor control centre

415 V power cum motor control centre with incomers as shown in the Electrical Key SLD (ACB controlled), required number of working and spare outgoing feeders for control of various ESP drives and loads (including ESP, control building lighting and air-conditioning & ventilation system loads) shall be provided for each unit.

Each ESP PMCC will be fed from 11kV unit switchgears located in Power House building via dry type L.T. transformers to be installed adjacent to ESP PMCC within ESP Equipment Building. LT transformers will be connected to ESP PMCC by non-segregated phase L.T. bus duct. The rating of all the LT Transformers feeding the ESP PMCCs shall be of same rating.

3.19.00 Cables

All Power and Control cables including special cables as required for inter connection of L.T. PMCC, control cubicles, auxiliary control panel, Transformer and Rectifier units, heaters and rapping mechanism motors, remote signaling devices etc. of EP system and air conditioning, ventilation equipment shall also be supplied. All cables shall be as specified in Volume-II of the specification.

3.20.00 Earthing and Shielding

All electrical equipment shall be properly protected and two terminals shall be provided for earthing of each equipment. Earthing of electrical equipment shall be done as detailed elsewhere. Special electronic type earthing shall be envisaged for PLC/microprocessor system.

3.21.00 Cabling

Supply and installation of cable trays and layings, termination and connection of all power and control cable is to be included. Cabling shall be complete with cable numbering (computerized) tags, core ferrules, indicating termination and destination at both ends, cable glands, supports and accessories. Connection between the transformer rectifier units and the discharge system shall be provided by bus bar in ducting.

3.22.00 Safety Interlocks

Safety sequential interlocks with mechanical key exchange boxes shall be provided to prevent access to interior of precipitator or hoppers unless all transformer rectifier sets are de-energized and grounded.

This should be achieved by key interlock between the rectifier feeder circuit breakers and the door lock of the precipitator hoppers and roof doors.

3.23.00 Power Supply

11 KV power will be fed to ESP L.T. transformer by cables and 415V, 3 phase, 50 Hz power from secondary of the L.T. transformer will be received at 415 V ESP PMCC. Other power supply requirement if any shall be derived from this supply by Bidder.

3.24.00 Monorail and Hoist

Suitable monorail with electrical hoist of adequate capacity for handling TR set and/or 250 litres/hr oil filter machine from ground level to ESP top shall be provided by the Bidder.

3.25.00 Opacity Monitor

The successful Bidder shall provide one (1) opacity monitor per unit for on line monitoring of dust concentration at the outlet of each ESP path. For details, refer specification Volume-II-E of this specification.

3.26.00 The successful Bidder shall provide test points at inlet and outlet ducts of ESP for P.G. Test/measurement of outlet emission from field etc.

4.00.00 GENERAL PERFORMANCE REQUIREMENT

4.01.00 The Bidder shall perform model study (Physical scale modeling as well as CFD modeling) to achieve an optimum size and layout of the ducting, uniform flue gas distribution, maximum particulate collection, minimum draft loss, minimum dust drop out and build up and minimum re-entertainment from within the precipitator.

- (a) The Bidder shall conduct physical model testing of ESP by fabricating a transparent scaled model of ESP. As a minimum the study shall be conducted to simulate 100% and 80% of gas flow. While the requirements of EP-7 shall have to be met at the 100% guarantee point gas flow, efforts shall be made to meet this requirement for 80% of guarantee point gas flow also. The Bidder shall fabricate a three dimensional complete model of the precipitator and its ducting with a scale of not less than 1:10. The model study shall also include a gas distribution study in the inlet and outlet duct as well as, the cross over duct to find out the effect of isolation of one stream of the ESP, The Bidder shall submit the detailed procedure for carrying out model study for the approval of the Owner.
- (b) The model study shall include the design of all connecting duct work from the air preheater gas outlets to the induced draft fans inlets, induced draft fan outlet to chimney flue inlet including the inlet duct transition piece, including all dampers, turning vanes and distribution

devices. Based on the model test studies, the Bidder shall finalize the design of the ductwork, guide vanes, sampling points etc. The model study shall be carried out in the presence of the Owner. Test instruments similar to those used by the supplier shall be made available during the model test so that the readings could be verified manually by Owner's Representative during the test. A test report shall be submitted covering the complete model study including the details of the recommend external duct work, baffles or vanes etc. The Bidder shall be required to maintain the precipitator model until the Electrostatic Precipitators have successfully met all the performance guarantees.

- 4.01.02 In addition to the above physical model testing, the Bidder shall also conduct computer model based study using CFD modeling techniques. The CFD modeling shall configure ESP's and complete duct work as indicated above and shall recommend finalization of duct work design , guide vanes, flow splitters etc. so as to achieve minimum objectives as spelt out above. The computer model shall incorporate details of the gas distribution screen, the collecting plates and hopper baffles for accurate visualization of flow patterns & hopper re-entrainment.

In this process the modeling shall

- (a) Investigate the flow characteristics and estimate accuracy.
- (b) Improve accuracy based on observation on modification to achieve the desired flow pattern.

The results of CFD modeling shall be validated by physical model testing and by the actual testing/measurements at site.

- 4.02.00 Justification of Proposed Design

- 4.02.01 All the design procedures, systems, and components proposed shall have already been adequately developed and have demonstrated good reliability under similar or more arduous conditions elsewhere.

- 4.02.02 The Bidder shall submit with the Offer, comprehensive information on how the specific collection area, effective migration velocity or total migration velocity of the proposed design has been arrived at. The Bidder shall also submit along with the offer, a detailed write up on the proposed design features with recent design modifications, if any, and their specific advantages over the previous designs.

5.00.00 TESTING AND INSPECTION

Testing and inspection procedure of the ESP shall meet all the requirements spelt out in Volume: IIA . In addition to that the following tests are also to be conducted, as described below, on the following parts :

5.01.00 Discharge and collecting electrodes

5.01.01 Work tests for discharge electrodes shall include the following (for the wire type electrodes):

- a) Chemical and tensile tests.
- b) Metallographic examination-longitudinal and transverse (250X)
- c) Surface finish and surface purity from chloride ions.
- d) Spring back and surface finish after coiling (applicable to helical discharge electrodes)

5.01.02 Work tests for collecting electrodes and rigid discharges electrode shall include the following:

- a) Chemical and mechanical properties.
- b) Check for profile and straightness.
- c) Check for surface finish and dimensional accuracy.
- d) Cupping test for deep drawn sheets.

5.02.00 ESP structure

- a) Visual inspection of all welds shall be performed in accordance with AWS D1.1.
- b) Also the butt and fillet welds for built up plates and columns shall be inspected by 100% MPI.
- c) Radiographic examination shall be performed on butt welds as per AWS D1.1. 100% radiography on tension flange (bottom flange) welds and spot radiography on all joints in compression flange (top flange) of all beams and columns shall be carried out. The minimum length of welds for spot radiography and acceptance criterion shall be as per AWS D 1.1.
- d) Edge preparation for field welding shall be examined by MPI. It will be conducted for thickness beyond 50 mm.

The Performance Guarantee Test shall be conducted along with the performance test of the respective boiler as specified in Volume: I.



Annexure-I

SPECIFIC DESIGN CRITERIA FOR ELECTROSTATIC PRECIPITATOR SIZING

Each Electrostatic Precipitator shall be designed to comply with the requirements stipulated under 'Guarantee point and design point' in the table below:

SL. NO.	ITEMS	UNIT	GUARANTEE POINT	DESIGN POINT (Max. Ambient Temperature)
1.	Boiler Load		100% TMCR	100% BMCR
2.	Type of fuel		Design Coal	Worst Coal
3.	No. of Gas Paths per boiler		Minimum Six (6) independent operating gas paths.	
4.	Ambient air condition		27.5°C and 66%RH	48°C and 66%RH
5.	Gas flow per ESP at the ESP inlet when firing respective fuel	m ³ /sec	To be worked out by the Bidder when firing specified design coal at 100% TMCR load considering 25% excess air at economizer outlet, (or actual whichever is higher), 15% air heater in leakage (or actual whichever is higher) and 2% duct leakage as a minimum.	To be worked out by the Bidder when firing specified worst coal with maximum ash at 100% BMCR load considering 25% excess air at economizer outlet, 15% air heater inleakage (or actual whichever is higher) and 2% duct leakage as a minimum.
6.	Gas temperature at ESP inlet	°C	125°C or as predicted under conditions stipulated above, whichever is higher.	145°C or as predicted under conditions stipulated above, whichever is higher.
8.1	Gas temperature at ESP exit considering air ingress in ESP	°C	Bidder to specify.	Bidder to specify.
8.2	ESP dust collection efficiency	%	To be worked out corresponding to outlet dust burden and inlet dust burden as mentioned below.	To be worked out corresponding to outlet dust burden and inlet dust burden as mentioned below.
8.3	Moisture in flue gas at ESP inlet % by weight.	%	Bidder to specify	Bidder to specify
9.0	Inlet Dust Burden	gm/Nm ³	85% of ash or actual /predicted	90% of ash or actual /predicted





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SL. NO.	ITEMS	UNIT	GUARANTEE POINT	DESIGN POINT (Max. Ambient Temperature)
	(Considering maximum Fly Ash)		whichever is higher being carried forward to ESP while firing specified design coal	whichever is higher being carried forward to ESP while firing specified worst (maximum ash) coal.
10.1	ESP Dust Collection loading at ESP outlet @ 6% O ₂ Dry	mg/Nm ³	15 (With all fields in service)	30 (with One (1) field each in all the passes out of service)
10.2	ESP Dust Collection loading at ESP outlet, when all fields of each pass in service @ 6% O ₂ Dry	mg/Nm ³	15	Bidder to specify
10.3	Minimum specific collection area (SCA) with one field out of service in each pass	m ² /m ³ /sec	Bidder to specify	200 (minimum) corresponding to 400 mm collecting electrode spacing considering required collection efficiency based on predicted maximum inlet and specified outlet dust burden.
11.	Maximum flue gas velocity through the ESP	m/sec	1.0	
12.	Treatment time of the flue gases (minimum)	Sec.	20	
13.	Other Design Parameters			
a)	Minimum Aspect Ratio		2.0	
b)	Design internal pressure	mmWC	±660 at 67% yield strength or maximum conceivable pressure of ID/FD fan system, whichever is higher	
c)	Maximum permissible pressure drop through the gas flow path at guarantee point	mm WC	25	Bidder to specify
d)	Type of control		Semi pulse	
e)	Precipitator mechanical design	deg. C	200	200





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SL. NO.	ITEMS	UNIT	GUARANTEE POINT	DESIGN POINT (Max. Ambient Temperature)
	temperature			
f)	Short temp excursion temperature (for approx. thirty (30) minutes at a time)	deg. C	300	300
g)	Migration velocity	m/s	Bidder to specify	Bidder to specify
h)	Minimum no. of T/R sets per stream per series electrical field	Nos.	One (1)	One (1)
i)	Maximum collection area served by one T/R set	m ²	4000	Bidder to specify
j)	Minimum no. of bus sections per T/R set		One (1)	One (1)
k)	Minimum dust hopper storage capacity each (upto the maximum trip level based on design point conditions (while firing at 100% BMCR worst coal with maximum ash)	hours	Minimum Eight (8) hours while firing at 100% BMCR worst coal with maximum ash	
l)	Minimum hopper valley angle to the horizontal	degrees	Sixty five (65)	
m)	Height of the lowest ash hopper outlet flange from ground level	M	Minimum 3.5 M. Bidder to assure minimum 2.5 m headroom for ash dumping in trucks in case of ESP failure. ESP structure / bracing should be such as to enable truck entry. Also ESP hoppers shall have additional blanked spout for such emergency ash unloading.	
n)	Spacing between the collecting electrodes (Centre line to centre line) transverse to the gas flow	mm	400	
o)	Minimum installed corona power per unit effective collection area *	Watts/m ²	17	17





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SL. NO.	ITEMS	UNIT	GUARANTEE POINT	DESIGN POINT (Max. Ambient Temperature)
p)	Maximum nos. of ash hoppers	Nos.	Two (2) for one TR set.	Two (2) for one TR set.

Note:

- * The corona power shall be defined as the product of average bus voltage and mean current divided by the collection area served by one T/R set.
 - Nm^3 : calculated at NTP.
 - Discharge side of ESP shall be suitable for either of two (2) ID Fans

