

3X800 MW PATRATU TPS

**TECHNICAL SPECIFICATION
FOR
CATHODIC PROTECTION SYSTEM**

SPECIFICATION NO.: PE-TS-434-509-E001 REV. 00



**BHARAT HEAVY ELECTRICALS LIMITED
POWER SECTOR
PROJECT ENGINEERING MANAGEMENT
NOIDA**



**TECHNICAL SPECIFICATION FOR
CATHODIC PROTECTION SYSTEM
3X800 MW PATRATU TPS**

SPECIFICATION NO. PE-TS-434-509-E001

VOLUME II

SECTION

REVISION 00

DATE: 19.11.19

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COMPLIANCE CERTIFICATE

The bidder shall confirm compliance to the following by signing/ stamping this compliance Certificate and furnishing same with the offer.

1. The scope of supply, technical details, construction features, design parameters etc. shall be as per technical specification & there are no exclusion/ deviation with regard to same.
2. There are no deviation with respect to specification other than those furnished in the 'schedule of deviations'.
3. Only those technical submittals which are specifically asked for in NIT to be submitted at tender stage shall be considered as part of offer. Any other submission, even if made, shall not be considered as part of offer.
4. Any comments/ clarifications on technical/ inspection requirements furnished as part of bidder's covering letter shall not be considered by BHEL, and bidder's offer shall be construed to be in conformance with the specification.
5. Any changes made by the bidder in the price schedule with respect to the description/ quantities from those given in 'BOQ-Cum-Price schedule' of the specification shall not be considered (i.e., technical description & quantities as per specification shall prevail).

BIDDER'S STAMP & SIGNATURE



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SECTION - I

SPECIFIC TECHNICAL REQUIREMENTS

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1.0 SCOPE OF ENQUIRY

1.01 The intent of specification is to cover the following activities for **Cathodic Protection System for buried MAKE-UP WATER PIPES FROM DAM TO RAW WATER PUMPS** (Refer Piping layout attached) as per BoQ/ Price Schedule:

- Carrying out required corrosion survey and collection of data for design and implementation of both Sacrificial Anode and Impressed Current (ICCP) Cathodic Protection Systems.
- Implementation of Cathodic Protection systems by interpretation of survey data, detailed design, engineering, getting approval of survey data/ engineering documents from BHEL/ Owner, manufacturing, fabrication, assembly, inspection and testing at manufacturer's works as per approved documents, proper packing and delivery at site, unloading and storage at site, execution of all associated civil works, installation of various equipments, inspection, field testing & commissioning as per the approved commissioning procedure, performance testing and handing over to BHEL/Owner.
- Periodic Monitoring periodic monitoring of the protection level of the pipelines/structures, interference testing & mitigation is required during post commissioning period and submission of complete documents to Employer for record.

Detailed activities in respect of above are listed under clause 4.0 [Scope of Work].

Site erection and commissioning activities shall be carried out by successful bidder at site for this package. Skilled and unskilled labour required for related site activities listed at a-d shall be arranged by successful bidder.

1.02 Detailed specifications for the equipment/ work included in this specification are given in Section-II Annexures:

Annexure I	Data Collection/Survey
Annexure II	Anodes & Anode Ground Bed
Annexure III	CP Stations and CP Transformer/ Rectifier Units
Annexure IV	Test Stations
Annexure V	Miscellaneous Equipment

1.03 BILL OF QUANTITIES

The bidder to quote for items as per price schedule attached with NIT.

2.0 SPECIAL INSTRUCTIONS TO BIDDERS

- Wherever a material or article is specified or described by the name of a particular brand, manufacturer or trade mark, the same shall be understood as establishing the type, function and quality desired. Other manufacturers' products may also be considered provided sufficient information is furnished so as to enable BHEL to determine that the products are equivalent to those named.
- Details of pipelines are indicated in the BOQ enclosed.
- The Bidder is advised to visit the site in order to acquaint himself with all the necessary information such as soil conditions, transportation facilities, data of similar pipelines and underground cables & cable trench/corridor in the adjacent pipe corridor, transmission line/railway line interferences, etc. for proper

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design and execution of the work. Ignorance of the site conditions will not be accepted as a basis of claim for any compensation whatsoever.

- 2.04 The Cathodic Protection System also includes certain works related to pipelines such as provision of Insulation Joints.
- 2.05 The scope of work shall include monitoring services for a period of six months after completion of initial operation or commissioning of Cathodic Protection system. During this period, the Vendor shall visit the site and carry out testing and measurements of the system parameters in presence of Owner/ BHEL to ascertain the safe and sound operation of the same. Any adjustment in the operating parameters shall be recommended to Owner/ BHEL during the course of such monitoring activity along with technical justification for the same if required. In case of failure of any bidder's supplied equipment during the specified period, it shall be replaced by bidder without any techno-commercial impact to BHEL. The periodicity of the visits during the monitoring period of six months shall be as per the requirement.
- 2.06 Quantities or rating of the equipment, if mentioned in the specification, are indicative only and are minimum requirements. Bidder shall check the specified BOQ, inclusive of number and weight of anodes, rating of transformer rectifier units, size and types of cables, etc. as per the standards/ codes, practices specified and considering the basic design data / guidelines specified in this Section. Any improvement with respect to the rating, number, and size of all equipment to meet the requirements of Technical Specification shall be considered while bidding and the same shall be supplied, erected and commissioned within the quoted price without any cost implication to BHEL.
- 2.07 It is not the intent to specify herein all the details of design and manufacture. However, the equipment shall conform in all respects to high standards of design engineering and workmanship and shall be capable of performing in continuous commercial operation up to bidder's guarantee.
- 2.08 The bidders shall be responsible for and governed by all requirements stipulated hereinafter.
- 2.09 Requirements of specification shall be agreed upon for total compliance by bidders without any deviations. Price offers of only those bidders complying with this requirement shall be acceptable.
- 2.10 The documents shall be in English language and MKS system of units.

3.0 DESCRIPTION OF CATHODIC PROTECTION SYSTEM

Cathodic protection is a method which protects the pipe reliably even at undetected coating/wrapping holidays. The protective current supplies electrons to the pipe which is to be protected. These electrons replace the electrons which would otherwise be produced by metal decomposition to cover the electron requirements for the reduction of oxygen at the metal surface. The potential of the metal surface is sufficiently reduced to prevent the dissociation of positive iron ions from the material. The anodic reaction is replaced by a cathodic reduction of the oxygen and the entire pipe surface protected is transformed into a safe cathode.

3.01 Sacrificial Cathodic Protection System

- a. It is proposed to provide Sacrificial type Cathodic protection System for the buried pipeline by using the Zinc/Magnesium anodes packed in highly conductive backfill at regular intervals of 1 (one) Kilometer for the complete pipe length. However the actual anode installation location shall be decided as per design criteria in consultation with Owner.
- b. This shall primarily protect the pipeline during the construction phase till the Permanent Impressed Current type Cathodic (ICCP) Protection System is commissioned. The Sacrificial anode CP System shall be supplied and installed concurrently along with the erection of every portion of

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buried pipe which is to be protected so that pipe gets protected against corrosion after the same is erected till the permanent CP system is commissioned along with the complete piping system.

- c. A typical anode installation consist of conductive connection (through thermit welding) of cables of specified size to the metal (Cathode) structure to be protected, connection of the cabling from this joint to the terminal of test station, installation of pre-packed anode at suitable depth from the pipeline, connection of tail cable of anode to the terminal of test station. The protective current which flows due to the potential difference between pipe and anode metal shifts the corrosion from the metal structure to the anode.
- d. The system shall include provision of required numbers of permanent Test Stations at regular intervals along the pipe line for monitoring the system parameters.
- e. The system shall be decommissioned after the successful commissioning of Permanent ICCP system.

3.02 Impressed current type Cathodic Protection system

- a. In Impressed current system, the protective current required shall be supplied either by Transformer rectifier (TRU) units connected to the electrical main supply or by any alternate electric supply source as detailed elsewhere in specification and fed into the pipeline by buried impressed current anodes. The system consists of following main components:
 - a) Transformer rectifier stations feeding the Protective current.
 - b) Impressed current anodes packed with backfill.
 - c) Cables between rectifier/alternate source, pipeline and impressed current anodes.
 - d) Alternate source of power as detailed in cl 3.04.00 a) of this sub section, feeding the protective current at location where AC Supply is not available.
- b. The anodes may be of either High Silicon Cast Iron (HSCI) type or Mixed Metal Oxide (MMO) coated Titanium anode type.
- c. The test stations proposed to be provided with the Sacrificial type CP system shall be utilized for this ICCP system also for system monitoring and testing along with additional test stations if required.
- d. The transformer rectifier units shall be the source of power for the ICCP system. The output of T/R unit shall be automatically varied to achieve the setting of pipeline to soil potential.

3.03 Suitable measures as per national / international practice will be taken to mitigate any interference current and cross currents from any source.

3.04 Special protection shall be provided at cased-crossing (Road-crossing/ Rail crossing etc.). Additional sacrificial anodes for casings/ carrier pipes within casings shall be provided by the vendor

4.0 SCOPE OF WORK

4.01 The broad scope of work shall cover the following for the various systems and equipments mentioned under this clause:-

- (i) Complete soil resistivity survey for the pipelines along the entire pipe lengths. Any resistivity data mentioned, if any in the specification is indicative only (Vendor is free to visit site at any stage). Vendor to do the soil resistivity test and verify the data at their end and collecting other soil conditions like data of similar pipelines and underground cables & cable trench/corridor in the adjacent pipe corridor, transmission line/railway line interferences, etc. for proper design and

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execution of the work and submitting the survey report for BHEL's/ customer's review, approval and records.

- (ii) Detailed design as per the design data, standards and codes of practices specified and the approved soil data.
- (iii) Carrying out detailed engineering to BHEL approval.
- (iv) Complete manufacture including shop fabrication, assembly, and testing and inspection at manufacturer's works.
- (v) Proper packing, forwarding and transportation from the manufacturer's works to site.
- (vi) Erection and commissioning, including but not limited to fabrication and/ or pre-assembly, if any, civil works, testing and putting into satisfactory operation of all the equipment/ system and handing over to Owner / BHEL and successful completion of initial operation.
- (vii) Conducting Functional Guarantee tests after successful completion of initial operation.
- (viii) Monitoring of the system for period of six months after completion of initial operation or commissioning of Impressed Current Cathodic Protection (ICCP) system and Sacrificial Anode Type Cathodic Protection for Make Up Water pipeline system from Dam to space for Raw Water pumps (including modification work if any required for satisfactory operation of the system).
- (ix) Providing all the design drawings, design calculations, technical data sheets, "As Built" drawings, manufacture and assembling practices, construction/ installation practices, test procedures followed during manufacturing, erection and commissioning, conducting Performance & Guarantee testing, carrying out monitoring services etc., and submitting Operation & Maintenance manuals for BHEL's review, approval and records.

4.02 All erection and commissioning activities are included in vendor's scope. Vendor's technical personnel of suitable qualification and experience and in sufficient numbers shall be deputed to project site for soil resistivity survey and for complete erection and commissioning till the system is successfully commissioned to the satisfaction of owner / BHEL i.e. acceptance of PG testing of the system and handed over to Owner/BHEL till the period of six months of the monitoring of the system. During this complete activity mentioned above Vendor shall be responsible if any parts of Cathodic Protection System are lost or damaged and are broken during installation. All damage and thefts shall be made good by the vendor till the installation is handed over to the customer after successful monitoring period.

4.03 Supply and installation of Sacrificial Anode CP system consisting of:

- a) Required number of Sacrificial Zinc and or Magnesium anodes with pre-packed with special backfill.
- b) Required number of manual test stations (common for both Sacrificial & Impressed current type CP systems) and data retrieval computer.
- c) Required junction boxes, cables & cabling
- d) Associated civil, structural and electrical materials for installation of sacrificial type CP system as elaborated elsewhere.
- e) Monitoring of the performance of the Sacrificial anode CP system and taking corrective actions till the commissioning of ICCP system.

4.03 Supply and Installation of Impressed Current Cathodic Protection System (ICCP) shall typically consist of:



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- a) Required no of Distributed tubular Anode or Deepwell anode bed with anodes with canister and backfill materials connected with Anode lead cables in parallel is proposed for providing Cathodic protection of pipeline. Linear anodes shall be provided for proper CP current distribution in congested areas where space for anode bed installation is not available. The anodes shall be either High Silicon Cast Iron (HSCL) type or Mixed Metal Oxide (MMO) coated Titanium Anode type.
- b) 1 No. anode junction box/cathode junction box per TR unit.
- c) Required No of Transformer Rectifier Unit (TRU). Bidder to note that Bidder's AC supply shall be available at Two points only, one near Make Up Water Pump House and other near the reservoir area of the Plant end. In case CP Stations are required at location in between of these two points, bidder has to make suitable arrangement for alternate power supply source (like solar power etc) for such CP stations. Solar powered electric supply or any other alternate source shall be provided with battery bank suitable for min. 100 hours backup at 100% load and other necessary accessories required to complete the system.
- d) Anode tail cable shall be single core stranded tinned copper conductor, Kynar/HMWPR unarmoured.
- e) Required thermit weld cartridges complete with mould and all accessories of cathodic measurement bonding cables with pipeline and welding of the same with the pipeline.
- f) Pure epoxy encapsulation of the anodes, required junction boxes, cabling and cable connections to pipeline. All materials required for laying and termination of cables including cable trays, GI conduits, lugs, glands, markers, grounding material, etc.
- g) Required numbers of Electrical Resistance probes & E/R resistance reading instrument.
- h) Required grounding cells, grounding anodes, Kirk cells and test stations shall be provided for the ICCP system for system monitoring and testing.
- i) Required numbers of resistance bonding with test stations at power line crossing/ electrical traction/ rail crossing as and where required.
- j) Surge Diverters and Polarisation Cell
- k) Polarisation Coupons
- l) Required insulation joints & neoprene wrap. All the nearby structures shall be isolated to avoid interference.
- m) Required numbers of permanent reference cells.
- n) All civil, structural and electrical materials required for installation of Impressed Current Cathodic Protection System (ICCP) system.
- o) Complete protection of casing and carrier pipelines (for 25 years) using additional anodes at each encased pipe crossing. CP System at cased crossings.
- p) Two sets of portable reference cells, instruments and accessories required to monitor the performance of CP system such as corrosion voltmeters, multimeters, meggar, portable reference cells, electrodes etc.
- q) Outdoor type test stations along the pipe routing at intervals not exceeding 1000 meters and at locations of each of the road/ rail/ drain crossings.

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- r) Barbed wire fencing along with appropriate support and lockable gate to be provided around the anode bed and the TRU (if located outdoor) of ICCP system.

Successful bidder shall submit a complete Bill of Materials for the complete system after approval of basic design documentation which shall be to BHEL's approval/ customer approval.

- 4.04 Supply of required Monitoring instruments, monitoring of ICCP system (till the system is handed over to Employer for a period of 6 months after commissioning of the complete ICCP System) & training Employer's personnel for monitoring services.
- 4.05 All other materials which may be necessary but not mentioned herein specifically to complete the cathodic protection system in all respects to the best engineering practices shall be in the vendor's scope.
- 4.06 All materials, consumables, special tools and tackle, testing instruments and machines required for execution of the work are also included in vendor's scope.
- 4.07 Vendor shall be responsible for conduction of all tests required as per specification. The scope includes making all arrangements (including supply of materials) for all tests, overseeing the performance of tests in presence of Owner/ BHEL's representative. Submission of results for approval and all rectification work, if required.
Vendor shall also be responsible for accurately recording and maintaining records of all tests as per requirement of Owner/ BHEL representative.
- 4.08 All instruments and consumables required during erection/ pre-commissioning, performance testing and monitoring shall be arranged by the vendor.
- 4.09 Support pipes/ structures for junction boxes etc. shall be part of scope of supply.
- 4.10 All other materials necessary but not mentioned herein specifically to complete the cathodic protection system in all respects to the best engineering practices shall be included by the bidders.
- 4.11 Terminal points: BHEL/Owner shall provide 2 nos. (1working + 1 standby) 415 or 240 V, three or single phase, 50 Hz AC power supply uncabled feeder modules at LT panels/AC distribution boards located in/near Make Up Water Pump House and Reservoir area of the plant end. BHEL/Owner's AC supply for Cathodic Protection System shall be available at above two points only. Bidder to indicate the rating of feeders and power requirement for the same. Cables from the feeder modules / changeover between feeders/ inter-locks/protection devices/ any other supply etc. and further distribution of supply shall be in bidder's scope only.
- 4.12 Cathodic protection system shall provide completely unattended operation under all operating conditions.
- 4.13 The installations of each screening channel in the plant water pumping station as well as other equipment Installed in both pumping stations shall be equipped with a fully automatically controlled cathodic Corrosion.
- 4.14 In case of mismatch between various clauses, more stringent requirement to be followed.
- 4.15 Miscellaneous scope of work such as:
a) Suitable Markers with legible marking along with buried cabling work at anode locations of both Sacrificial & ICCP System, TLP etc. are to be provided by the Contractor. Support pipes/structures for junction boxes etc.
b) All other materials which may be necessary but not mentioned herein specifically to complete the Cathodic Protection System in all respects to the best engineering practices.
c) All tools and tackles, testing instruments and machines required for execution of the work.

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- d) All skilled, semi-skilled, unskilled supervisory and Managerial Manpower required for execution of the work. Contractor shall also be responsible for carting away all discarded or surplus material anywhere within the site boundaries as per instructions of the Engineer.
- e) All tests required as per specification. Contractor shall be responsible for making all arrangements (including supply of materials) for all tests, performance of tests in presence of Employer/ Employer's representative.
- f) Submission of results for approval & all rectification work if required. Contractor shall also be responsible for accurately recording and maintaining records of all tests as per requirement of Owner's representative.
- g) Contractor shall mobilize at site adequate testing equipments/apparatus including skilled, unskilled, managerial manpower required at site for all testing. All instruments and consumable required during erection/pre commissioning, performance testing & monitoring shall be arranged by the Contractor.
- h) Maintaining records of all the works and inspections as per advice of the Engineer.
- i) All other materials necessary but not mentioned herein specifically to complete the Cathodic Protection system in all respects to the best engineering practices shall be included by the Bidder.

5.0 BASIC DESIGN DATA/ GUIDELINES

5.1 A) FOR SACRIFICIAL ANODE CP SYSTEM

- (i) The data of pipelines to be protected and the wrapping and coating employed for the protected pipelines are indicated elsewhere in the specification (please refer BOQ sheet).
- (ii) The cathodic protection system will be sized in order to guarantee, at each point of same system, the minimum pipe-to-soil potential value of (-) 0.95 V versus Cu/CuSO₄ half-cell reference electrode. The maximum negative potential value allowable at the drainage point will be (-)1.2V (as per BS7361/ 1991- Section 2, table 1
- (iii) The design life of system shall be minimum two (2) years. However, those parts of sacrificial anode CP system which are to be integrated with permanent ICCP system shall be designed based on permanent CP paremeters / design basis as mentioned below.
- (iv) Under temporary CP design basis, the minimum protection current density shall be (i) 40 $\mu\text{A}/\text{m}^2$ for the pipeline surrounded by soil of resistivity more than 100 ohm.m (ii) 75 $\mu\text{A}/\text{m}^2$ for the pipeline surrounded by soil of resistivity of 10 ohm.m to 100 ohm.m and (iii)500 $\mu\text{A}/\text{m}^2$ for resistivity of soil less than 10 ohm.m. Under marshy conditions the protection density shall be 1000 $\mu\text{A}/\text{m}^2$ for temporary CP system design. However the actual current density to be adopted shall be suitably increased by contractor based upon soil conditions, current drainage survey details, foreign pipe line / structures and other interference areas affecting the installation.
- (v) At horizontal crossings the pipeline protection current density applicable for marshy area shall be considered.
- (vi) Safety factor for current density shall be minimum 1.3 for degradation of coating.
- (vii) Anode utilisation factor shall be 0.8 (max) and 0.6 (max) for solid and ribbon anodes respectively.

5.1 B) FOR IMPRESSED CURRENT CATHODIC PROTECTION (ICCP) SYSTEM

- (i) The data of pipelines to be protected and the wrapping and coating employed for the protected pipelines are indicated elsewhere in the specification (please refer BOQ sheet).

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- (ii) The cathodic protection system will be sized in order to guarantee, at each point of same system, the minimum structure-to-soil potential value of (-) 0.85 V versus Ag/AgCl half cell reference electrode.
 - (iii) The maximum negative potential value allowable at the drainage point will be (-)1.2V (as per BS7361/1991 - Section 2, Table 1).
 - (iv) The design life of system shall be minimum twenty five (25) years.
 - (v) The minimum protection current density shall be (i) 200 $\mu\text{A}/\text{m}^2$ for the pipeline surrounded by soil of resistivity more than 100 ohm.m (ii) 300 $\mu\text{A}/\text{m}^2$ for the pipeline surrounded by soil of resistivity of 10 ohm.m to 100 ohm.m and (iii) 2000 $\mu\text{A}/\text{m}^2$ for resistivity of soil less than 10 ohm.m. Under marshy conditions the protection density shall be 5000 $\mu\text{A}/\text{m}^2$. **However the actual current density to be adopted shall be suitably increased by contractor based upon soil conditions, current drainage survey details, foreign pipe line / structures and other interference areas affecting the installation.**
 - (vi) The minimum end of life pipe protection current requirement shall be considered as the current requirement indicated above or 4 times the current density value measured by the current drainage survey whichever is maximum.
 - (vii) At horizontal crossings the pipe protection current density applicable for marshy area shall be considered.
 - (viii) Safety factor for current density shall be minimum 1.3 for degradation of coating.
 - (ix) Anode utilisation factor shall be High Silicon Cast Iron (HSCI) anode 0.8 (max) and 0.6 (max) for solid center connected anodes and end connected anodes respectively.
 - (x) The maximum anode surface current density shall not be considered more than 10 Amp/Sq.M for HSCI anodes.
 - (xi) The coating efficiency to be considered for design shall be 70% maximum throughout the design life.
 - (xii) Anode consumption rate for HSCI anodes shall minimum 0.4 Kg/Amp/Year.
 - (xiii) For mixed metal coated titanium anode (MMO type) the anode surface current density and anode consumption rate etc shall be as per the guranteed values published by the manufacturer and supported by the tests certificates / field proneness.
 - (xiv) The sizing of transformer rectifier or any alternate electric supply source shall be done considering an additional requirement of 25% power compared with the power required under normal operating condition.
 - (xv) Criteria shall be adjusted to cater for variations in salinity, soil analysis, salinity of water and other environmental factors temperature etc., where applicable without any cost implication to BHEL.
- 5.2.0 Vendor shall submit detailed design calculations for the design of the entire system after award of contract for BHEL approval/ customer approval.
- 5.3.0 As part of corrosion survey full particulars regarding secondary structure including power cables, communication lines, electrical railway tracks etc. which would adversely influence the system or would be influenced by the system must be collected. The cathodic protection system would incorporate suitable mitigation measures for varying types of soil and moisture content.
- 5.4.0 Cathodically protected section of the pipe line shall be electrically isolated by use of insulating joints. Whenever it is not possible to use insulating joints, losses due to leakage current shall be taken care through allowance margin.



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5.4.0 The carriers in the cased crossings with seals shall be protected by zinc sacrificial anodes. The anodes shall be in the form of ribbon or arc shaped rod and would be welded to the carrier pipe by thermit welding as close to the carrier pipe as practically possible. The length of the ribbon anode would be equal to the length of the carrier pipe inside the casing and anodes will be mounted over the circumference in such a way that it is distributed equally at 120° angle between them.

5.5.0 The external of casings would be coated in the same manner as carrier pipes and also provided with zinc anodes on both sides of the pipe.

5.6.0 Test Lead Point (TLP) to be used to monitor pipe-to-soil potential (P-S-P) level in the underground/buried metal structures.
The main purpose of TLP is the measurement of (P-S-P). Other than (P-S-P) some of these TLPs will have in-built facility for line current measurement also bonding at pipe crossings protection of casing pipe (if any) and connecting surge diverter (at I/F, if any).

In order to verify the protection of the pipeline along its route bidder shall install the following test lead points:

- Equipotential test points (E.T.P.) where interference with other buried steel structure will be carried out.
- Shorting insulating joints (S.I.J) at each insulating joint.

Installation of TLP shall depend on site conditions as per prior approval of BHEL to be mounted above ground with steel enclosures which shall be weather proof IP: 55 with hinged lockable shutters. It shall have a bakelite terminal block with adequate number of anti-locking brass nut bolts for measurement purposes. The cable connection from (underground) pipe has to terminate in one of these TLPs. It shall be suitable for cable gland entries for incoming and outgoing cables.

Construction from steel of 3mm (min) thickness is recommended. The frame must be set in a concrete foundation sufficient to provide sturdy support.

Name plate shall be provided inside each TLP giving following information: TLP No., connection scheme diagram, location details etc.

6.0 CODES & STANDARDS AND PERFORMANCE CRITERIA

6.01 Standards and Code of Practice

The design, manufacture, shop testing, erection, fabrication at site testing and Initial operation of the cathodic protection system shall conform to the latest revision of following standards and code of practice as specified herein after.

1	NACE SP-0169	Control of external corrosion on underground and submerged piping systems
2	NACE SP-0572	Standard Practice design, installation, operation and maintenance of impressed current deep groundeds
3	NACE SP-0177	Mitigation of alternating current and lightning effects on metallic structures and corrosion control systems
4	NACE SP-0200	Cased steel pipeline practices



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5	NACE Standard TM0497	Measurement Techniques Related to Criteria for Cathodic Protection on Underground or Submerged Metallic Piping Systems
6	NACE Publication No. 54276	Cathodic Protection Monitoring for Buried Pipelines
7	IS 8062	Cathodic Protection of Buried Pipeline/ Structure for Transportation of Natural Gas, Oil and Liquids- Code of Practice
8	NACE SP-0286 Standard Practice	Electrical isolation of cathodically protected pipelines
9	NACE SP-0187	Design considerations for corrosion control of reinforcing steel in concrete
10	DNV RP-B043	Recommended Practice Monitoring of Cathodic Protection systems.
11	DNV RP-B401	Recommended Practice Cathodic Protection Design
12	NACE SP-0308	Inspection Methods for corrosion evaluation of conventionally reinforced concrete structures
13	BS 7361 Part 1	Cathodic Protection Code Practice for Land and Marine Application
14	--	Latest international practices, acts and regulations.

The responsibility of establishing conformance to above shall lie with the vendor.

6.02 PERFORMANCE CRITERIA FOR CATHODIC PROTECTION

To achieve a reliable and an easy check of the effectiveness of cathodic Protection System it is necessary to determine one or more parameters measured that serve as criteria for the protective effect achieved. Hence while monitoring cathodic protection effectiveness, following criteria shall be applied in principle.

6.02.01 Sacrificial type Anode CP System

- The pipe to soil potential measurements shall be between (-) 0.95V (ON) and (-) 1.8 V (ON) for coal tar coated pipe lines with respect to a copper / copper sulphate reference electrode.
- At the locations of polarizations coupons, the coupon to soil potential measurement shall be between (-) 0.9 V (OFF) to (-) 1.18 V with respect to a copper / copper sulphate reference electrode.
- A positive potential swing of 100 millivolts or more shall be considered sufficient to indicate the presence of an interaction / interference situation requiring investigation and incorporation of mitigation measures by the Contractor.

6.02.02 ICCP System

- The pipe to soil potential measurements shall be between (-) 0.9V (OFF) and (-) 1.18 V (OFF) with respect to a copper / copper sulphate reference electrode.
- In rare circumstances, a minimum polarisation shift of (-) 100 millivolts may be accepted as an adequate level of cathodic protection for the pipeline with the approval of Owner.
- A positive potential swing of 100 millivolts or more shall be considered sufficient to indicate the presence of an interaction / interference situation requiring investigation and incorporation of mitigation measures by the Contractor.

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7.0 FUNCTIONAL GUARANTEE

7.1 The vendor shall give functional guarantee as elaborated below:

- a) The vendor shall guarantee that the performance/ function of the CP system installed shall be strictly in accordance with and conforming to the codes specified and shall perform the specified duties as per the performance criteria specified in CI 6.02 of this Section.
- b) If the vendor fails to prove the functional guarantee of the CP system set forth in the tender documents, the vendor shall investigate the causes and provide free of cost to BHEL, services of vendor's Project Engineer to rectify/ replace the detects within a reasonable period to prove the guarantees. Vendor's liabilities in this respect shall be unlimited.
- c) If the vendor fails to prove the guarantee within a reasonable period, BHEL shall have the option to take over the equipment and rectify the same to fulfil the guarantee and/ or to make necessary additions to make up the deficiency at the Vendor's risk and cost. All expenditure incurred by BHEL in this regard shall be to vendor's account.
- d) Functional guarantees shall be in respect of the entire cathodic protection system including material supplied and utilized in the CP system.
- e) The functional guarantees for Cathodic Protection system after allowing for applicable tolerances as per codes shall be demonstrated by the vendor to BHEL.
- f) On successful completion of initial operation, the systems and equipments shall be subjected to functional guarantee test and parameters shall be verified during the test.
- g) After successful conductance of the guarantee tests, the monitoring services of the system shall be carried out by the vendor and the system parameters shall be maintained.

8.0 INSPECTION & TESTS

8.1 The vendor shall arrange inspection of the following material before their use at site:

- a) All items procured by the vendor whether indigenous or imported.
- b) Shop fabricated items at vendor's workshop.
- c) Erection work at site (stage wise) including testing of complete Cathodic Protection System.

8.2 The successful vendor shall submit the quality & inspection plans of all equipments during contract stage and the same shall be subject to BHEL/ customer approval without any cost/ delivery implication.

8.3 Owner/ BHEL or their authorized representative reserves the right to visit vendor's, vendor's sub-vendor's shops for the inspection/ quality assurance control & expediting and to be present at the time when the vendor's inspection is being carried out. Such inspection by the Owner / BHEL however in no way relieves the vendor of his responsibilities & obligations.

8.4 The Vendor is responsible for carrying out all tests and checks envisaged in compliance with specifications & to request the Owner / BHEL's inspector to be present when required so as to meet the provisions of the contract. All expenditure in respect of testing of materials shall be borne by the Vendor unless otherwise specified.

8.5 All inspection & tests shall be according to the method indicated in the specifications/ codes/ construction drawings.

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- 8.6 The entire erection of the CP system shall be finally inspected by the Owner/ BHEL to check its conformity with all the drawings & specifications furnished. The vendor shall rectify all the defects and finally hand over the system to the entire satisfaction of Owner/ BHEL.

9.0 SYSTEM TESTING/ COMMISSIONING

Vendor shall furnish the detailed field testing and commissioning procedure for BHEL/ Customer approval. Field tests as per approved procedures shall be carried out on the equipment/ systems being put into service. Field testing and commissioning shall generally include but not be limited to the following:

9.1 System Testing

- Vendor shall perform pre-commissioning operations after installation of the system including pre-commissioning checks, calibration and setting of all instruments, control and protective devices. All site tests, reliability and performance tests shall be carried out including supply of all materials and consumables. Before the electrical facilities are placed in operation, vendor shall perform suitable tests to establish to the satisfaction of the Project Engineer in-charge that all equipment, devices wiring and connections have been correctly installed and are in good working conditions.
- All the test results shall be filled in the proforma to be developed by the vendor and subsequently approved by the Project Engineer-incharge. The proforma shall be jointly signed by the Project Engineer-incharge and vendor.
- Generally the following tests shall be carried out and recorded on the proforma given in subsequent clauses.

Checking : Visual inspection, comparison with drawings and specifications.

Inspection : Detailed physical inspection and if necessary, by taking stage wise inspection of component parts.

Testing : Simultaneous tests and trial runs of entire equipment to determine its operational fitness.

9.02 Proforma for testing

Remarks

a) Transformer Rectifier Unit

- Location/ Station
- Type, Size & Sl. No.
- Rating
- Insulation resistance primary to earth,
Secondary to earth, primary to secondary
- Polarity check
- Testing of oil (If any)
- Check neutral connection
- Equipment Earthing



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- Operation of tap changer
- Rectifier continuity & diodes polarity.

b) Cables

- Cable No.
- Voltage grade
- Conductor cross section
- Continuity check
- DC test voltage
- Insulation resistance values

Between each core & earth and

Between each core & other

All control cables shall be tested by 500 V megger and all LT power cables shall be tested by a 1000 V megger.

c) Panel

- Location
- Assembly Inspection
- Checking of wiring as per schematics
- Inspection of safety features and their functioning
- Testing anti condensation heaters
- Check circuit numbering
- Insulation resistances of different independent circuits
- Panel to panel connection
- Checking of external cable connections
- Checking of indicating measures and recording circuits
- To carryout simulation test

d) Insulating flanges/joints

- Checking of insulation resistance across the joint before and after charging the line
- by means of insulating-flanges/joint tester.



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e) Earthing network

- Location / Station
- Number of electrodes
- Type of electrodes
- Earthing resistance of each electrodes
- Earthing resistance of earthing net work
- Earthing conductor (Type & Size)
- Earthing electrodes shall be inspected before they are installed

f) Anode-Ground Beds

- Location / Station
- Check for its actual & its comparison with drawings
- Resistance of each individual anode
- Current dissipation by each individual anode at different likely voltage
- Total resistance of complete anode bed.
- Mutual interference

9.03 Commissioning Procedure

The installed cathodic protection system shall be commissioned as per following general procedure and the same shall be modified as per the system design parameters.

- a) On completion of installation of cathodic protection stations, anode-beds and modification/ integration of corrosion monitoring system as envisaged in this specification, all the elements of the system shall be individually checked, tested and compared against the agreed specifications and procedures. Subsequently the parameters of the anode-beds shall be checked for their veracity. Total anode-bed resistances shall not exceed the calculated design figures.
- b) Current dissipating capacity of each anode bed shall be measured and checked.
- c) Electrical continuity of the entire pipeline shall be verified in conformity with design and terminal resistances shall not be allowed to be less than anticipated across the insulating joints.
- d) All the insulating joints shall be individually checked for intended electrical isolation.
- e) Input resistances of the pipeline at the drainage points shall be checked and recorded.
- f) Overall circuit resistance of individual installation shall be measured and recorded.
- g) Grounding and polarization cells shall be checked for their expected performance.



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- h) If any temporary protection facilities are provided, the same shall be disconnected from the system.
- i) Bonding between individual pipes in common ROW/ pipe trench shall be ensured.
- j) Protection to all lines installed in existing CP Stations shall be switched off and the lines be depolarised for minimum 48 hours.
- k) Before the pipelines are put on charge by switching on any of the CP Stations, natural pipe-to-soil potential values shall be measured with respect to Cu/CuSO₄ half cell.
- l) For each CP system, one of the T/R unit at one CP station end shall be energized to an output regulated manually so as to achieve a maximum structure-to-electrolyte potential of w.r.t. Cu/CuSO₄, half cell nearest to drainage points of each line. Observations of spread of protection of each line under this system shall be taken for structure to electrotype potential at each of the installed test station till a value of (-)0.95 volts w.r.t to CU/CuSO₄ is reached. Also the pipe line current values across the cross section of the pipeline shall be determined at all the intended test stations influenced by this station. Operating parameters of the T/R unit shall also be recorded.
- m) Thereafter the T/R unit at the other CP station end shall be energized after switching off the CP station which was tested. The same procedure as (l) shall be adopted and PSP values recorded. This T/R station shall then be switched off. After ensuring that both T/R units are in order, both shall be switched on simultaneously and PSP values shall be recorded along the entire pipelines at each test station.
Sufficient time must be allowed to elapse between switching on the CP station and recording of pipe to soil potential values.
- n) Three complete sets of observation shall be recorded every 24 hours interval of line having stayed on charge after the completion of Sl. No. (m).
It is to be ensured that there is no appreciable difference in the observations and in case of any variations in potentials, the procedure shall be repeated. All the commissioning records shall be recorded in a prescribed proforma and analysed.
- o) During the commissioning, maximum protective potential should not be permitted to exceed the design value.
- p) Next, the output of the CP station shall be so adjusted that the sites of occurrence of minimum protective potentials are brought down to (-)1.00 V for portion. A full set of observations shall again be taken 72 hours after the first set and the protective systems shall be left in this state or operation.
- q) Care shall be exercised that power supplied remains uninterrupted during the period of commissioning, otherwise, in case of an interruption, the test in progress shall be repeated. More sets of observations may be advised to be taken by the Project Engineer in any of the above mentioned steps.
- r) After proper polarization (minimum 72 hours), the CP system shall be switched off and the immediate momentary pipe to soil potential measured. This gives the OFF potential which should match with the design value at any point of the pipeline.
- s) PSP potentials at all the insulation joints shall be checked before and after energisation of the CP station and shall be recorded.
- t) A Pearson survey/ CPL shall finally be run over the entire length of pipeline to detect any holes in the coating which may have developed during backfilling. Coating repairs if any shall be carried out by the vendor. Vendor shall submit a procedure for running this survey for Project Engineer's

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approval. This step may have to be performed as soon as back filling and compaction is completed.

- u) Finished records of testing & commissioning shall be completed with interpretation and submitted for approval.
- v) As a result of these tests, if any deficiencies are found in the system, the same shall be rectified by the vendor to the satisfaction of Project Engineer. Such deficiencies shall include mitigation of interaction problems that may be found existing in the course of testing and commissioning. This shall also include a set of SEP observations taken during the peak of first dry season in the area after commissioning the system into regular operation.
- w) While commissioning if it is found that the sites of occurrence of minimum protective potentials are below design value for marshy land portion even after 72 hours, the maximum protective drainage point potentials shall be increased depending on Anode Ground Bed current in consultation with Project Engineer. In any case, rectified potential value and the Off Potential of the CP system shall not exceed the design value w.r.t. Cu/CuSo₄ cell. The upper limit of pre-set reference SEP value at transformer rectifier unit at which it should operate at permanent half cell failure should then be adjusted according to rectified maximum protective potential value.
- x) Vendor shall arrange during commissioning, a cable less potential sensing or any other suitable means proved viable to measure structure-to-electrolyte potentials without requiring physical contact with the monitored structure for the offshore portion only.

10.0 DOCUMENTATION

10.01 Technical offer along with bid

Two signed and stamped copies of the following shall be furnished by the bidder as compliance to the specification:

- a) Unpriced Price Schedule (As enclosed with the specification) with bidder's signature and company stamp.
- b) A copy of the sheet ("Instructions to Bidders for Preparing Technical Offer") and previous sheet ("Contents"), with bidder's signature and company stamp.

10.02 The technical offer shall also include the following as a minimum requirement:

- a) Complete technical write-up of system including brief details of major equipments
- b) Typical schemes / drawings
- c) Catalogues/ leaflets
- d) List of orders successfully executed/ under execution
- e) Performance feedback for completed orders
- f) Details of internal cathodic protection of pipeline successfully done by bidder earlier

10.03 The following minimum design documentation [not essentially limited to these only] shall be furnished by the successful vendor (for review and approval) at contract stage.

1. Corrosion survey report with interpretation.
2. Basic design package and system optimisation studies.
3. Material and equipment specifications, data sheets.
4. Quality plans for all equipment/ items.
5. Field Quality Plan covering site storage, handling, installation and commissioning checks.



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6. Detail engineering and final design report.
7. Key diagrams of each discrete systems and complete CP system.
8. Anode installation drawings representing all variations in type, environment, depth, placement, supports etc. including anode.
9. Cable layout schedules and terminals.
10. Foundation, weather protection cover details and support details for T/R sets, anodes, Test Station, distribution boxes and cables of all description.
11. Installation details of T/R sets, test stations distribution boxes etc.
12. Design package on T/R sets essentially incorporating circuit diagrams, fabrications and installation details, parts list, description on operation and maintenance.
13. Design package on anodes essential incorporating composition, fabrication and installation details.
14. Connection schemes for all applicable type of test stations and their schedules.
15. Fabrication and installation details of test stations.
16. Fabrication and installation details of anode and cathode junction boxes, schedules and connection schemes.
17. Interconnection, sectionalisation, isolation schemes for all structures to be protected and those to be isolated but to be checked out for interaction.
18. Power supply arrangement for each T/R set.
19. Safety earthing details.
20. Procedures for testing during installation, commissioning and monitoring of (after installation) complete CP system & each equipment.
21. Design and drawings that may be required for mitigation purposes.
22. Complete CP system layout drawings for each CP station.
23. Cable to pipe joint arrangement using thermite welding.
24. Material test certificate for the materials purchased by the vendor along with copy of manuals.
25. Inspection and test certificates for items fabricated and erected.
26. Performance Test Report.
27. Final check list and completion report.
28. Composite Operation and Maintenance Manual.
29. Monitoring formats.
30. Monitoring schedules.



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31. List of E&C Spares.
32. Billing break-up
33. Bill of material

Note: The list of deliverables shall be finalised during kick-off meeting at contract stage.

The Reference List of Drawings with Drawing Titles and numbers are indicated below:

S.No.	Doc. No.	Description	
1	PE-V0-434-509-E001	TECHNICAL DATA SHEET OF BARE GROUND COPPER CONDUCTOR	NOT APPLICABLE
2	PE-V0-434-509-E002	GA DRGS. OF BARE GROUND COPPER CONDUCTOR	NOT APPLICABLE
3	PE-V0-434-509-E101	SITE SURVEY PROCEDURE	Primary
4	PE-V0-434-509-E102	SITE SURVEY REPORT	Primary
5	PE-V0-434-509-E103	SUB-VENDOR LIST	Primary
6	PE-V0-434-509-E104	TECHNICAL DATA SHEET FOR TR UNITS	Primary
7	PE-V0-434-509-E105	TECHNICAL DATA SHEET FOR ANODE (ICCP)	Primary
8	PE-V0-434-509-E106	TECHNICAL DATA SHEET FOR ANODE (SACRIFICIAL)	Primary
9	PE-V0-434-509-E107	TECHNICAL DATA SHEET FOR CABLES	Primary
10	PE-V0-434-509-E108	TECHNICAL DATA SHEET FOR AJB/ CJB	Primary
11	PE-V0-434-509-E109	TECHNICAL DATA SHEET FOR REFERENCE ELECTRODES	Primary
12	PE-V0-434-509-E110	TECHNICAL DATA SHEET FOR INSULATING JOINT GASKET	Primary
13	PE-V0-434-509-E111	TECHNICAL DATA SHEET FOR SURGE DIVERter	Primary
14	PE-V0-434-509-E112	TECHNICAL DATA SHEET FOR GROUNDING CELL/ POLARISATION CELL	Primary
15	PE-V0-434-509-E113	TECHNICAL DATA SHEET FOR THERMIT WELD	Primary
16	PE-V0-434-509-E114	TECHNICAL DATA SHEET FOR POWER DB	Primary
17	PE-V0-434-509-E115	DESIGN CALCULATION FOR CATHODIC PROTECTION SYSTEM	Primary
18	PE-V0-434-509-E116	GA DRG. FOR TR UNITS	Primary
19	PE-V0-434-509-E117	GA DRG. FOR ANODE (ICCP)	Primary
20	PE-V0-434-509-E118	GA DRG. FOR ANODE (SACRIFICIAL)	Primary
21	PE-V0-434-509-E119	GA DRG. FOR TEST STATIONS	Primary
22	PE-V0-434-509-E120	GA DRG. FOR REFERENCE ELECTRODES	Primary
23	PE-V0-434-509-E121	GA DRG. FOR GROUNDING CELL/ POLARISATION CELL	Primary
24	PE-V0-434-509-E122	GA DRG. FOR SURGE DIVERter	Primary
25	PE-V0-434-509-E123	GA DRG. FOR AJB/ CJB	Primary
26	PE-V0-434-509-E124	GA DRG. FOR POWER DB	Primary
27	PE-V0-434-509-E125	ICCP OVERALL LAYOUT DRG.	Primary
28	PE-V0-434-509-E126	ICCP SCHEMATIC DRG.	Primary
29	PE-V0-434-509-E127	TCP SCHEMATIC DRG.	Primary
30	PE-V0-434-509-E128	INSTALLATION PROCEDURE FOR TR UNITS	Secondary



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31	PE-V0-434-509-E129	INSTALLATION PROCEDURE FOR ANODE (ICCP)	Secondary
32	PE-V0-434-509-E130	INSTALLATION PROCEDURE FOR ANODE (SACRIFICIAL)	Secondary
33	PE-V0-434-509-E131	INSTALLATION PROCEDURE FOR AJB/ CJB & TEST STATION	Secondary
34	PE-V0-434-509-E132	INSTALLATION PROCEDURE FOR SURGE DIVERTER	Secondary
35	PE-V0-434-509-E133	INSTALLATION PROCEDURE FOR REFERENCE ELECTRODES	Secondary
36	PE-V0-434-509-E134	INSTALLATION PROCEDURE FOR GROUNDING CELL/ POLARISATION CELL	Secondary
37	PE-V0-434-509-E135	INSTALLATION PROCEDURE FOR THERMIT WELD	Secondary
38	PE-V0-434-509-E136	TESTING & PRE-COMMISSIONING PROCEDURE	Secondary
39	PE-V0-434-509-E137	COMMISSIONING PROCEDURE	Secondary
40	PE-V0-434-509-E138	CONNECTION SCHEME FOR TEST STATIONS	Primary
41	PE-V0-434-509-E139	CIRCUIT DIAGRAM FOR TR UNITS	Primary
42	PE-V0-434-509-E901	QUALITY PLAN OF BARE GROUND COPPER CONDUCTOR	NOT APPLICABLE
43	PE-V0-434-509-E902	MANUFACTURING QUALITY PLAN FOR TR UNITS	Primary
44	PE-V0-434-509-E903	MANUFACTURING QUALITY PLAN FOR CABLES	Primary
45	PE-V0-434-509-E904	MANUFACTURING QUALITY PLAN FOR ANODE (ICCP)	Primary
46	PE-V0-434-509-E905	MANUFACTURING QUALITY PLAN FOR ANODE (SACRIFICIAL)	Primary
47	PE-V0-434-509-E906	MANUFACTURING QUALITY PLAN FOR AJB/ CJB	Primary
48	PE-V0-434-509-E907	MANUFACTURING QUALITY PLAN FOR TEST STATION	Primary
49	PE-V0-434-509-E908	MANUFACTURING QUALITY PLAN FOR MISC. ITEMS	Primary

10.04 For **Primary documents** R-0 within 14 days from PO & subsequent revisions within 10 days of comments received from BHEL. BHEL shall furnish comments / approval on each submission within 18 days from receipt.

For **Secondary documents** R-0 within 30 days from PO & subsequent revisions within 10 days of comments received from BHEL. BHEL shall furnish comments / approval on each submission within 18 days from receipt.

10.05 Drawings submitted shall be complete in all respects with revised drawing being submitted shall incorporate all comments. Any incomplete drawing submitted shall be treated as non-submission with delays attributable to bidder's account.

10.06 Drawings/documents shall be submitted through Document Management System (DMS).

10.07 O&M manuals have to be submitted in English



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TECHNICAL REQUIREMENTS FOR CATHODIC PROTECTION EQUIPMENTS



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ANNEXURE-I

TECHNICAL REQUIREMENTS

FOR

DATA COLLECTION/SURVEY



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1.0 DATA COLLECTION / SURVEY

- 1.01 The details of soil resistivity data enclosed with this specification is indicative and for general guidance of the contractor. Vendor to do the soil resistivity test required for the system design. (Vendor is free to visit site at any stage).
- 1.02 The contractor shall carry out corrosion survey and soil resistivity survey at anode ground bed locations (for both sacrificial & ICCP) for proper design of ground beds using Wenner's 4-pin method or approved equal shall be used for such measurements. One or more ground bed plots may be required to be selected and surveyed at each CP station to form a suitable ground bed for ICCP system.
- 1.03 The following additional data shall be collected to generate design data:
- i) Design Data regarding of foreign service / pipelines in and around or crossing the right of way and diagram representing existing structure / pipe-to-soil potential records.
 - ii) Data regarding existing and proposed DC/AC power sources and systems using earth return path such as HVDC substations / earthing stations in the vicinity of the entire pipeline route.
 - iii) Crossing and parallel running of electrified and non-electrified traction.
 - iv) Crossing or parallel running of any existing or proposed EHV/HV AC/DC overhead power lines.
 - v) Data regarding Voltage rating, phases, sheathing details of underground power cables along ROW or in its vicinity.
 - vi) Topographic Survey for the ground plots of anode ground bed, CP stations etc if required.
- 1.04 On completion of all field work, a report incorporating all the results generated from surveys and details of additional data collected, detailed interpretation of survey results and resistivity (on semilog graph sheets) data, probable interference prone areas, selected locations for anode ground beds, etc. to form a design basis for the scheme of cathodic protection shall be prepared. This report shall also include various drawings prepared in connection with the above work.



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ANNEXURE-II

TECHNICAL REQUIREMENTS

FOR

ANODES & ANODE GROUND BEDS

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ANODES & ANODE GROUND BEDS

1.0 Sacrificial type Anodes & anode beds

- a) Anodes of type 1 as per ASTM-B-418 standard shall be used for seawater, brackish water or saline electrolyte application and anode of type II as per ASTM – B -418 standard shall be used for fresh water, back fill and soil applications.
- b) Zinc anodes where soil resistivity predominantly remains ranges from 0-10 ohm.m and pH value is within 9.
- c) Low potential magnesium anodes where soil resistivity range is from 10 ohm.m to 30 ohm.m
- d) High potential magnesium anodes along ROW where soil resistivity is in the range from 30 ohm.m to 50 ohm.m. In the area, where the resistivity is of the order of 50 ohm.m and above magnesium ribbon anodes shall be installed all along the pipelines by the side of the pipeline in the pipeline trench.
- e) Anodes shall be installed along the pipeline at suitable intervals (not more than 1000 m apart) as per pipeline protection voltage attenuation calculations and ground bed resistance/current output of anode installations. At high resistivity area the magnesium ribbon anodes shall be installed.
- f) Selected sacrificial anodes shall be checked for its suitability for the soil conditions with particular attention to carbonates, bicarbonates, phosphates, nitrates etc in the soil.
- g) The anodes shall be laid in proper type of back fill along with suitable safe guards against anode passivation in prevailing soil, such that the effect of soil is minimum on the anode effectiveness and life shall be taken by the contractor.
- h) Single type of anode shall be protected totally each section of electrically continuous pipeline
- i) The anode shall be installed at sufficient depth to reach moist soil.
- j) The anode shall be separated from the pipeline by at least 5m in case of magnesium anodes and 2 m for zinc anodes. The magnesium ribbon anode shall be separated from the pipeline by at least one meter.
- k) The anode connections to pipe line shall be routed through test stations.
- l) In case of temporary CP anode ground bed, the leads of all the anodes shall be joined together in a junction box filled with epoxy and buried. A single cable shall be routed from the junction box to test station.
- m) In case of sacrificial anode ground bed which is intended for permanent CP system and /or which is to be integrated with permanent CP system, the test leads of all the anodes shall be brought up to the test station and shall be terminated.
- n) The quantity of anodes at each ground bed shall be sufficient for providing the required protection current density considering the ground bed resistance, cable resistance etc.
- o) Any deficiency in the protection system if noticed during the commissioning or during the monitoring shall be corrected by the CP Contractor by suitably augmenting the system with additional anodes without any extra cost to Employer.

2.0 Anode Ground Beds of Impressed CP System

- i) Each CP station shall have an independent anode ground bed, shallow or deep well construction type.
- ii) Ground bed shall be located away from the pipeline and foreign pipeline / other buried metallic structures, at least by 100 meters away preferably in moist strata and as far as possible, horizontal ground beds shall be at right angles to the pipeline.
- iii) Anodes shall be of high silicon cast iron type or mixed metal oxide coated titanium anodes.
- iv) Sheet steel anode canisters of adequate size filled with petroleum coke breeze shall be provided for each anode. In case of deep well ground beds non-canistered anodes with petroleum coke breeze in the well surrounding the anodes shall be provided.
- v) Each shallow anode-bed shall be positioned horizontally or vertically in the soil with suitable backfill. The depth of anodes shall be minimum 2 meter from grade level.
- vi) Layout shall show anode installation details, anode grouping, anode wiring, anode cable routing, etc, the details of anodes, deep well casing, anode positioning, anode cable supporting, deep well gas venting, active, passive portions of the ground bed, etc.
- c) Anodes shall be supplied complete with tail cables, which shall be long enough for termination on without intermediate joints.
- d) In case of two parallel pipelines running in the same ROW, the anode ground beds of the respective pipelines shall be located on the respective sides of the pipelines.

3.0 CP for Cased Crossing



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i) The carrier pipe inside the painted or coated casing shall be protected by zinc ribbon anodes weld connected to the outer surface of bottom of carrier pipe extending up to hour hand positions of 4 and 8 O'clock. The anodes shall be at close intervals with minimum one number of anode installed between every two supports provided between carrier and casing. The anodes shall be sized based on the permanent CP design parameters for marshy area and design life of permanent CP system.

ii) In case, casing is coated, the casing shall also be protected by sacrificial anode installations provided at both ends of casing based on the permanent C.P. design parameters and design life of permanent CP system. Where casing is uncoated or unpainted additional protection for carrier pipe may not be required.

4.0 Details of Sacrificial type Anodes:**4.1 Magnesium Anodes**

i) The anode shall conform to the requirements of ASTM-B 843 standard. The anode shall be of high manganese, magnesium alloy packed with special back fill. The metallurgical composition, potential and consumption rate of anode shall be as below:

a) Metallurgical Composition

Element	Weight (High potential type)	Weight (Low potential type)
Manganese	0.5 – 1.3%	0.15 – 0.7%
Copper	0.02% max	0.02% max
Silicon	0.05% max.	0.1% max.
Zinc	--	2.5% - 3.5%
Aluminium	0.01% max	5.3% - 6.7%
Iron	0.03%	0.003 % max
Nickel	0.001% max	0.002% max.
Calcium	--	--
Other metallic elements		
Each	0.05% max	--
Total	0.3% max.	0.3% max
Magnesium	Balance	Balance
b) Anode open circuit potential	1.75 volts	1.55 volts
c) Anode consumption rate	7.9 kg/(A yr) max	7.9 kg/(A yr)max

4.2 Zinc Anodes

The anode shall conform to the requirements of ASTM-B 418 standard. The metallurgical composition of anode, potential and consumption rate of anodes shall be as below. The anode shall be packaged with special backfill except ribbon type anodes. The type of ribbon anode at cased crossing shall suit the type of soil outside the casing

i) Composition:

Element	Weight (Type I)	Weight (Type II)
a) Aluminium	0.1% to 0.5%	0.005 % max
b) Cadmium	0.025-0.07%	0.003% max.
c) Copper	0.005% max.	0.002% max.
d) Iron	0.005% max.	0.0014% max.
e) Lead	0.006% max.	0.003% max.
f) Others	0.01% max.	-
g) Zinc	Balance	Balance



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- ii) Anode open circuit potential 1.1 volts 1.1 volts
iii) Anode consumption rate 11.24kg/(A yr)max. 11.24kg/(A yr) max.

4.3 Miscellaneous Requirements

- a) The anodes shall be provided with cable tail of sufficient length to reach test station/buried junction box, without any intermediate joint in the cable and with minimum of 1 m cable slack provided at each anode and test station ends.
- b) The anode shall be pre packaged with special backfill of composition given below adequately and the thickness of back fill shall not be less than 50 mm on all the sides of the anode.
The composition of special back fill for anodes shall be as below:
Gypsum 75%
Bentonite 20%
Sodium Sulphate 5%
- c) The anodes for grounding of CP protected above ground pipelines at intermediate distribution portions etc, grounding of motor operated valves on CP protected portion pipeline, grounding of pipeline through polarisation cell at EHV/HV line crossings or running in parallel, etc, shall be minimum 20 kg net weight each of sacrificial anode of the same type as the one provided for the protection of the pipeline.

5.0 Anode for Impressed Current CP system**5.1 High Silicon Cast Iron Anodes**

- a) High silicon cast iron type anodes shall be center-connected hollow type or end connected solid type. Composition shall be as below and shall also conform to ASTM A518-86 Gr.III

Element	Weight
Silicon	14.2 – 14.75%
Manganese	1.5% max.
Carbon	0.7% - 1.1%
Chromium	3.25 – 5.0%
Copper	0.5% max.
Molybdenum	0.2% max.
Iron	Balance

- b) Surface current density rating of the anode shall not be less than 10A/sq.m. for continuous operation.
- c) Anode consumption rate shall not be more than 0.2 kg/AmpYr.
- d) Sheet steel anode canisters of adequate size shall be provided for each anode for shallow anode ground bed filled with petroleum coke breeze with following specification conforming to IS: 8502, Grade-A type.

Chemical composition of petroleum coke breeze.

Fixed carbon content by mass	:	99% min.
Ash by mass	:	0.5% max.
Moisture by mass	:	0.1% max
Volatile matters by mass	:	0.5% Max
Bulk density	:	800 kg/M3 to 1200 kg/M3
Real density	:	2.03 kg/litre min.
Particle size	:	1 mm max. dust free
Resistivity	:	0.1 ohm cm max at 150 PSI

For deep well ground beds, calcined petroleum coke breeze slurry conforming to above shall be supplied along with the anodes.

5.2 Mixed Metal Oxide Coated Titanium Anode.



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- i) Mixed metal oxide coated titanium anodes shall be of pure titanium having substrate composition of titanium of ASTM B 338, Grade II, over laid with mixed oxide of noble metals (MMO coated) and shall be dimensionally stable. The anodes shall be centre connected sealed tubular type.
- ii) The design life of anode under burial condition, at the design operating current in minimum be the design life of the CP system specified.
- iii) The guaranteed design parameters of anode regarding current density, consumption rate, design life, rated current output, dimensions, shape, noble metal oxide coating thickness (gm/square meter), their physical and mechanical properties shall be substantiated by manufacturer's published catalogues and backed up by type test reports.
- iv) The anodes shall be provided with sheet steel canisters and coke breeze as described for HSCI anodes above.

5.3 Each anode shall be supplied with anode tail cable connected to it, which shall be long enough for termination on anode lead junction box without intermediate joint and joint of anode and cable shall be carried out at shop before dispatch of anode and and the joint insulated.

5.4 For deep well ground beds steel pipe casing for active portion of the ground bed and non metallic pipe casing for the tope inactive portion of the ground bed shall be provided. Anode supporting pipe, anode centralisers and gas venting pipes shall be provided for the ground bed.

5.5 Heat Shrunk Anode Cap : Each Anode shall be provided with anode Cap to prevent from any environmental degradation. The Caps shall be moulded out of radiation cross-linked Polyethylene material which shall be heat shrinkable and matching with the anode size.

6.0 Testing

6.1 In addition to the requirements specified elsewhere in this Technical Specification, following shall also apply. Inspection, routine tests and final acceptance tests shall be carried out at manufacturer's works.

6.2 Sacrificial type Anodes & HSCI anodes

- a) Visual inspection on all the anodes regarding surface finish excessive shrinkage, cracks, cable joint to anode cone, etc.
- b) Dimensional weight check of minimum 10% of number of anodes from each heat.
- c) One anode per heat shall be subjected to radiographic test completely to evaluate cracks, voids, slag inclusion, etc.
- d) At least one anode per heat shall be subject to destructive testing for slag inclusions, bond between the anode material and steel inserts.
- e) One anode sample per heat shall be subject to chemical analysis by spectrographic method.
- f) Type test certificate for electrochemical test such as open circuit potential, anode consumption rate, Visual examination of corrosion pattern (uneven consumption, inter granular attack, etc) shall be submitted to Employer. The test should have been conducted within the last two years otherwise fresh electrochemical test on One anode from the lot to be supplied shall be conducted for this project.

6.3 Mixed Metal Oxide Coated Titanium Anode

All the tests listed above under CI 6.3 above shall generally applicable and the Contractor shall furnish list / details of the tests that will be conducted by manufacturer of anode and their acceptance criteria and the same shall be discussed and mutually agreed to.

6.4 Petroleum coke breeze and special back fill

The petroleum coke breeze material shall be tested for chemical composition, bulk density, real density, particle size and resistivity and test certificate shall be furnished. The special back fill material for the sacrificial anodes shall be tested for composition and test reports shall be submitted.



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ANNEXURE-III

TECHNICAL REQUIREMENTS

FOR

**CT STATIONS AND CP TRANSFORMER/RECTIFIER
UNITS**

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CP STATIONS AND CP TRANSFORMER / RECTIFIER UNITS

1.0 CATHODIC PROTECTION STATIONS

- Minimum two numbers of CP stations shall be provided one each at the either end of the pipelines. The number and exact locations shall be based on the corrosion survey data to be collected and as per the guidelines below.
- Availability of nearby low resistivity areas for location of associated ground beds may be ensured, as far as possible, for selection of CP stations.
- The requisite current drainage tests / survey shall be conducted by the contractor to establish the adequacy of CP current requirement, adequacy of number, ratings of CP stations for permanent CP system indicated in the data sheet.

2.0 CP TRANSFORMER RECTIFIER UNIT

Cathodic protection power supply module and Cathodic Protection Transformer Rectifier Unit (TRU) shall be located indoor inside a permanent enclosure and the same shall be provided by the Contractor. One TRU shall be provided for each CP station.

3.0 SPECIFICATION FOR TRANSFORMER RECTIFIERS

3.1 Scope

This specification covers the manufacture, testing and inspection of transformer-rectifiers for Cathodic Protection System.

- The transformer rectifier units shall be a standard product of a manufacturer regularly engaged in production of Cathodic Protection power supplies. The units shall be supplied in accordance with the following specifications and data sheets.

3.3 Applicable Standards

If not otherwise indicated on "Data Sheet", transformer rectifier shall meet the requirement of IEC Recommendations.

IEC 76 Power Transformer

IEC 404-2 Methods of measuring magnetic and electrical properties of magnetic sheet and strip for transformers.

IEC 287 Calculation of the continuous current rating of cables. IEC 144 Degree of protection of enclosures for low voltage switchgear and control gear.

IEC 146 Semiconductors convertors

IEC 296 Insulating oils for transformers and switchgear.

- When no. IEC standard exists,, the standards of the country of origin shall be used but the bidder must state this in his offer and be prepared to submit copies of said standards in the English language.
- NEMA Pub. No. MR-20-1953,, Reaffirmed by NEMA 1971,, 1975. Semiconductor rectifiers. Cathodic Protection Units.
- NEMA Standard Publication/No. 250-1979,, including Rev. No. 1 December 1980 enclosures for electrical equipment (100 volts maximum).
- ANSI 342 Practice and Requirements for Semiconductor Power Rectifiers.
- NEPA-70-1981 National Electrical Code.
- MIL-C-45662- Calibration systems requirements.

3.4 Transformer

The transformer will be the isolation type having separate primary and secondary windings. An electrostatic shield, composed of heavy copper foil, shall be placed between the two windings and grounded to the rectifier cabinet. The transformer core and windings shall be dipped in insulating materials to withstand 2,000 volts (RMS value at 50 hertz) applied for one minute between the windings and between each winding and the transformer core. Magnet wire insulation and transformer interlayer



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insulation shall be of class H type. Transformer lead wires will be not less than 500 circular mils of cross section area per ampere of A.C. Current carried at full load. The transformer will be dipped in thermo-setting varnish and baked. Transformer varnish will meet the standard for 155 degree C. operation. Actual transformer hot spot temperature rise will not exceed 85 degree C at full load in ambient temperature of 55 degreeC.

Transformer regulation will not exceed 3% from full load to 1/4 rated load. Transformer efficiency will not be less than 95%. Magnetic core losses at full rated output will not exceed 0.83 watts per pound.

3.5 Rectifying Elements

The power rectifier units will be Silicon Controlled Rectifier (SCR's) mounted on heat sinks of sufficient size to prevent the temperature rise from exceeding 100oC at rated ambient temperature 55 o C. The peak inverse voltage ratio of the SCR's will be 2. The SCR's will be sized for 200% full load current rating of T/R unit.

3.6 A.C. Input

The transformer rectifier units shall operate on 230 Volts AC(+ 20%) single phase, 50 Hz power.

3.7 DC Output

The rectifier shall be capable of operating continuously at rated load at any output voltage from zero to 100% without damaging any rectifier components.

Silicon Controlled Rectifier (SCR's) shall be used in the power circuit for control of the output voltage in automode.

The SCR's of the rectifiers will be controlled by commands from electronic circuit cards. These cards shall be the plug-in type printed circuit cards mounted on the front panel of the rectifier for easy field replacement. The printed circuit card contact pads will be gold plated to provide easy conduction and to eliminate contact corrosion. Completed printed circuit controllers will be sealed with a circuit card sealant to prevent atmospheric corrosion and fungus contamination. Separate fast fuse shall be provided for protection of each SCR/DIODE.

3.8 DC Output Adjustments / Control

i) The DC output control shall be capable of operating in any of the following modes, with the help of a selector switch.

ii) Manual Mode:

Output voltage control at 2 volt steps from 0 V shall be available by means of coarse and fine tap changing switches.

iii) Auto Mode :

A constant current control will be provided to set the output current to any value up to the rectifier rating. The output current shall not vary more than 1% while the output voltage may vary from zero to 100% depending upon the setting of the voltage control potentiometer. In the constant current mode, the voltage control potentiometer may be used to set the output voltage limit to a desired value.

3.9 DC Output Ripple

The single phase rectifiers shall have an output ripple not to exceed 5%.

Input Over Load Protection

Protection from over loads on the input will be provided by moulded case, magnetic circuit breakers on the input side. These circuit breakers will hold at 100% of rated load. They may trip between 101% and 125% of the rated load and must trip at 125% and above. The trip point will be unaffected by ambient temperature. Circuit breakers will be the manually reset type. The trip handles of individual pole circuit breakers will be mechanically linked so all lines are opened when an overload occurs.

3.10 Output Overload Protection

Protection from overload on the output will be provided by an electronic current limiting feature. The current limit is to be set by current limit switches marked "coarse" & "fine". The coarse switch shall give limit of 0, 15A, 30A, 45A, 60A, 75A and so on upto required current level in steps of 15 A, while fine switch shall give limit of 0. 3A, 6A, 9A, 12A, 15A. The limit of the two switches shall be algebraically additive and shall give required steps of 3A each. The maximum current limit can be set by operator at any desired value in 3A step and in any circumstances even in case of short circuit the output current

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should not exceed the maximum set current limit. In addition to above current limiting feature HRC fuse of suitable ratings to be used at positive and negative terminals to disconnect T/R unit quickly in case of over loads in the output circuit.

3.12 Voltage Surge Protection

Each silicon controlled rectifier (SCR) shall be protected from voltage surges by means of RC circuitry. These devices will be rated such that they will conduct heavily before the peak inverse voltage rating of the SCR's is exceeded. In addition, lightning arrestors shall be provided in the AC input and DC output circuit of the rectifier.

3.13 Cooling

The rectifiers will be natural air cooled capable of operating simultaneously at rated output in ambient temperature of 55 degrees C.

3.14 Input and Output Terminals

DC terminals shall be located convenient to the cable entrance and shall be solderless pressure type terminals of tin plated copper. Output terminals shall be suitable for 50mm square cable cross section. Two negative and one positive output terminals shall be provided.

AC terminals shall be insulated to withstand 2000 volts 50 Hz to the enclosure, shall be shielded to prevent accidental contact and shall be sized to take cable sizes of 25mm².

3.15 Meters

The transformer rectifier units shall be equipped with a separate continuous reading voltmeter and ammeter for the DC output and for the AC input voltage and current. These meters shall have a full scale capacity at least 10% above the output rating of the unit.

The transformer rectifier units shall also be supplied with a 0 to + 2.5 volt corrosion voltmeter with a 10 megaohm input impedance. This meter shall be connected to a two-way on and off selector switch to allow structure to electrolyte potential measurements to be taken with respect to either of two reference electrodes. This meter is not intended to control the output of the transformer rectifier.

All meters shall be electronic digital type with LED display arrangement and should be able to indicate the current and voltage ranges as per data sheet upto three decimals. Digit size should be 15mm x 10mm (minimum). Meters shall be rectangular in shape and accurate to within + 2% of full scale at 55 o C. They shall be temperature compensated to vary no more than 1% per 10% temperature changes.

All ammeters and voltmeters shall be provided with separate fuse and toggle switch.

3.16 Annunciation

Each transformer rectifier shall be supplied with a continuous signal light which will go out at loss of AC input. This light will be mounted on the top of the transformer rectifier unit.

3.17 Enclosures

All transformer rectifier units shall be located in non-classified area, shall be housed in air cooled enclosure vermin proof and shall be in IP 55 as per IEC or ISIS standards. Minimum cabinet thickness shall be 12 SWG.

Accessibility shall be provided by hinged and removable front and sides or by hinged doors and removable chassis. A Plexiglas viewing window shall be provided to allow the meters to be read without opening the transformer rectifier unit.

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The enclosure shall be supplied with an engraved warning label with the words "DANGER". Transformer rectifier enclosure shall be furnished with gland plate mounted with double compression cable glands for the AC input, DC output and potential measurement cables as per the data sheet.

After fabrication the entire enclosure shall be sand blasted to Sa 2 1/2 SURFACE. An inorganic zinc primer shall then be sprayed to a total thickness of 3 mils. The finish coat shall be a dark Grey shade of polyamide cured epoxy in three coats to achieve total thickness of 15 mils.

3.18 Enclosure Earthing

All normally dead metallic parts shall be electrically continuous, one earthing terminal suitable for 25mm square cable connection shall allow their connection to power supply earthing and two earthing terminals suitable for 35mm square cable connection shall allow an electrical connection to the local earthing pit.

3.19 NAME PLATE

A permanently stamped metal plate shall be attached to the outside of the case with the following information:

- (a.) Manufacturer's name
- (b.) Year of manufacture
- (c.) AC input voltage and current rating
- (d.) AC frequency
- (e.) Phase
- (f.) Maximum output DC Volts and Amps rating
- (g.) Weight in Kg of T/R unit
- (h.) Model number
- (i.) Serial number

3.20 Data Sheet of T/R Units

The parameters for which the TR set is to be sized is given below. These represent a minimum requirement:-

Description	Data
a) AC Input Voltage	: 415/230 volts + 10%. 50 Hz three/single phase
b) DC Power Output	: As per system requirement
c) DC Output Voltage	: As per system requirement
d) DC Output Current	: As per system requirement
e) Current rating for Diodes/SCR's	: 100% excess current capacity of T/R unit.
f) Full load Efficiency of Transformer Rectifier Assembly	: More than 75%
g) Full load Efficiency of Transformer alone	: More than 95%
h) Power Factor	: 0.9 lagging
i) Insulation level	: 2 KV
j) Peak Inverse Voltage of diodes/SCR's	: 2 KV
k) Filtering Circuit	: L.C. Filter
l) Ripple & Hum at rated output	: Less than 5%
m) Surge Diverters foR Diodes/SCR's	: R-C circuitry
n) Lightning Arrestor	: At both input and output side of the T/R unit of voltage rating 280 V RMS, Max. Spark over voltage 3.0 KV Current discharge capacity 10 KA.
o) Protection	: MCB having thermal over load and magnetic short circuit protection for input in addition to separate HRC fuse protection for each SCR/diodes and at output positive(+), Negative terminals.
p) Meters/Instruments	: As per Sec. 3.1.13 1 No. DC Voltmeter



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|---------------------------|---|---|
| | : | 1 No. DC Ammeter |
| | : | 1 No. AC Voltmeter |
| | : | 1 No. Corrosion Meter : + 25000 MV |
| | : | voltmeter with 10 megohm input resistance. |
| q) Enclosure | : | As per Specification. |
| r) Construction | : | Floor mounted indoor type |
| s) Cooling | : | Air cooled |
| t) Cable Entry | : | Through double compression gland for required sizes of cables |
| u) Enclosure painting | : | As per Specification |
| v) Fabrication, Schematic | : | Contractor to furnish prior to and wiring diagram fabrication of T/R units. |
| w) Spare Parts | : | Supply as per Specification. |

3.21 TEST CERTIFICATES

The following test certificates/ documents are to be furnished by the Vendor before shipment of material and equipments.

All major material and equipments e.g. T/ R unit, CP System Distribution Board, cables etc. shall be tested and inspected by BHEL or its representative.

Following routine tests shall be done by manufacturer as per any approved international codes.

- Efficiency test of Transformer Rectifier Assembly at 25%, 50%, 75% and 100% rated current. Efficiency test of transformer alone after isolating rectifier at 100% rated current.
- Heat run test for max. temp. rise test of winding at 100% rated current after continuous operation of 48 hours (min.)
- Ratio and polarity test at 25%, 50%, 75% and 100% rated for all T/ R units.
- Insulation resistance test at 2 KV between Primary and Secondary, Primary and earth, secondary and earth for all T/ R units.
- The electronic current control feature of T/ R unit to be tested by varying supply voltage 25% and changing load resistance 100%.
- The electronic current limiting feature of the T/ R unit to be tested by short circuiting positive and negative terminals of the T/ R unit and setting max. current limits at any desired values in steps of 3a.
- Calibration tests of Ammeters & Voltmeters of all T/ R units.

3.22 DRAWINGS/ DOCUMENTS

Fabrication drawings and data sheet of T/ R unit with all dimensions, ratings and weight in final issue, including installation/ foundation arrangement details.

Front view and typical section of T/ R unit panel with arrangement of equipment, control, protection and metering.

Data sheet of all accessories and circuit element of T/ R unit including ratings.

Schematic and wiring diagram of T/ R unit circuitry including Auto/ Manual Mode of control.

Fabrication drawings, connection scheme details and data sheet of Distribution Board with all dimensions, rating and weights in final issue including mounting details, Instruction/Operation and maintenance manual submitted as per Employer's requirement after award of Contract.



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ANNEXURE-IV

TECHNICAL REQUIREMENTS

FOR

TEST STATIONS

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TEST STATIONS (COMMON FOR SACRIFICIAL & ICCP SYSTEM)

- 1.0 Test stations shall be provided along the ROW (Right of Way) considering the following design criteria, for monitoring the performance of the CP system and bonding of pipe lines in common pipe trench or ROW at intervals not exceeding 1000m. Test Stations shall have, besides pipe-to-soil potential measurement and bonding facilities, four terminal facilities for line current measurement.
 - a) At sacrificial anode ground beds and at all insulating joints. Test station shall have terminal facility for connection of grounding cell to pipeline. Besides terminals shall also be provided for pipe-to-soil potential measurement on both shoulders of joint.
 - b) At both sides of metallised road crossings, major river crossings, cased crossings and at crossings of other pipelines / structures.
 - c) At locations with drastic changes in soil resistivity.
 - d) At railway line crossings and along lines running parallel to the pipeline.
 - e) At EHV/HV, AC/DC overhead line crossings, at locations where EHV/HV overhead line is in the vicinity of the pipeline, at EHV/HV cable crossings or along routes where EHV/HV cables are running in parallel.
 - f) In the vicinity of DC networks or grounding system where interference problems are suspected.
 - g) At locations of pipe distribution valve stations.
 - h) At locations of surge diverters, polarization coupons, pipeline grounding through polarisation cells, zinc and magnesium anodes, reference cell, and electrical resistance probe installation etc.
 - i) At crossing of other foreign pipe lines (bonding facility with resistor shall be provided).
 - j) At any other locations required by Employer during commissioning & testing period.
- 2.0 Test stations used for sacrificial anodes shall have shunt for measurement of anode current, provision for resistance insertion to limit the anode current output and anode disconnecting link. Test stations for bonding shall be provided with shunt and resistor as a means to monitor and control current flow between the pipeline and foreign pipelines or structures that may exist in common ROW.
- 3.0 Current measuring facility shall be provided at interference prone areas, on both sides of major river crossings, near marshy areas and minimum one for every 5 Km maximum along the pipeline and at each CP station drainage point.
- 4.0 Test stations at location of insulating joints shall be installed independently. Details of terminal facilities and connection schemes for individual type of test station/ current measuring station/ test-cum-bond station shall be as per relevant standards.
- 5.0 The location of all the test stations shall be marked with their connection schemes and other relevant information on alignment sheets as a part of detailed engineering. A test station schedule shall also be prepared.
- 6.0 Potential test-cum-bond station provided at regular interval as a means to bond, monitor and control current flow in structures laid in common ROW/trench. These potential test-cum-bond station shall allow detection and mitigation of any interference on foreign structures that may result from operation of this CP system.
- 7.0 Test stations, facing the pipeline shall be provided with nameplate of anodised aluminium with black back ground and white letters fixed to the inner side, with the information such as chainage in km, connection scheme, distance from pipeline in meter, direction of water flow etc.
- 8.0 Minimum two cables from the pipeline shall be provided at any test station and twenty percent spare terminals shall be provided. A detailed test-station schedule shall be prepared before implementation and got approved from Employer.
- 9.0 Test station enclosure shall be made of sheet steel of at least 3 mm thickness and shall be suitable for GI pipe post mounting. Test stations shall have weatherproof enclosure having degree of protection IP-55 or better and hinged locked shutter. The inner and outer surface of test stations shall be epoxy painted.



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- 10.0 The resistors for control of current provided in the test stations, anode/cathode junction box. etc shall be of variable, grind coil type. The resistors shall be suitable for operation over the design life for the permanent CP system specified in the project specification/data sheet. At the locations of solid state polarisation cells the test station size be suitable for mounting the polarisation cell inside the test station.

BOX TYPE

- 2.01 The box shall be of stainless steel. It shall be suitable for use in highly corrosive environment.
- 2.02 The box shall have a removable gland plate at its base. A hinged detachable front facing shall be provided with a minimum of one locking point. A suitable lock shall be provided along with two (2) sets of keys. The box shall be weather proof IP 55 or better and sealed against the ingress of dust and moisture, exceeding the requirements of British standard 5490: 1970. Both the gland plate and the lid shall be provided with scaling gaskets. Cork gaskets are not acceptable.
- 2.03 The box shall be provided with a rail mounted termination panel affixed to internal standoff tapered pillars, allowing adequate clearance behind the termination panel.
- 2.04 On completion of all welding, drilling and other fabrication operations, boxes shall be provided with a coat of primer and two coats of epoxy painting of suitable shade both internally and externally.
- 2.05 Details of the nominal dimensions of the box along with proposed interior mounting and fitting shall be to approval of BHEL.
- 2.06 The boxes shall be frame mounted such that their horizontal centreline is approximately 1.5m above grade. Details of the proposed frame shall be to BHEL approval. Each zinc rod shall have copper cable of minimum 3m length to reach test station.

The entire grounding cell consisting of zinc rod surrounded by backfill with an overall dimension of 515X515X1500 mm shall be laid underground at a minimum depth equal to pipe burial depth and adjacent to pipe.

- 2.07 Each box type TLP box shall be labelled individually. The labels shall be engraved to give white letters on a black background and shall be securely attached to the door. Approximate dimensions shall be 50 mm by 150 mm.

CLEAT TYPE

- 3.01 A carbon steel cleat/ plate of 3" X 3" or as approved by BHEL is to be welded below the first above ground flange wherever pipes emerge overground. At the centre of this cleat plate in a predrilled hole, brass nut head is to be fixed to serve as measurement point.
- 3.02 A carbon steel nut to be welded from the nut head side, below the first overground flange, whenever the pipes emerge overground to serve as measurement point.



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ANNEXURE-V

TECHNICAL REQUIREMENTS

FOR

MISCELLANEOUS EQUIPMENT



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1.0 POLARISATION COUPONS

- 1.1 To monitor the adequacy of the CP system to polarize / protect coating holidays steel coupons of pipeline material shall be provided along the pipeline at CP station drainage points, predicted cathodic protection mid points along the pipeline, at locations where the pipeline is bonded, interference prone areas, at locations such that minimum one coupon is installed for every 10 km approximate. The coupons shall be constructed from the pipeline material and shall have uncoated surface of 100 mm x 100mm exposed to soil. Two cables one for connection to pipeline for protection and other for potential measurement shall be provided for each coupon. The protection cable shall be connected through a magnetic reed switch inside the test station to enable measurement of coupon 'OFF' potential. A permanent reference electrode shall be installed adjacent to the coupon in a manner so as to measure the representative potential of the coupon. Magnets for operation of reed switch shall also be provided.
- 1.2 The polarisation Coupons shall be made from the material of the pipeline. The coupon shall have one side exposed area of 100 mm x 100 mm. Cable connection of 10mm² and 4 mm² shall be provided to the coupon for connecting it to pipeline for cathodic protection and potential measurements respectively. Connection of coupon to pipeline shall be through a vacuum sealed magnetic reed switch housed inside the test station. The magnetic reed switch shall be rated to carry and break minimum 50mA at 50 V DC.

2.0 SURGE DIVERTER AND POLARISATION CELL**2.1 Surge Diverter**

- i) Explosion proof spark gap surge diverter shall be provided across each insulating joint to protect it from high voltage surges. coming across it due to lightning strikes, electrical faults, etc. on the above ground portion of the pipeline. The surge diverter shall be of spark gap type. The device shall have weatherproof enclosure suitable for out door mounting. The surge diverters shall be of explosion proof type.
- ii) The minimum ratings of the device shall be as below:-
- | | | |
|------------------------------------|---|----------------------------------|
| a) Type | : | Spark gap, explosion proof type. |
| b) Current, 8/20 micro second wave | : | 100 Kilo Amp. |
| c) Spark – over AC voltage | : | |
| - 50 Hz | : | 1 KV |
| - Impulse (1.2/50 microsecond) | : | 2.2 KV |

2.2 Polarisation Cell

- i) At each crossing or parallel run of pipeline and overhead 66 KV and above EHV lineS, the pipeline shall be grounded through polarisation cell with zinc galvanic anodes of minimum 20 kg net each. In case transmission lines are running parallel within 25 meters of the pipeline, the Grounding shall be done at regular intervals of maximum 1 km to control any surges.
- ii) The Polarisation cell shall be installed inside test station. The minimum ratings of the device shall be as below:-
- iii) Polarisation cell shall be a solid state device designed to simultaneously provide isolation for DC current and low resistance path for AC current. The device shall have weather proof enclosure and shall be suitable for mounting inside a test station. the DC blocking voltage shall not be less than 1.2 volts. The DC leakage current at 1.2 volt shall not be more than 0.5 mA. The minimum ratings of the device shall be as below:-

DESCRIPTION

RATING

- 50Hz steady state current
- AC fault current
- AC voltage under maximum
rated AC fault current

35A min at 650C and min 2V DC
6 kA min for 1 cycle, 3.5kA min for 30 cycles
Less than 10 V peak to peak



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- 2.3 The surge diverter and polarisation cell system shall be suitable for the design life of permanent CP system.
- 2.4 Motor operated valves (MOV) where located on the cathodically protected portion of the pipeline shall be grounded by a zinc anode of 20 kg net where the type of anode provided for the CP system of the pipeline is zinc or magnesium respectively.
- 2.5 The above ground cathodically un-protected pipeline at terminals, intermediate distribution stations, etc. shall be earthed with GI earth electrodes and resistance to earth of grounding shall be limited to 5 ohms max.. Each electrodes shall be 100 mm dia, 3000 mm long, and 13 mm thick conformity to IS 3043.

3.0 PERMANENT REFERENCE CELLS

- High purity copper / copper sulphate reference cells (Silver/Silver Chloride type in place of copper / copper sulphate cells at marshy area locations, where water table is high and chloride concentration is more than 300 ppm) shall be provided for potential measurement of stable coupon to soil at the locations of polarization coupons and at CP stations of Impressed Current CP System.
- The test station connection scheme shall clearly indicate the type of the reference electrode (Cu CuSO₄/Ag AgCl).
- The permanent reference cells shall have a required design life under installed / buried condition and in high resistivity area, the same shall be suitable for the prevailing dry soil conditions.
- The permanent reference cells shall be installed in natural soil conditions as per the recommendations of the cell manufacturer.
- The reference cells shall be provided with cable tail long enough for connection to without any joint in between up to CP power source at CP stations and up to test stations at the locations of polarization coupons. The cable up to CP power source shall be routed through test stations near pipelines.

4.0 ELECTRICAL RESISTANCE PROBE

- At the bottom portion of pipeline, Electrical resistance probes (E/R probes) utilising the electrical resistance technique shall be provided along the pipeline at marshy areas (if applicable) and at vulnerable location to monitor the external corrosion activity on the pipeline.
- The material of the E/R probe element shall be of the same alloy as of the pipeline material.
- The lead-wires of the probe shall be connected to pipeline through test station and terminated inside test station enabling periodic resistance measurement of the probe using a portable probe measuring instrument.
- One number Portable E/R probe reading instrument shall be supplied and the same shall be suitable for use in field and shall have IP 55, weatherproof enclosure. The probe reading instrument shall be of digital type with 3.5 digit display. The instrument shall run on rechargeable batteries. The instrument shall be able to directly read out the resistance of probes.

5.0 REFERENCE CELL ACCESS POINTS

Reference cell access points near insulating joint locations wherever the ground is paved, for measurement of pipe to soil potentials shall be provided. A perforated PVC pipe filled with native soil and buried at the location shall be provided for the purpose. The length of the PVC pipe shall be adequate to reach the native soil below the paving.

6.0 ANODE JUNCTION BOX

- Each ground bed shall be provided with one or more anode junction boxes depending on the size of anode ground beds, All tail cable from individual anodes shall be terminated onto the respective anode junction boxes, which shall be further connected to the main anode junction box (where applicable) which in turn shall be connected to the cable coming from CP power source.
- Junction boxes shall have sheet steel enclosure of minimum 3 mm thickness and hinged lockable shutters and shall be weatherproof with degree of protection IP – 55. It shall be epoxy painted on inside and outside surface.
- Junction boxes shall have anode bus of copper with nickel/ silver plated or tinned.



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- iv) Provision shall be made for measurement and control of individual out going circuit /anode current by providing suitable shunt and resistors of grid coil type and each outgoing circuit shall be labeled.
- v) Disconnecting links shall be provided for each out going / anode circuit. 30% spare out going circuits shall be provided in each anode junction box.
- vi) A nameplate of anodised aluminium with black back ground and white letters shall be fixed to the inner side of the junction box shall be provided with the information such as Ground bed current rating, Ground bed resistance, Connection scheme, Distance from pipeline and CP station in metres.

7.0 CATHODE JUNCTION BOX

- i) A cathode junction box shall be provided near the pipelines - wherever output of the CP power supply unit is connected to multiple pipelines-at the location of connection of the negative drainage cable to the pipelines.
- ii) The negative of the CP power source shall be connected to the incoming circuit of the cathode junction box. The junction box shall have separate out-going circuit one for each pipeline to collect the negative drainage currents from each of the parallel pipelines.
- iii) The incoming circuit shall have a current measurement shunt. Each out going circuits shall have isolation link, variable resistance of grid coil type and a current measurement shunt. One number spare outgoing circuit shall be provided.
- iv) Junction boxes shall have sheet steel enclosure of minimum 3 mm thickness and hinged lockable shutters and shall be weatherproof with degree of protection IP – 55. It shall be epoxy painted on inside and outside surface. Identification labelling shall be provided for each terminal and shall clearly indicate the size and identification of the pipeline to which it is connected.
- v) A nameplate of anodised aluminium with black back ground and white letters shall be fixed to the inner side of the junction box shall be provided with the information such as Chainage in KM, Connection scheme, Direction of flow in pipeline, Distance from pipeline and CP station in metres.

8.0 CABLES

- i) Cables shall be with annealed high conductivity stranded copper conductor, PVC insulated, 650/1100 V grade, armoured, PVC sheathed conforming to IS 1554 Part – I, except for the cables for anode tail, reference cells and pipeline for potential measurements.
- ii) The minimum size of the copper conductor shall be:
 - a) 6 sq.mm (minimum) for anode tail cable from anode to buried junction box or test station (in case of permanent CP anode ground bed).
 - b) 10 sq.mm (minimum) from buried junction box to test station and from test station to pipeline.
 - c) 10 sq.mm (minimum) for polarisation coupon protection cable.
 - d) 25 sq.mm(minimum) for bonding, polarisation cell, grounding anodes and surge diverter connections or shall be suitable for the maximum fault current.
 - e) 35 sq.mm (minimum) for positive & negative drainage cables and 10 sq.mm for anode tail cables of ICCP System
 - f) 6 sq.mm for current measurement.
 - g) 4 sq.mm (minimum) copper conductor, 650/1100V grade, PVC insulated, armoured, PVC sheathed for the TRU incomer cable. The cable shall be of 3 core type for single phase units and of 4 core type for 3 phase TRU.
- iii) The length of anode tail cable shall be sufficient for routing from anode to buried junction box or test station for anode for temporary CP or permanent CP respectively.
- iv) The cables for reference cells, coupon and pipeline potential measurements shall be of 4 sq.mm copper conductor, PVC insulated, Aluminium backed by mylar / polyester tape shielded, PVC sheathed, armoured, PVC over all sheathed type.
- v) The anode tail cables shall be PE insulated, 650V grade, unarmoured, PVC sheathed and length shall be sufficient without any joint in between.

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- vi) Cable conductor sizes indicated above are minimum only and higher sized cables shall be provided for proper operation of the CP system.

vii) Cable Laying

- Cables shall be laid in accordance with layout drawings. No straight through joint shall be permitted. Cable route shall be carefully measured and cables cut to required length. Minimum one meter cable slack shall be provided near anodes, anode junction box, pipeline and test stations to account for any settling.
- All cables inside station / plant area shall be laid at a depth of 1.0 metre. Cables outside station / plant area shall be laid at a depth of minimum 1.5 metres.
- Cables shall be laid in sand under brick cover and back filled with normal soil. For cables laid outside the station / plant area, polyethylene warning mats shall be placed at a depth of 0.9 metre from the finished grade, to mark the route.
- In case of above ground cables, all unarmoured CP cables shall be laid in GI conduits for protecting against the mechanical damage.
- All underground unarmoured cables including anode tail cables shall run through PE sleeves. Permanent reference cell cables routed along the pipeline shall be carried at the top of the carrier pipe by securely strapping it at intervals.
- PVC pipes of proper class & size shall be provided for all underground cables for road crossings.
- The cables for reference cells and pipeline potential measurement shall be routed in a separate trench other than the trench provided for the rest of the CP system cables, AC cables for TRU units etc.
- The armour of the cables from CP station to test station (potential measurement, reference cell & drainage cables etc.), CP station to ground bed (anode cable) and test station to pipeline shall be earthed only at CP station end and test station end respectively of the cables. The cable armour shall be insulated to avoid armour carrying CP current.

viii) Cable to Pipe Connections

- Connections of all cables other than cathode drainage cables to the pipeline or to charged pipelines shall be made by low temperature thermit welding as per the established procedure and anode cap shall be filled up with Epoxy hardener. The strength of the joint shall be tested by striking with hammer. The resistance of the cable to pipe at the pin brazing connection point shall not exceed 0.1 ohm.
- The cathode drainage cable shall be connected to a bolt welded to a metal plate, which is weld connected to the pipeline. The material of the plate shall be same as that of the material of the pipeline.
- Pipe coating shall be repaired after connection of cable to pipeline. The coating repair material shall be compatible with the original coating and shall prevent ingress of water along the cable surface and at the interface of coating repair with the original pipe coating.

ix) CABLE TERMINATION

- The cables shall be taken through double compression glands inside all equipment/ panels.
- Termination of cables shall be done with crimped heavy duty copper lugs supplied along with the equipment with proper crimping tools.
- Control cables of single strand shall be directly terminated on to the terminals. An aluminium tag/ PVC ferrule for identification of the cable shall be attached to each cable at both ends. Power cables shall be identified with red, black and blue PVC adhesive tapes/ sleeves.

x) CABLE IDENTIFICATION

- All cables will be identified and labelled at terminal blocks of test station and transformer rectifier.

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- b) To this purpose, coloured heat shrinkable sleeves will be supplied for use as per following colour code key:

Structure to protect	:	Black
Structure to T/R U connection	:	Red
AJB to T/R U	:	Red
Casting Pipe	:	Blue
Plant side shorting connection	:	Green/Brown
Monitoring connection	:	Black : White
Reference cell		
Half cell	:	Yellow
Structure	:	Yellow/Green
Anode to JB	:	Black

9.0 THERMIT WELDING

Thermite welding shall be used for cable attachment to steel or iron with metallurgically limited usage. This process enables copper to be welded to steel or iron without the use of welding equipment. The temperature of the reaction is such that the surface layer of base metal undergoes a metallurgical change by both heat treatment and partial alloying with the copper content of the thermit charge.

Because of the intense reaction, extreme care shall be taken in preparation and firing together with the correct choice of attached cable size, change and mould.

9.01 Both horizontal and vertical connections can be achieved in the following manner:

- Clean off a 50X50mm area to clean, bright dry metal
- Cut back 50mm of insulation from the cable; keep clean, dry and grease free.
- Insert cable into slot in bottom of mould and place squarely on the cleaned area.
- Break open the charge cartridge and upend the powder into centre mould after placing metal retainer disc in bottom. Ensure that the fine starter powder which sometimes gets left behind in the container, is shaken onto the top.
- Hold mould firmly onto pipe, shut the lid, and spark off with a flint gun.
- Allow to cool for thirty seconds and remove mould.
- Tap off slag and test adhesion when cool by a sharp sideways rap with a 2 lb hammer.
- Carefully mould over the top using material compatible with the pipeline coating.
- The thermit welded joints shall then be appropriately encapsulated by epoxy encapsulation as stated elsewhere.



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9.02 The same parameters shall apply for the brazing method and type of charge necessary for welding to advice on the bond size and type of charge necessary for welding to be approved at site (by the inspecting authority/ BHEL).

9.03 Each thermite weld connection will basically require the following equipment :

- a. Thermite well mold.
- b. Thermite weld metal.
- c. Thermite weld cap
- d. Steel disc.
- e. Copper sleeve
- f. Flint ignitor.
- g. Mould packing.
- h. Epoxy encapsulation kit.

9.04 THERMIT WELDING EQUIPMENT**9.04.1 Connections for Cathodic Protection****i) Steel pipes**

Place end of cable under centre of top hole. For weld to steel pipe smaller than 100mm, place end of cable even with far side of tap hole. On all type HA welds, pack cable opening with packing material. Hold down mould cover to prevent mould from tipping.

9.04.2 CARTRIDGE**i) For Steel Pipe**

Cartridge supplied with starter power and metal retainer disc:

Cartridge No.	Copper/ Steel	No in box
F33-15	*2.5-10 sq.mm	20
F33-25	16 sq.mm	20
F33-45	25-35 sq.mm	20
F33-65**	50-70 sq.mm	20

Use sleeve with 2.5 sq.mm.

ii) For Iron Pipe

Cartridge No.	Copper/ Steel	No in box
XF19-25	*2.5-10 sq.mm	20
XF19-45	16-25 sq.mm	20
XF1965	35-50 sq.mm	20

9.04.3 ACCESSORIES

Moulds: Type HA for Steel, Type HB for Iron, Type HC for trough (50-100 fires per mould)
Flint Cun, Scrapper, Cu sleeves for 2.5 sq.mm cable, Wire Brush, Rasp.



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ANNEXURE-VI

LIST OF APPROVED SUB-VENDORS

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The bidder shall select the make of components of cathodic protection system from the reference list below. However, the bidder may propose name of additional sub-vendors based on their experience, which will be subject to BHEL/NTPC approval. The details of manufacturing facility, experience, customer certificates etc for any such proposed sub-vendor shall be enclosed with the offer. The proposal for additional sub-vendor at contract stage will not be entertained.

All makes shall be subject to customer approval during details engineering without any Commercial or delivery implication to BHEL.

- | | | | |
|-----|--------------------------------------|---|--|
| 1. | MMO anode | : | Matcor (USA), Tyco Adhesives (USA), Berry plastics (USA) or equivalent make |
| 2. | Conductive Polymer anodes | : | Raychem (USA) |
| 3. | Transformer Rectifier Unit | : | Raychem RPG Ltd., Kriston Systems, Advance Electronics |
| 4. | Anode and Cathode JBs | : | Baliga Lighting Equipments Ltd., Cooper Crouse-Hinds, Flexpro Electricals, Flame Proof Equipment Pvt. Ltd., CEAG Flame Proof Control Gears, further refer list below |
| 5. | Calcined Petroleum Coke Breeze | : | Loresco DW3 (USA), Goa Carbon, Indian Carbon, Petrocarbon & Chemical Company |
| 6. | Permanent Reference Electrodes | : | Harco (USA), Borin Manufacturer (USA), M C Miller (USA), Corrttech (Zulu), AES (Baroda) |
| 7. | Portable Reference Electrodes | : | M C Miller (USA), Tinker Rasor, Corrttech |
| 8. | Heat Shrink Cap Anode to cable joint | : | Raychem (USA), Matcor (USA) |
| 9. | Digital Multimeter | : | Beckmann, Fluke, AVO, KEW, further refer list below |
| 9. | DC clip on Ammeter | : | HCK (Germany), Kyoritsu Electrical (Japan) |
| 10. | Cables | : | Refer below table |
| 11. | MCCB/ MCB for PDBs | : | Siemens, L&T, MDS, Indo Asian, AEG, Hager, Havells, ABB, Merlin Gerin, further refer list below |
| 12. | Other equipment | : | Subject to BHEL/ customer approval. Further refer list below |



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2	1.1 KV Ppower cable	1	Q-02		Universal Cable Ltd.	Satna
	(PVC & XLPE)					
					NICCO	Shamnagar , Kolkata
					Torrent Cable Ltd	Nadiad
					Incab	Pune
					Hindustan Vidyut Products Ltd	Faridabad
					KEI Industries	Bhiwadi
					Delton Cable Ltd	Faridabad
					Paramount Cable	Khushkhera
					Polycab Wires Pvt. Ltd	Daman
					Gemscabs Industries	Bhiwadi
					Cords Cables	Bhiwadi
					Havells India Ltd.	Alwar
					Sri ram Cables	Bhiwadi
					Ravin Cables	Pune
					Thermocables	Hyderabad
					Sbee Cables	Bangalore
					Suyog Cables	Vadodara
					Gupta Power Cables	Bhubaneswar
					Finolex	Pune
					Scot Innovation wires & cables	Baddi
					Anhui Hualing	China
					LS Cable	Korea
					Radiant Cables	Hyderabad

					KEC International	Vadodara
					Manisfield cables	G.Noida
					Diamond Power	Vadodara
					Crystal Cable	Kolkata
					Apar Industries	Umbergaon
					Krishna Electricals	Gwalior
					Special Cables	Rudrapur
					Dynamic Cables	Jaipur
					Tirupati Plastomatics	Jaipur
					Govind Cables	Kolkata
					Goyolene Fibre	Daman
					Chandresh Cables	Gandhinagar



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3	1.1 KV Control cable	I	Q-03		NICCO	Shamnagar , Kolkata
					Torrent Cable Ltd	Nadiad
					Incab	Pune
					Polycab Wires Pvt. Ltd	Daman
					Hindustan Vidyut Products Ltd	Faridabad
					KEI Industries	Bhiwadi
					Delton Cable Ltd	Faridabad
					Paramount Cable	Khushkhera
					Gemscabs Industries	Bhiwadi
					Cords Cables	Bhiwadi
					SPM Cables	Hyderabad
					Elkay Telelink	Faridabad
					Havells India Ltd.	Alwar

					R.R. Kabel	Silvasa
					Ravin Cables	Pune
					Gupta Power cable	Bhubaneswar
					Thermocables	Hyderabad
					Finolex	Pune
					Sbee Cables	Bangalore
					Suyog Cables	Vadodara
					Universal Cables	Satna
					Scot Innovation wires & cables	Baddi
					Anhui Hualing	China
					LS Cable	Korea
					Radiant Cables	Hyderabad
					KEC International	Vadodara
					Manisfield cables	G.Noida
					Diamond Power	Vadodara
					Crystal Cable	Kolkata
					Apar Industries	Vadodara
					Krishna Electricals	Gwalior
					Special Cables	Rudrapur
					Govind Cables	Kolkata
					Incom	Delhi
					Sam Cables	Rudrapur
					Advance Cables	Bangalore
					Tirupati Plastomatics	JAipur
					CMI	Faridabad
					Sarval India	Nimrana
					Advance Cable	Bangalore
					Goyolene Fibre	Daman
					Sriram Cables	Alwar
					Dynamic Cables	Jaipur



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2.	Floor mounted Fixed type indoor LT Switchgear Panel (ACDB / DCDB / Lighting DB / Solenoid valve distribution boards) (subject to sub- QR)	1	2		L&T	Mumbai / Coimbatore/ Ahmednagar
					GE	Bangalore
					Siemens	Mumbai
					C&S Electric	Noida / Hardwar
					Schneider	Nasik
					Unilec	Gurgaon
					Switching Circuits	Kolkata



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					Tricolite	Sahibabad / Manesar
					Hindustan Control & equipment Ltd	Kolkata
					Maktel	Vadodara
					Jakson	Greater Noida
					Vidyut Control	Gaziabad
					Adlec Power	Rohad (Jhajjar)
					Pyrotech	Udaipur



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					Anand Power Ltd.	Noida
					Control & Schematics	Hyderabad
					Positronics	Vadodara
					ABB	Bangalore
					Nitya Electrocontrols	Noida
						Heavy Electricals PS-MKTG
3	Wall mounted fixed type indoor / outdoor LT Switchgear non compartment alized Panel (Lighting panels / AC / DC Fuse boards / MCB boxes)	I	3		L&T	Mumbai / Coimbatore/ Ahmednagar
					GE	Bangalore
					Siemens	Mumbai
					C&S Electric	Noida / Hardwar
					Schneider	Nasik



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					Unilec	Gurgaon
					Switching Circuits	Kolkata
					Tricolite	Sahibabad / Manesar
					Hindustan Control & equipment Ltd	Kolkata
					Maktel	Vadodara
					Jakson	Greater Noida
					Vidyut Control	Gaziabad
					Adlec Power	Rohad (Jhajjar)
					Pyrotech	Udaipur
					Anand Power Ltd.	Noida
					Control & Schematics	Hyderabad
					Positronics	Vadodara
					Control Devices	Kolkata
					Jasper	Noida
					Havells	Faridabad



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					Novateur Electrical & distribution systems	Murthal
					Avaid Technovator	Manesar

8	Local Push Button Station	III			Main contractor approved sources for the box (with push button with CE/VDE/UL/CSA marked or BIS approved with valid CML no.)	
17.	Cable lugs	III			M/s Dowell M/s Billets Elektro Werke Ltd.	Mumbai Umbergaon
					(3 D) M/s Chetna	Nasik
					Additionally Any make's model with VDE or CE or UL or CSA marking or BIS approved with CML no. Refer Note-3	

19	JB (All Types) / Lighting Panel	II	190		C&S Jakson MAKTEL Pyrotech Schneider Space Switchgear TRICOLITE Unilec Switchgear DANISH Nitya Electrocontrols MILESTONES ULTIMA SWITCHGEARS ENTERPRISING ENGINEERS VIKAS POWER EQUIPMENTS PVT. LTD.	Noida Grearer Noida BARODA Udalpur Nashik Gurgaon SAHIBABAD Gurgaon JAIPUR Noida GURGAON ROORKEE BHOPAL LUCKNOW
----	---------------------------------	----	-----	--	---	--

26.	PVC conduit/hume pipe/lighting wire/GI pipes/HDPE pipe/Structural Steel	III			BIS licensee / ISI marked with valid CML number	
27.	GI steel rigid conduit/ epoxy conduit	III			BIS licensee with valid CML number	

50	Fiber optic cable	II			HFCL R&M Aksh Fibre Finolex Birla Ericson Molex Corning Schneider	Goa Switzerland Bhilwadi Pune/Goa Rawa UK USA GOA
		II			RPG Cables Uniflex Cables Terracom	India India India



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ITEM/SERVICE DESCRIPTION	VENDOR NAME	ADDRESS
AC CONTACTORS	SIEMENS	RC-IN I S NR DEL AREA, JIL BUILDING, TOWER-B, PLOT NO. 78, SECTOR 18, GURGAON-122015, INDIA
AC CONTACTORS	GE-POWER	KAMAK TOWER, 3RD FLOOR, PLOT NO. 12- A, TVK INDUSTRIAL ESTATE, EKKADUTHANGAL, GUINDY, CHENNAI- 600032
AC CONTACTORS	TELEMECHANIQUE/ SCHNEIDER ELECTRIC INDIA PVT. LTD.	9TH FLOOR, BLDG. NO. 10, TOWER-C, DLF CYBER CITY, PH-II, GURGAON-122002
AC CONTACTORS	L&T	32, SHIVAJI MARG, P.O. BOX- 6223, NEW DELHI-110015
AC CONTACTORS	BCH	20/4, MATHURA ROAD, FARIDABAD, HARYANA-121006
AUXILIARY RELAYS	ABB	14, MATHURA ROAD, FARIDABAD, HARYANA-121003
AUXILIARY RELAYS	ALSTOM LTD	A-7, SEC-65, NOIDA
AUXILIARY RELAYS	JYOTI LTD.	JYOTI LIMITED, E&CS DIVISION,3/15, BIDC, GORWA,VADODARA - 390 016, E-MAIL ID: ECS@JYOTI.COM
AUXILIARY RELAYS	OEN INDIA LTD	29/1479, VYTILLA, COCHIN - 682 019 KERALA, INDIA
AUXILIARY RELAYS	SIEMENS	RC-IN I S NR DEL AREA, JIL BUILDING, TOWER-B, PLOT NO. 78, SECTOR 18, GURGAON-122015, INDIA
CABLE GLANDS	ALLIED TRADERS & EXPORTERS	C-124 A, SECTOR-2,NOIDA -201 301, UTTAR PRADESH, INDIA
CABLE GLANDS	ARUP ENGG & FOUNDARY WORKS	391/119,PRINCE ANWAR SHAH ROAD, CALCUTTA-700068
CABLE GLANDS	BALIGA LIGHTING EQPT.PVT.LTD.	63A,CP RAMASWAMY ROAD, ALWARPET,P.B.No 6910, CHENNAI-600018
CABLE GLANDS	COMMET BRASS PRODUCTS	NUTAN CHEMICAL COMPOUND, WALBHAT ROAD, GOREGAON, MUMBAI-400063



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CABLE GLANDS	DOWELLS	M/S. DOWELLS ELECTRICALS 47/47A, SATGURU INDUSTRIAL ESTATE. OFF AAREY ROAD, GOREGOAN (EAST). MUMBAI 400 063.
CABLE GLANDS	ELECTROMAC INDUSTRIES	27/28AF NEW EMPIRE IND.ESTT., R.KRISHNA MANDIR RD.JB NGR ,ANDHERI(E),MUMBAI-400059
CABLE GLANDS	INCAB	HARE STREET,KOLKATA,WEST BENGAL- 700001
CABLE LUGS	DOWELLS	M/S. DOWELLS ELECTRICALS 47/47A, SATGURU INDUSTRIAL ESTATE. OFF AAREY ROAD, GOREGOAN (EAST). MUMBAI 400 063.
CABLE LUGS	UNIVERSAL MACHINES LTD.	4,B.B.D.BAG (EAST) 90,STEPHEN HOUSE,5TH FLR CALCUTTA-700001
JELLY FILLED CABLES	DELTON SALES LTD.	DELTON HOUSE 4801,BHARAT RAM ROAD,24DARYAGANJ N.DELHI-110002
JELLY FILLED CABLES	HINDUSTAN CABLES	A-40 ASIAN GAMES VILLAGE RANJIT SINGH BLOCK NEW DELHI-110049
JELLY FILLED CABLES	TELELINK-NICCO	NICCO HOUSE 2,HARE STREET,CALCUTTA- 700001
JELLY FILLED CABLES	USHA BELTRON LTD.	TATISILWAI , ranchi- 835105
DC CONTACTORS	SCHNEIDER ELECTRIC INDIA PVT. LTD.	9TH FLOOR, BLDG. NO. 10, TOWER-C, DLF CYBER CITY, PH-II, GURGAON-122002
DC CONTACTORS	BHEL (BHOPAL)	HEAVY ELECTRICAL PLANT
DC CONTACTORS	ELECTROMAC INDUSTRIES	27/28AF NEW EMPIRE IND.ESTT., R.KRISHNA MANDIR RD.JB NGR ,ANDHERI(E),MUMBAI-400059
DC CONTACTORS	L&T	32, SHIVAJI MARG, P.O. BOX- 6223, NEW DELHI-110015
DC CONTACTORS	SIEMENS	RC-IN I S NR DEL AREA, JIL BUILDING, TOWER-B, PLOT NO. 78, SECTOR 18, GURGAON-122015, INDIA
DC CONTACTORS	TELEMECHANIQUE/ SCHNEIDER ELECTRIC INDIA PVT. LTD.	9TH FLOOR, BLDG. NO. 10, TOWER-C, DLF CYBER CITY, PH-II, GURGAON-122002
DC CONTACTORS	GE-POWER	KAMAK TOWER, 3RD FLOOR, PLOT NO. 12- A, TVK INDUSTRIAL ESTATE, EKKADUTHANGAL, GUINDY, CHENNAI- 600032



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CONTROL SWITCHES/ SELECTOR SWITCH	KAYCEE	KAYCEE INDUSTRIES LTD., C/O-CMS COMPUTERS LTD., 35A, REAR BLDG., KILOKARI, NEW DELHI-110014
CONTROL SWITCHES/ SELECTOR SWITCH	GE-POWER	KAMAK TOWER, 3RD FLOOR, PLOT NO. 12- A, TVK INDUSTRIAL ESTATE, EKKADUTHANGAL, GUINDY, CHENNAI- 600032
CONTROL SWITCHES/ SELECTOR SWITCH	ALSTOM LTD	A-7, SEC-65, NOIDA
CONTROL SWITCHES/ SELECTOR SWITCH	SCHNEIDER ELECTRIC INDIA PVT. LTD.	9TH FLOOR, BLDG. NO. 10, TOWER-C, DLF CYBER CITY, PH-II, GURGAON-122002
CONTROL SWITCHES/ SELECTOR SWITCH	M/s Shrenik & Co.	39A/3, PANCHRATNA INDUSTRIAL ESTATE, SARKHEJ-BAVLA ROAD, CHANGODAR, AHMEDABAD – 382 213
CONTROL SWITCHES/ SELECTOR SWITCH	RECOM PVT. LTD.	M/S RECOM PVT. LTD., 16A , 2ND FLOOR A, WING RAJ INDUSTRIAL COMPLEX, MILITARY ROAD , MAROL ANDHERI (EAST),MUMBAI ,MAHARASHTRA STATE : 400059
CONTROL TRANSFORMER/ WINDING HEATING TRANSFORMER	AUTOMATIC ELECTRIC LTD.	96 AB LONAVLA INDUSTRIAL ESTATE NANGARGAON, LONAVLA-410401
CONTROL TRANSFORMER/ WINDING HEATING TRANSFORMER	INDCOIL	PLOT NO. A- 150/ 151, 23RD U ROAD, WAGLE ESTATE, THANE WEST, CST RD, FRIENDS COLONY, HALLOW PUL, KURLA WEST, MUMBAI, MAHARASHTRA 400070
CONTROL TRANSFORMER/ WINDING HEATING TRANSFORMER	KAPPA ELECTRICALS	KAPPA ELECTRICALS, KAPPA CONSOLIDATED PVT. LTD., 14, CART TRACK ROAD, MADUVANKARAI, CHENNAI - 600 042, INDIA.
CONTROL TRANSFORMER/ WINDING HEATING TRANSFORMER	LOGICSTAT	B-160, INDUSTRIAL AREA, C BLOCK RD, OKHLA I, OKHLA INDUSTRIAL AREA, NEW DELHI, DL 110020
CONTROL TRANSFORMER/ WINDING HEATING TRANSFORMER	PRECISE ELECTRICALS	47A-49A, CHAKALA ROAD ANDHERI(E), MUMBAI-99 MUMBAI, MAHARASHTRA, INDIA PIN-400 099
CONTROL TRANSFORMER/ WINDING HEATING TRANSFORMER	UNILEC ENGINEERS PVT. LTD.	PLOT NO: R-247, T.T.C. INDUSTRIAL AREA, M.I.D.C , RABALE, NAVI MUMBAI- 400 701 INDIA
LT- CURRENT TRANSFORMER	SIEMENS	RC-IN I S NR DEL AREA, JIL BUILDING, TOWER-B, PLOT NO. 78, SECTOR 18, GURGAON-122015, INDIA
LT- CURRENT TRANSFORMER	AUTOMATIC ELECTRIC LTD.	96 AB LONAVLA INDUSTRIAL ESTATE NANGARGAON, LONAVLA-410401
LT- CURRENT TRANSFORMER	INDCOIL	PLOT NO. A- 150/ 151, 23RD U ROAD, WAGLE ESTATE, THANE WEST, CST RD, FRIENDS COLONY, HALLOW PUL, KURLA WEST, MUMBAI, MAHARASHTRA 400070
LT- CURRENT TRANSFORMER	KAPPA ELECTRICALS	KAPPA ELECTRICALS, KAPPA CONSOLIDATED PVT. LTD.,



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		SOUTHERN ELECTRIKS 14, CART TRACK ROAD, MADUVANKARAI, CHENNAI - 600 042, INDIA.
LT- CURRENT TRANSFORMER	PRAGATI ELECTRICALS	280/3,II POKHRAN RD
LT- CURRENT TRANSFORMER	PRECISE ELECTRICALS	47A-49A,CHAKALA ROAD ANDHERI(E),MUMBAI-99 MUMBAI, MAHARASHTRA, INDIA PIN-400 099
LT- CURRENT TRANSFORMER	SILKAANS ELECT.MFG.CO.PVT.LTD	PLOT NO: R-247, T.T.C. INDUSTRIAL AREA, M.I.D.C , RABALE, NAVI MUMBAI- 400 701 INDIA
LT- CURRENT TRANSFORMER	PRAYOG ELECTRICALS PVT. LTD.	GROUND FLOOR, THAKORE INDUSTRIAL COMPUND, STATION ROAD, VIDYA VIHAR (W), NATHANI ROAD , OPP. AMIBIKA TEMPLE,MUMBAI Mumbai - 400086, Maharashtra, India
LT- CURRENT TRANSFORMER	C&S ELECTRIC LTD.	222, OKHLA IND. ESTATE, PH-III, NEW DELHI-110020
LT- POTENTIAL TRANSFORMER	SIEMENS	RC-IN I S NR DEL AREA, JIL BUILDING, TOWER-B, PLOT NO. 78, SECTOR 18, GURGAON-122015, INDIA
LT- POTENTIAL TRANSFORMER	AUTOMATIC ELECTRIC LTD.	96 AB LONAVLA INDUSTRIAL ESTATE NANGARGAON, LONAVLA-410401
LT- POTENTIAL TRANSFORMER	INDCOIL	PLOT NO. A- 150/ 151, 23RD U ROAD, WAGLE ESTATE, THANE WEST, CST RD, FRIENDS COLONY, HALLOW PUL, KURLA WEST, MUMBAI, MAHARASHTRA 400070
LT- POTENTIAL TRANSFORMER	KAPPA ELECTRICALS	KAPPA ELECTRICALS, KAPPA CONSOLIDATED PVT. LTD., SOUTHERN ELECTRIKS 14, CART TRACK ROAD, MADUVANKARAI, CHENNAI - 600 042, INDIA.
LT- POTENTIAL TRANSFORMER	PRAGATI ELECTRICALS	280/3,II POKHRAN RD
LT- POTENTIAL TRANSFORMER	PRECISE ELECTRICALS	47A-49A,CHAKALA ROAD ANDHERI(E),MUMBAI-99 MUMBAI, MAHARASHTRA, INDIA PIN-400 099
LT- POTENTIAL TRANSFORMER	SILKAANS ELECT.MFG.CO.PVT.LTD	PLOT NO: R-247, T.T.C. INDUSTRIAL AREA, M.I.D.C , RABALE, NAVI MUMBAI- 400 701 INDIA
LT- POTENTIAL TRANSFORMER	PRAYOG ELECTRICALS PVT. LTD.	GROUND FLOOR, THAKORE INDUSTRIAL COMPUND, STATION ROAD, VIDYA VIHAR (W), NATHANI ROAD , OPP. AMIBIKA TEMPLE,MUMBAI Mumbai - 400086, Maharashtra, India
DC SWITCH	GE-POWER	KAMAK TOWER, 3RD FLOOR, PLOT NO. 12- A, TVK INDUSTRIAL ESTATE, EKKADUTHANGAL, GUINDY, CHENNAI-



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		600032
DC SWITCH	KAYCEE	KAYCEE INDUSTRIES LTD., C/O-CMS COMPUTERS LTD., 35A, REAR BLDG., KILOKARI, NEW DELHI-110014
DC SWITCH	SIEMENS	RC-IN I S NR DEL AREA, JIL BUILDING, TOWER-B, PLOT NO. 78, SECTOR 18, GURGAON-122015, INDIA
DISTRIBUTION BOX	M/S SHRENIK & CO.	39A/3, PANCHRATNA INDUSTRIAL ESTATE, SARKHEJ-BAVLA ROAD, CHANGODAR, AHMEDABAD – 382 213
FUSE BASE	INDO ASIAN	B-24, PHASE - II , NOIDA - 201305, U.P.
FUSE BASE	GE-POWER	KAMAK TOWER, 3RD FLOOR, PLOT NO. 12-A, TVK INDUSTRIAL ESTATE, EKKADUTHANGAL, GUINDY, CHENNAI-600032
FUSE BASE	L&T	32, SHIVAJI MARG, P.O. BOX- 6223, NEW DELHI-110015
FUSE BASE	C&S ELECTRIC LTD.	222, OKHLA IND. ESTATE, PH-III, NEW DELHI-110020
FUSE BASE	SIEMENS	RC-IN I S NR DEL AREA, JIL BUILDING, TOWER-B, PLOT NO. 78, SECTOR 18, GURGAON-122015, INDIA
FUSE BASE	ABB	14, MATHURA ROAD, FARIDABAD, HARYANA-121003
FUSE BASE	SPACEAGE SWITCHGEARS LTD.	68 & 13-A INDUSTRIAL DEVELOPMENT COLONY, MEHRAULI ROAD GURGAON, HARYANA-122001
FUSE BASE	SCHNEIDER ELECTRIC INDIA PVT. LTD.	9TH FLOOR, BLDG. NO. 10, TOWER-C, DLF CYBER CITY, PH-II, GURGAON-122002
FUSE BASE	ALSTOM LTD	A-7, SEC-65, NOIDA
FUSE BASE	ESSEN DEINKI	FLAT NO. 502, SKYLINE HOUSE 85, NEHRU PLACE NEW DELHI
HRC FUSES	INDO ASIAN	B-24, PHASE - II , NOIDA - 201305, U.P.
HRC FUSES	GE-POWER	KAMAK TOWER, 3RD FLOOR, PLOT NO. 12-A, TVK INDUSTRIAL ESTATE, EKKADUTHANGAL, GUINDY, CHENNAI-600032
HRC FUSES	L&T	32, SHIVAJI MARG, P.O. BOX- 6223, NEW DELHI-110015
HRC FUSES	C&S ELECTRIC LTD.	222, OKHLA IND. ESTATE, PH-III, NEW DELHI-110020
HRC FUSES	SIEMENS	RC-IN I S NR DEL AREA, JIL BUILDING, TOWER-B, PLOT NO. 78, SECTOR 18, GURGAON-122015, INDIA
HRC FUSES	ABB	14, MATHURA ROAD, FARIDABAD, HARYANA-121003
HRC FUSES	SPACEAGE SWITCHGEARS LTD.	68 & 13-A INDUSTRIAL DEVELOPMENT COLONY, MEHRAULI ROAD GURGAON, HARYANA-122001



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HRC FUSES	SCHNEIDER ELECTRIC INDIA PVT. LTD.	9TH FLOOR, BLDG. NO. 10, TOWER-C, DLF CYBER CITY, PH-II, GURGAON-122002
HRC FUSES	ALSTOM LTD	A-7, SEC-65, NOIDA
HRC FUSES	ESSEN DEINKI	FLAT NO. 502, SKYLINE HOUSE 85, NEHRU PLACE NEW DELHI
GALVANISING	Jenco Industrial Corporation	Chincholi Bunder Khkar Road Near Link Road Devruwadi Malad (W) Mumbai 400064
GALVANISING	National Galvanizing Company	66, Barrackpore Kamarhatt Trunck Road Calcutta-700058
GALVANISING	Sigma Galvanising Pvt. Ltd.	Plot No.C-169, TTC, MIDC Ind Area Navin Mumbai-400705
GALVANISING	B.P. Projects PVT LTD	167A, Vivekananda Road Kolkata-700006
GALVANISING	Standard Galvanisers	Makardah Road, Kabar Para, Bankra, Howarah -711403
GALVANISING	Steel Products	National Highway No. 6, Chamrail, Kona, Howrah-711114
GALVANISING	Unitech Fabricators & Engineers Pvt. Ltd.	Village- Ajab Nagar, P.O. -Molla Simlla, P.S. - Singur, Dist - Hoogly, Pin-712223
GALVANISING	Shivam Engineers & Fabricators	A0-282-284, Industrial Area, South Side of G.T. Road, Ghaziabad, U.P.
GALVANISING	B.G. Shirke Construction Technology Pvt. Ltd	72-76, Mundhawa, Pune - 401 036
GALVANISING	Galbro Ispat Galvanizers Pvt. Ltd.	GUT 11 AND 12, OPP. Kudus Steel,Rolling Mill, Wada, Thane , Mumbai
GALVANISING	Eros Metals	G-97, MIDC, Bhutibori , Nagpur
GALVANISING	Industrial Perforation (India) Pvt. Ltd.	Ganganagr, Katakhal, Kolkata-700132
GALVANISING	Indmark Formtech Pvt. Ltd.	Phase - 3, E - 11 / 1, M. I. D. C., Chakan, Pune - 410 501, Maharashtra, India.
GALVANISING	Namdhari Industrial Traders Pvt. Ltd.	Village Latton Dana, Chandigarh Road, Ludhiana
GALVANISING	Neha Galvaniser	Jalan Industrial Estate, Gate No-1, 1st Right Choise Lane, Near N.G-6, Jangalpur, PO Domjur Howrah - 700071, West Bengal, India
GALVANISING	Patny Systems (P) Ltd.	Unit-IV, Sy No. -228/9, Plot No. 6, IP Kuchavaram, Toopran(M) Dist.- Medak, Telegana - 502336
GALVANISING	Parmar Metal Company	Survey No.207,Veraval (Shapar) Dist. Rajkot, India.
GALVANISING	Rukmani Electrical & Fabricators Pvt, Ltd.	Urla Industrial Area, Urla Sarora Road, Raipur- 493 221 (Chhattisgarh)



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GALVANISING		Shankharidaha Baniyarah, Jalan Industrial Complex, Gate no.3, Lane no. 4, Domjur, Howrah , W.B .- 71141
GALVANISING	DMP Projects Pvt.Ltd.	Dulagarh Industrial Park , PS-Sankrail , Howrah -711302
GALVANISING	Vinfab Engineers India Private Limited	Gut no. 224/1 &2 Bhiwandi Wada State Highway, Village khupri, Dist. Thane, Maharashtra -421303
GALVANISING	Saral Projects & Processors	B-1, Industrial Area, Site-II, Amawan Road Rae Bareli
GALVANISING	Brahampuri Steels Limited	172 (F) Industrial Area, Jhotwara, Jaipur-302013
GALVANISING	Indiana Gratings PVT. LTD	F-5, MIDC Jejuri, Pune-412 303
GALVANISING	M/s AVAIDS TECHNOVATORS PVT. LTD.	131, MATSYA INDUSTRIAL AREA, ALWAR RAJASTHAN
GI WIRE & FLAT	INDUSTRIAL PERFORATION (I) PVT.LTD.	MR. A. K. SAHA 327, R.N.GUHA ROAD, DUM DUM KOLKATA-West Bengal-India Phone- 9830241788 Pincode : 700028 Email : ipipl@cal2.vsnl.net.in
GI WIRE & FLAT	INDIA ELECTRICALS SYNDICATE	Mr. Suresh Kumar Agarwal 55, Ezra Street, Kolkata-West Bengal-India Phone- 033-22354047 Pincode : 700001 Email : cabletray@vsnl.com
GI WIRE & FLAT	INDMARK FORMTECH PVT. LTD.	Mr. Narendra R. Meher J Block, Plot No.-375, MIDC BHOSARI PUNE-MAHARASHTRA-INDIA Phone- 020-27130546 Pincode : 411026 Email : indmarkformtech@vsnl.net
GI WIRE & FLAT	PREMIER POWER PRODUCTS (CAL) PVT. LTD.	Chatterjee International Centre, 33A, Jawaharlal Nehru Road, 6th Floor, Suit No. - 11A, Kolkata,-West Bengal-India Phone- 9331008739 Pincode : 700071 Email : hemantdaga@dagaventures.com
GI WIRE & FLAT	PATNY SYSTEMS (P) LTD	PATNY PLAZA 160 , SARDAR PATEL ROAD SEUNDRABAD SECUNDRABAD-TELANGANA-INDIA Phone- 040-27902451 Pincode : 500003 Email : mr.mkt@patnysystems.com
GI WIRE & FLAT	PASSIVE INFRA PROJECTS PVT. LTD.	MR. VARUN AGRAWAL 182, VAISHALI, PITAMPURA Delhi-DELHI-INDIA Phone- 9871183059 Pincode : 110088 Email : ATANU.SAHA@PASSIVEINFRA.COM
GI WIRE & FLAT	RUKMANI ELECTRICAL & COMPONENTS PVT LTD	11A , MAHARISHI DEBENDRA ROAD 1ST FL , ROOM NO.4 KOLKATA-WEST BENGAL-INDIA Phone- Pincode : 700007 Email : maruthikabra@gmail.com
GI WIRE & FLAT	RATAN PROJECTS &	MR. G.D. SINGHEE/MR. MAHESH SINGHEE



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	ENGINEERING CO. PVT.LTD.	26, P.K. TAGORE STREET, MAIN BUILDING KOLKATA-WEST BENGAL-INDIA Phone- 9830177331 Pincode : 700006 Email : mahesh@ratans.com
GI WIRE & FLAT	RABI ENGINEERING WORKS PVT. LTD.	MR. TAPAN KUMAR SEN/MR. SIDDHARTHA 327, R.N. GUHA ROAD, DUM DUM, KOLKATA-WEST BENGAL-INDIA Phone- 9748753002 Pincode : 700028 Email : rabiengineering@gmail.com
GI WIRE & FLAT	RAJASTHAN METAL SMELTING CO.	Mr. R. K. Tibrewala D-80, Road No. 7, V.K.I.A., Jaipur-Rajasthan-India Phone- 0141-2332269 Pincode : 302013 Email : info@rmscoindia.com
GI WIRE & FLAT	SARAL INDUSTRIES	Mr. Y.K. Gupta L-1, L-2, Industrial Area-1 Sultanpur Road Rae Bareli-Uttar Pradesh-India Phone- 0535-2702474 Pincode : 229010 Email : saralindustries@gmail.com
GI WIRE & FLAT	PARCO Engineers Pvt. Ltd.	401, skyline Epitom Building ,Near to Jolly Gym Khana, Kirol Road , Vidhyavihar, MH 400086 India
GI WIRE & FLAT	UNITECH FABRICATORS and ENGINEERS PVT LTD	INDRAPRASHTHA APARTMENT 24 , M.B.RAOD , BIRATI KALABAGAN KOLKATA KOLKATA-WEST BENGAL-INDIA Phone- Pincode : 700051 Email : ufepl@vsnl.net; ufepl@rediffmail.com
IND.POWER & WLDG SOCKETS	CROMPTON GREAVES	3RD FLOOR, EXPRESS BUILDING,9-10, BAHADUR SHAH ZAFAR MARG, NEAR ITO CROSSING,NEW DELHI-110002, INDIA
IND.POWER & WLDG SOCKETS	CYCLO ELECTRIC DEVICE & SERV.CO.	: A-3, NEAR ANTHEM BIOSCIENCE, KSSIDC INDUSTRIAL AREA, BOMMASANDRA, BOMMASANDRA INDUSTRIAL AREA, BANGALORE, KARNATAKA 560099
IND.POWER & WLDG SOCKETS	BCH	20/4, MATHURA ROAD, FARIDABAD - 121006, HARYANA, INDIA
IND.POWER & WLDG SOCKETS	BEST & CROMPTON	Best & Crompton Engineering Ltd 28C, Ambattur Industrial Estate (North) Ambattur, Chennai - 600 098
IND.POWER & WLDG SOCKETS	AJMERA INDUSTRIES & ENGG. WORKS	AJMERA INDL. AND ENGG. WORKS. AJMERA HOUSE, A-61 / KHAIRANE MIDC. , TTC INDL. AREA, NAVI MUMBAI – 400705.
INTERPOSING RELAY	ABB	14, MATHURA ROAD, FARIDABAD, HARYANA-121003
INTERPOSING RELAY	ALSTOM LTD	A-7, SEC-65, NOIDA
INTERPOSING RELAY	JYOTI LTD.	JYOTI LIMITED, E&CS DIVISION,3/15, BIDC, GORWA,VADODARA - 390 016, E-MAIL ID: ECS@JYOTI.COM
INTERPOSING RELAY	OEN INDIA LTD	29/1479, VYTILLA, COCHIN - 682 019 KERALA, INDIA
INTERPOSING RELAY	SIEMENS	RC-IN I S NR DEL AREA, JIL BUILDING, TOWER-B, PLOT NO. 78, SECTOR 18,



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		GURGAON-122015, INDIA
INDICATING LAMPS	BCH	20/4, MATHURA ROAD, FARIDABAD, HARYANA-121006
INDICATING LAMPS	C&S ELECTRIC LTD.	222, OKHLA IND. ESTATE, PH-III, NEW DELHI-110020
INDICATING LAMPS	ESSEN DEINKI	FLAT NO. 502, SKYLINE HOUSE 85, NEHRU PLACE NEW DELHI
INDICATING LAMPS	VAISHNO(HOTLINE SWGR.& CONTROL)	G-19, SECTOR - 11, NOIDA - 201301, UTTAR PRADESH, INDIA
INDICATING LAMPS	GE-POWER	KAMAK TOWER, 3RD FLOOR, PLOT NO. 12- A, TVK INDUSTRIAL ESTATE, EKKADUTHANGAL, GUINDY, CHENNAI- 600032
INDICATING LAMPS	SIEMENS	RC-IN I S NR DEL AREA, JIL BUILDING, TOWER-B, PLOT NO. 78, SECTOR 18, GURGAON-122015, INDIA
INDICATING LAMPS	SCHNEIDER ELECTRIC INDIA PVT. LTD.	9TH FLOOR, BLDG. NO. 10, TOWER-C, DLF CYBER CITY, PH-II, GURGAON-122002
JUNCTION BOXES (NON FLAME PROOF)	JASPER ENGINEERS PVT. LTD.	A-23, SECTOR - 8, NOIDA-201301
JUNCTION BOXES (NON FLAME PROOF)	Electro Controls & Devices	M/S ELECTRO CONTROLS & DEVICES, F-41, SITE-C, SURAJPUR INDUSTRIAL AREA GREATER NOIDA, UTTAR PRADESH :201308
JUNCTION BOXES (NON FLAME PROOF)	M/s Shrenik & Co.	39A/3, PANCHRATNA INDUSTRIAL ESTATE, SARKHEJ-BAVLA ROAD, CHANGODAR, AHMEDABAD – 382 213
JUNCTION BOXES (NON FLAME PROOF)	M/s PHOENIX MECANO LTD.,	388 BHARE, TALUKA MULSHI, POST GHOTAWADE, PIRANGOOT, INDUSTRIAL AREA, PUNE-412115
JUNCTION BOXES (NON FLAME PROOF)	Adroit Control Engineers Pvt.Ltd.	M/S ADROIT CONTROL ENGINEERS PVT.LTD. PLOT-3, KRISHNA INDL. AREA, SECTOR-25 FARIDABAD – 121004
JUNCTION BOXES (NON FLAME PROOF)	M/s PHOENIX MECANO LTD.,	388 BHARE, TALUKA MULSHI, POST GHOTAWADE, PIRANGOOT, INDUSTRIAL AREA, PUNE-412115
JUNCTION BOXES (NON FLAME PROOF)	MIKA ENGINEERS	BRANCH OFFICE : 'D'-101, DHEERAJ HERITAGE RESIDENCY II, SHASTRI NAGAR, SANTACRUZ (W), MUMBAI 400 054.
JUNCTION BOXES (NON FLAME PROOF)	M/s PHOENIX MECANO LTD.,	388 BHARE, TALUKA MULSHI, POST GHOTAWADE, PIRANGOOT, INDUSTRIAL AREA, PUNE-412115
JUNCTION BOXES (NON FLAME PROOF)	BAJAJ ELECTRICALS	BAJAJ ELECTRICALS LTD. ENGINEERING & PROJECTS BU (NORTH) 3rd FLOOR, GULMOHARHOUSE, COMMUNITY CENTRE 161/B-4,



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		GAUTAM NAGAR, YUSUF SARAI NEW DELHI – 110049
JUNCTION BOXES (NON FLAME PROOF)	AJMERA INDUSTRIES & ENGG. WORKS	AJMERA INDL. AND ENGG. WORKS. AJMERA HOUSE, A-61 / KHAIRANE MIDC. , TTC INDL. AREA, NAVI MUMBAI – 400705.
JUNCTION BOXES (NON FLAME PROOF)	S.B. ELECTRICAL ENGINEERING CORPORATION	03, SARDAR GRIHA BUILDING, LOHAR CHAWAL, MUMBAI-400002
JUNCTION BOXES (NON FLAME PROOF)	RITTAL INDIA PVT. LTD.	Espire Building ,Level -1 A-41, Mohan Co- Operative Industrial Estate ,Mathura Road, New Delhi -110044
JUNCTION BOXES (FLAME PROOF)	SUDHIR SWITCHGEAR	305/6, APEEJAY HOUSE, 130, BOMBAY SAMACHAR MARG, MUMBAI - 400 023. INDIA
LIGHTING SWITCH , SOCKET & S/F UNIT	ELEXPRO ELECTRICALS PVT/ LTD.	C 1/27 & 37 GIDC KABILPORE NAVSARI- 396424
LIGHTING SWITCH , SOCKET & S/F UNIT	ANCHOR	STEEL HOUSE, B WING, PLOT NO. 24, MAHAL INDUSTRIAL ESTATE, MAHAKALI CAVES ROAD, NEAR PAPER BOX, ANDHERI (E), MUMBAI, MAHARASHTRA.- 400093
LIGHTING SWITCH , SOCKET & S/F UNIT	KAYCEE	KAYCEE INDUSTRIES LTD., C/O-CMS COMPUTERS LTD., 35A, REAR BLDG., KILOKARI, NEW DELHI-110014
LIGHTING SWITCH , SOCKET & S/F UNIT	L&T	32, SHIVAJI MARG, P.O. BOX- 6223, NEW DELHI-110015
LIGHTING SWITCH , SOCKET & S/F UNIT	SIEMENS	RC-IN I S NR DEL AREA, JIL BUILDING, TOWER-B, PLOT NO. 78, SECTOR 18, GURGAON-122015, INDIA
LIGHTING SWITCH , SOCKET & S/F UNIT	INDO ASIAN	B-24, PHASE - II , NOIDA - 201305, U.P.
MCB	MDS SWITCHGEAR LTD	314-317SHAH NAHAR ESTATE
MCB	INDO ASIAN	B-24, PHASE - II , NOIDA - 201305, U.P.
MCB	SCHNEIDER ELECTRIC INDIA PVT. LTD.	9TH FLOOR, BLDG. NO. 10, TOWER-C, DLF CYBER CITY, PH-II, GURGAON-122002
MCB	S&S POWER SWITCHGEAR LTD,	NEW NO. 67, OLD NO. 19, DR. RANGA ROAD, MYLAPORE, CHENNAI - 600004
MCC (FIXED TYPE)	SPACEAGE SWITCHGEARS LTD.	68 & 13-A INDUSTRIAL DEVELOPMENT COLONY, MEHRAULI ROAD GURGAON, HARYANA-122001
MCC (FIXED TYPE)	ASSOCIATED SWGR & PROJ.LTD.	C-10, UPSIDC, INDUSTRIAL AREA, SITE-IV, KASNA ROAD, GREATER NOIDA-201306
MCC (FIXED TYPE)	BCH	20/4, MATHURA ROAD, FARIDABAD, HARYANA-121006
MODULAR SWITCH BOARD	ANCHOR	STEEL HOUSE, B WING, PLOT NO. 24, MAHAL INDUSTRIAL ESTATE, MAHAKALI CAVES ROAD, NEAR PAPER BOX, ANDHERI (E), MUMBAI, MAHARASHTRA.- 400093
MODULAR SWITCH BOARD	ELEXPRO ELECTRICALS	C 1/27 & 37 GIDC KABILPORE NAVSARI-



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	PVT/ LTD.	396424
MODULAR SWITCH BOARD	HAVELLS INDIA LIMITED	QRG TOWERS , 2D SECTOR-126, NOIDA-201301
SWITCH BOX	ANCHOR	STEEL HOUSE, B WING, PLOT NO. 24, MAHAL INDUSTRIAL ESTATE, MAHAKALI CAVES ROAD, NEAR PAPER BOX, ANDHERI (E), MUMBAI, MAHARASHTRA.- 400093
SWITCH BOX	ELEXPRO ELECTRICALS PVT/ LTD.	C 1/27 & 37 GIDC KABILPORE NAVSARI-396424
SWITCH BOX	BAJAJ ELECTRICALS	BAJAJ ELECTRICALS LTD. ENGINEERING & PROJECTS BU (NORTH) 3rd FLOOR, GULMOHARHOUSE, COMMUNITY CENTRE 161/B-4, GAUTAM NAGAR, YUSUF SARAI NEW DELHI – 110049
SWITCH BOX	AJMERA INDUSTRIES & ENGG. WORKS	AJMERA INDL. AND ENGG. WORKS. AJMERA HOUSE, A-61 / KHAIRANE MIDC. , TTC INDL. AREA, NAVI MUMBAI – 400705.
SWITCH BOX	S.B. ELECTRICAL ENGINEERING CORPORATION	03, SARDAR GRIHA BUILDING, LOHAR CHAWAL, MUMBAI-400002
TIMERS - PNEUMATIC	BCH	20/4, MATHURA ROAD, FARIDABAD, HARYANA-121006
TIMERS - PNEUMATIC	ALSTOM LTD	A-7, SEC-65, NOIDA
TIMERS - PNEUMATIC	L&T	32, SHIVAJI MARG, P.O. BOX- 6223, NEW DELHI-110015
TIMERS - PNEUMATIC	TELEMECHANIQUE/ SCHNEIDER ELECTRIC INDIA PVT. LTD.	9TH FLOOR, BLDG. NO. 10, TOWER-C, DLF CYBER CITY, PH-II, GURGAON-122002
TIMERS - PNEUMATIC	SCHNEIDER ELECTRIC INDIA PVT. LTD.	9TH FLOOR, BLDG. NO. 10, TOWER-C, DLF CYBER CITY, PH-II, GURGAON-122002
TIMERS - PNEUMATIC	ELECTRONIC AUTOMATION PVT. LTD.	20, KHB INDUSTRIAL AREA YELAHANKA BANGLORE-560064
TIMERS - ELECTRONIC	ESSEN DEINKI	FLAT NO. 502, SKYLINE HOUSE 85, NEHRU PLACE NEW DELHI
TRANSDUCERS	AUTOMATIC ELECTRIC LTD.	ADDRESS : 96 AB LONAVLA INDUSTRIAL ESTATE NANGARGAON, LONAVLA-410401
TRANSDUCERS	SOUTHERN TRANSDUCERS	INTERTECH B-83, FLATTED FACTORY COMPLEX, NEAR MODI MILLS, OKHLA, NEW DELHI-110020
ENERGY METER (ANALOG)	BHEL (EDN)	MYSORE ROAD,BANGALORE-560026
ENERGY METER (ANALOG)	SIMCO ENGG. LTD	NO. 126, K ROAD, TIRUCHIRAPPALLI - 620001, TAMIL NADU
ENERGY METER (ANALOG)	RISHABH INST.PVT LTD	RISHABH INSTRUMENTS PVT. LTD. F-31, MIDC, SATPUR NASHIK - 422007 MAHARASHTRA INDIA
ENERGY METER (ANALOG)	AUTOMATIC ELECTRIC	96 AB LONAVLA INDUSTRIAL ESTATE



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	LTD.	NANGARGAON, LONAVLA-410401
ENERGY METER (ANALOG)	CONZERVE SYSTEMS PVT. LTD.(SCHNEIDER)	87, 1ST FLOOR INDUSTRIAL DEVELOPMENT COLONY (IDC) MEHRAULI ROAD, UGURGAON 122001 HARYANA, INDIA.
ENERGY METER (DIGITAL)	CONZERVE SYSTEMS PVT. LTD.(SCHNEIDER)	87, 1ST FLOOR INDUSTRIAL DEVELOPMENT COLONY (IDC) MEHRAULI ROAD, UGURGAON 122001 HARYANA, INDIA.
AMMETER	AUTOMATIC ELECTRIC LTD.	96 AB LONAVLA INDUSTRIAL ESTATE NANGARGAON, LONAVLA-410401
AMMETER	RISHABH INST.PVT LTD	RISHABH INSTRUMENTS PVT. LTD. F-31, MIDC, SATPUR NASHIK - 422007 MAHARASHTRA INDIA
VOLTMETER	AUTOMATIC ELECTRIC LTD.	96 AB LONAVLA INDUSTRIAL ESTATE NANGARGAON, LONAVLA-410401
VOLTMETER	RISHABH INST.PVT LTD	RISHABH INSTRUMENTS PVT. LTD. F-31, MIDC, SATPUR NASHIK - 422007 MAHARASHTRA INDIA
MULTIFUNCTION METER	CONZERVE SYSTEMS PVT. LTD./ SCHNEIDER ELECTRIC INDIA PVT. LTD.	87, 1ST FLOOR INDUSTRIAL DEVELOPMENT COLONY (IDC) MEHRAULI ROAD, GURGAON 122001 HARYANA, INDIA.



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(ANNEXURE-A)

BILL OF QUANTITY

3X800 MW PATRATU TPS: Cathodic Protection Pipe Details

ANNEXURE-A

BILL OF QUANTITIES

SI No.	Sytem	From	To	Material of Construction	Coating type (Internal)	Pipe installation	Type of cathodic protection		Drg No.	PIPE SIZE	BEND	VALVES
							SACRIFICIAL	IMPRESSED CURRENT CATHODIC PROTECTION				
MAKE-UP WATER PIPING												
1	MAKE UP WATER PIPES	PATRATU DAM	RAW WATER PUMPS	MILD STEEL SPIRALLY WELDED (SAW) FE 410 OF IS 3589	3LPE	MOSTLY BURIED, FEW REGIONS OF CONNECTED PORTION ABOVE GROUND (REFER LAYOUT)	YES	YES	PE-DG-434-100-M041 PE-DG-434-100-M044	REFER MENTIONED LAYOUT DRAWINGS		

1. DETAILS OF COATING AS MENTIONED ABOVE (COATING NOT IN SCOPE OF BIDDER)

2. REFERENCE DRGS. ENCLOSED:

A) PLOT PLAN (1 SHEET) DRG. NO. PE-DG-434-100-M001

B) SKETCH-1 (DRG NO. PE-DG-434-100-M041): LAYOUT OF MAKE UP WATER PIPE

C) SKETCH-2 (DRG NO. PE-DG-434-100-M044): LAYOUT IN & AROUND PLANT WATER PUMPS AREA

Note:

1 THIS BILL OF QUANTITIES CONTAINS DETAILS OF BURIED/ABOVE GROUND PIPELINES, THAT ARE REQUIRED TO BE PROVIDED WITH CATHODIC PROTECTION.

2 THE ABOVE SHALL BE USED BY BIDDERS FOR WORKING OUT THE QUANTITIES OF ALL EQUIPMENT, COMPONENTS & CONSUMABLES REQUIRED TO BE SUPPLIED TO COMPLETE THE CATHODIC PROTECTION SYSTEM FOR ABOVE PIPELINES. THE UNPRICED PRICE SCHEDULES SHALL BE SUBMITTED BY ALL BIDDERS FOR BHEL REVIEW.

3 ANY OTHER ITEMS NOT INCLUDED IN THE PRICE SCHEDULES BUT REQUIRED FOR COMPLETION OF THE WORK SHALL BE DEEMED TO BE INCLUDED IN THE BIDDER'S OFFER AND SHALL BE SUPPLIED BY THE BIDDER WITHOUT ANY COMMERCIAL IMPLICATION TO BHEL.



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APPENDIX - I

ELECTRICAL RESISTIVITY TEST

a central point such that $AM=MN=NB=a$. The outer two electrodes A & B were used for sending current (I) and inner two M & N were used for measuring the potential differences (ΔV). The distance between each consecutive electrode (a) was kept constant and was progressively increased to reach the depth at which resistivity information are wanted. Suitable electrode spacing determines the conductivity of the top soil as well as the various subsurface layers occurring in the area under study. At each location, 4 sets of observations were taken for each of the electrode spacing (a) in eight directions (N-S, E-W, NE-SW and NW-SE) and in ten different electrode spacing viz.: $a = 0.50\text{m}, 1.0\text{m}, 2.0\text{m}, 3.0\text{m}, 4.0\text{m}, 5.0\text{m}, 6.0\text{m}, 7.0\text{m}, 8.0\text{m}$ and 10.0m were used to know the nature of change of resistivity.

The apparent resistivity was determined by the formula –

$$\rho = 6.28 a \frac{\Delta V}{I} \text{ where 'a' is the distance between the two consecutive}$$

Electrodes and $\frac{\Delta V}{I}$ is R which is the observed resistance for measuring resistivity.

A Resistivity Meter model DDR-3 of GEOSENSOR make was used during the operation. The mean value of the resistivity estimated was taken as the representative one.

The depth of investigation in an isotropic and homogeneous formation can be approximated to the distance between the consecutive two electrodes (a).

TEST RESULTS:

The overall mean resistivity values at each ERT locations are presented below

APPARENT RESISTIVITY VALUES

Sl. No.	ERT Location	Co-ordinate (M)		Overall Mean Resistivity (Ohm-m)
		Easting	Northing	
1.	ERT-MWP01	(-)1011	(-)898	44.29
2.	ERT-MWP02	(-)1008	(-)922	95.99

ERT No. MWP01

Sl No.	S (M)	Apparent Electrical Resistivity (Ohm-m)				Mean
		(N - S)	(E - W)	(NE - SW)	(NW - SE)	
1	0.50	57.15	64.06	54.95	47.73	55.97
2	1.0	39.00	35.22	39.00	19.50	33.18
3	2.0	35.20	41.48	36.45	40.22	38.34
4	3.0	39.61	33.95	41.49	37.72	38.19
5	4.0	42.74	37.71	47.77	45.25	43.37
6	5.0	44.00	40.86	53.43	47.15	46.36
7	6.0	52.79	45.25	52.79	49.02	49.96
8	7.0	52.80	44.00	52.80	48.40	49.50
9	8.0	45.26	40.23	50.29	40.23	44.00
10	10.0	50.29	44.00	44.00	37.72	44.00

Mean Resistivity at ERT- MWP 01 is 44.29 Ohm - m.

ERT No. MWP02

Sl No.	S (M)	Apparent Electrical Resistivity (Ohm-m)				Mean
		(N - S)	(E - W)	(NE - SW)	(NW - SE)	
1	0.50	173.64	174.27	131.88	135.96	153.94
2	1.0	160.40	211.34	171.72	186.18	182.41
3	2.0	150.84	145.81	174.72	165.92	159.32
4	3.0	120.70	88.64	92.41	75.44	94.30
5	4.0	77.93	67.88	62.85	57.82	66.62
6	5.0	69.15	59.72	62.86	56.57	62.08
7	6.0	56.57	60.34	52.79	60.34	57.51
8	7.0	57.20	66.00	57.20	61.60	60.50
9	8.0	55.32	60.35	60.35	65.38	60.35
10	10.0	56.57	62.86	62.86	69.15	62.86

Mean Resistivity at ERT- MWP 02 is 95.99 Ohm - m.

ERT No. 43

SI No.	S (M)	Apparent Electrical Resistivity (Ohm-m)				Mean
		(N - S)	(E - W)	(NE - SW)	(NW - SE)	
1	0.50	22.67	23.99	22.36	21.85	22.72
2	1.0	24.66	20.38	16.67	21.51	20.81
3	2.0	20.74	16.72	17.10	18.60	18.29
4	3.0	17.35	17.16	19.05	17.73	17.82
5	4.0	19.86	18.86	19.61	19.36	19.42
6	5.0	17.29	20.12	20.43	19.17	19.25
7	6.0	20.36	21.87	20.74	17.72	20.17
8	7.0	21.12	25.96	24.64	19.80	22.88
9	8.0	22.13	22.13	20.62	21.12	21.50
10	10.0	25.77	25.14	23.26	24.52	24.67

Mean Resistivity at ERT-43 is 20.75 Ohm - m.

ERT No. 44

SI No.	S (M)	Apparent Electrical Resistivity (Ohm-m)				Mean
		(N - S)	(E - W)	(NE - SW)	(NW - SE)	
1	0.50	38.09	47.63	32.97	38.31	39.25
2	1.0	47.18	46.42	38.99	51.33	45.98
3	2.0	36.20	36.70	37.84	36.58	36.83
4	3.0	27.91	27.91	33.01	28.67	29.38
5	4.0	24.13	24.39	25.64	24.39	24.64
6	5.0	25.46	25.77	28.29	26.72	26.56
7	6.0	26.40	27.53	24.89	27.53	26.59
8	7.0	25.08	27.28	28.16	29.04	27.39
9	8.0	27.16	30.17	30.68	29.17	29.30
10	10.0	32.69	35.20	35.83	33.94	34.42

Mean Resistivity at ERT-44 is 32.03 Ohm - m.

ERT No. 45

SI No.	S (M)	Apparent Electrical Resistivity (Ohm-m)				Mean
		(N - S)	(E - W)	(NE - SW)	(NW - SE)	
1	0.50	81.14	66.44	70.34	76.62	73.64
2	1.0	36.10	25.03	25.41	24.91	27.86
3	2.0	16.09	16.84	16.59	14.58	16.03
4	3.0	15.47	15.09	16.22	16.97	15.94
5	4.0	17.10	18.10	18.10	19.61	18.23
6	5.0	20.12	20.74	20.12	19.49	20.12
7	6.0	20.36	21.87	22.63	22.63	21.87
8	7.0	21.12	22.88	21.12	23.76	22.22
9	8.0	21.12	23.13	20.11	24.14	22.13
10	10.0	25.14	26.40	22.63	27.66	25.46

Mean Resistivity at ERT-45 is 26.35 Ohm - m.

NAER
FIRE
STATION

ACW CT

WS
CONT
ROL
ROOM



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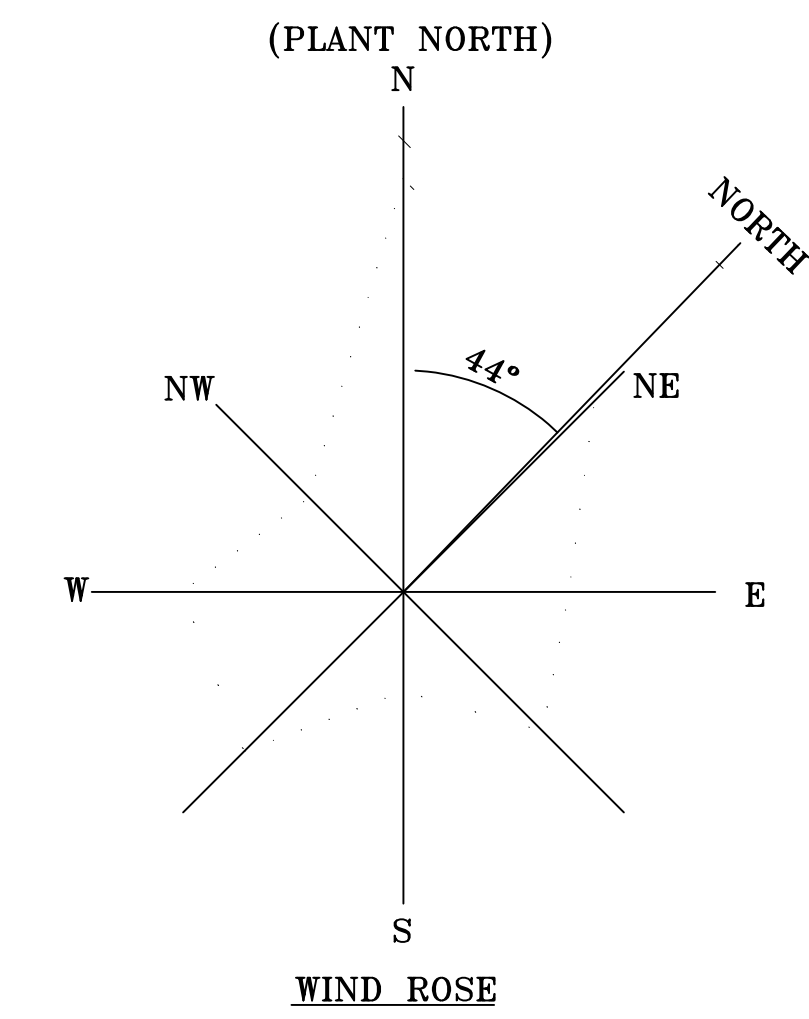
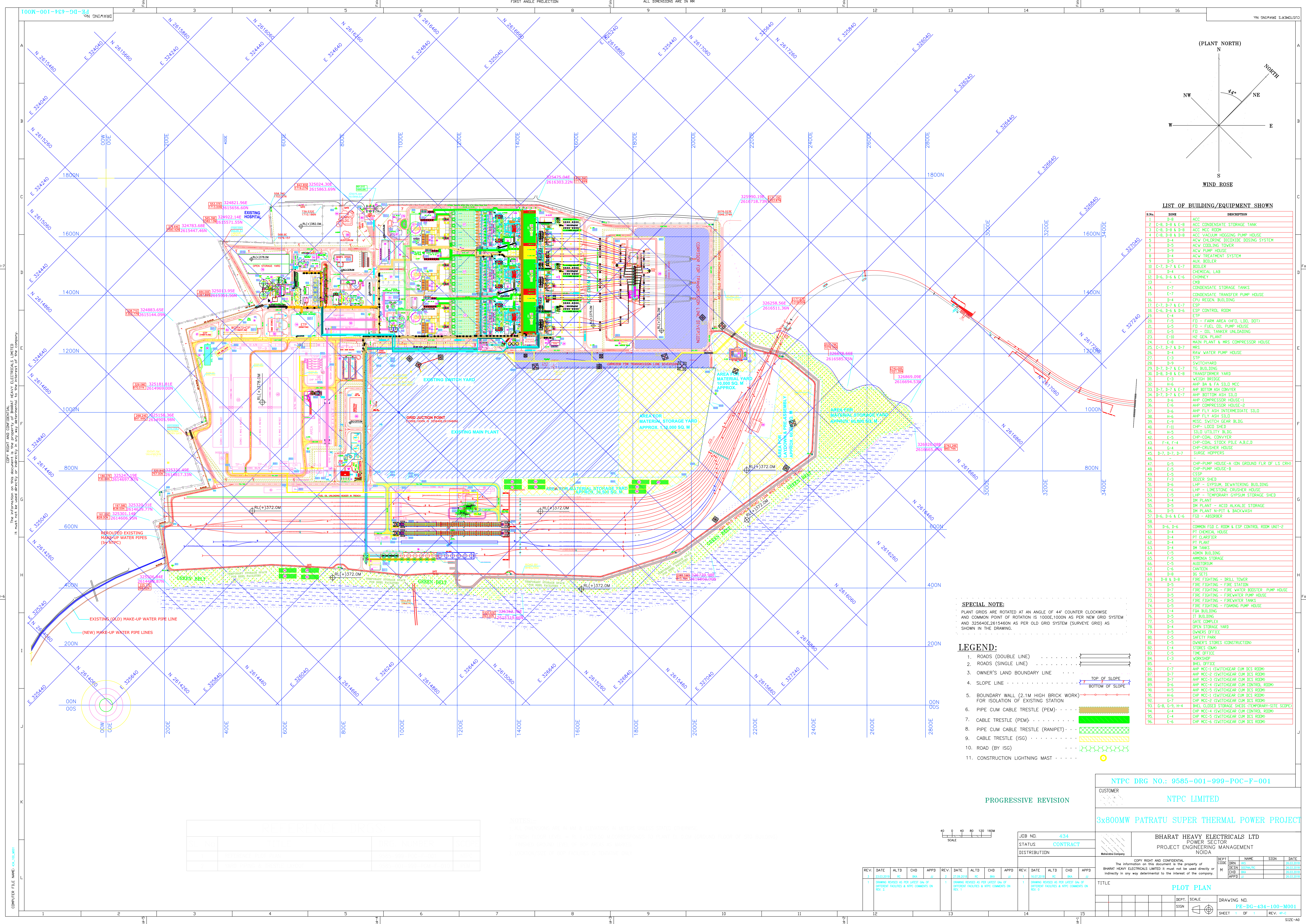
REVISION 00

DATE: 19.11.19

SHEET 1 OF 1

APPENDIX - II

DRAWINGS ENCLOSED WITH THE SPECIFICATION

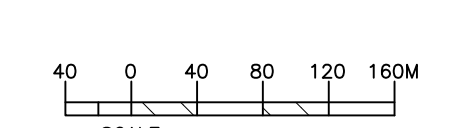


LIST OF BUILDING/EQUIPMENT SHOWN		
S.No.	ZONE	DESCRIPTION
1	D-8	ACC
2	C-8, D-8 & E-8	ACC CONDENSATE STORAGE TANK
3	C-8, D-8 & E-8	ACC MCC ROOM
4	C-8, D-8 & E-8	ACC VACUUM HOODING PUMP HOUSE
5	D-4	ACW CHLORINE DIOXIDE DOSING SYSTEM
6	D-5	ACW COOLING TOWER
7	D-9	ACW PUMP HOUSE
8	D-4	ACW TREATMENT SYSTEM
9	D-5	AUX. BOILER
10	C-7, D-7 & E-7	BOILER
11	D-4	CHEMICAL LAB
12	D-6, D-6 & E-6	CHIMNEY
13	-	CHB
14	E-7	CONDENSATE STORAGE TANKS
15	E-7	CONDENSATE TRANSFER PUMP HOUSE
16	D-4	CPU REGEN. BUILDING
17	C-7, D-7 & E-7	ESP
18	C-6, D-6 & E-6	ESP CONTROL ROOM
19	E-4	ETP
20	F-5	FD - FARM AREA (HFD, LID, DDT)
21	G-5	FD - FUEL OIL PUMP HOUSE
22	G-5	FD - OIL TANKER UNLOADING
23	E-10	HE GEN. PLANT
24	-	MAIN PLANT & MRS COMPRESSOR HOUSE
25	C-7, D-7 & E-7	MES
26	D-4	RAW WATER PUMP HOUSE
27	E-3	STP
28	D-9	SWITCHYARD
29	D-7, D-7 & E-7	TG BUILDING
30	D-8, D-8 & E-8	TRANSFORMER YARD
31	E-3	WEIGH BRIDGE
32	H-6	AHP BA & FA SILD MCC
33	D-7, D-7 & E-7	AHP BOTTOM ASH CONVEY
34	D-7, D-7 & E-7	AHP BOTTOM ASH SILD
35	D-6	AHP COMPRESSOR HOUSE-1
36	E-6	AHP COMPRESSOR HOUSE-2
37	D-6	AHP FLY ASH INTERMEDIATE SILD
38	H-6	AHP FLY ASH SILD
39	E-9	MISC. SWITCH GEAR BLDG.
40	F-1	CHP - LODD SHED
41	H-5	SILD UTILITY BLDG.
42	E-5	CHP-COAL CONVEY
43	F-4, F-4	CHP-COAL STOCK PILE A,B,C,D
44	G-4	CHP-CRUSHER HOUSE
45	D-7, D-7, D-7	SURGE HOPPERS
46	-	-
47	G-5	CHP-PUMP HOUSE-A CON GROUND FLR OF LS CRHD
48	E-5	CHP-PUMP HOUSE-B
49	E-5	CSSP
50	F-3	DOZER SHED
51	D-6	LHP - GYPSUM REWATERING BUILDING
52	E-6	LHP - LIME-STONE CRUSHER HOUSE
53	E-5	LHP - TEMPORARY GYPSUM STORAGE SHED
54	D-4	DM PLANT
55	D-5	DM PLANT - ACID ALKALIE STORAGE
56	D-5	DM PLANT N-PIT & BACKWASH
57	D-6, D-6 & E-6	FGD - ABSORBER
58	-	-
59	D-6, D-6	COMMON FGD C. ROOM & ESP CONTROL ROOM UNIT-2
60	D-4	PT CHEMICAL HOUSE
61	D-4	PT CLARIFIER
62	D-4	PT PLANT
63	D-4	DM TANKS
64	C-5	ADMIN BUILDING
65	F-5	AMMUNA STORAGE
66	C-5	AUDITORIUM
67	C-6	CANTEN
68	D-8	DG SETS
69	D-8 & D-8	FIRE FIGHTING - DRILL TOWER
70	D-5	FIRE FIGHTING - FIRE STATION
71	D-7	FIRE FIGHTING - FIRE WATER BOOSTER PUMP HOUSE
72	D-5	FIRE FIGHTING - FIREWATER PUMP HOUSE
73	D-5	FIRE FIGHTING - FIREWATER TANKS
74	G-5	FIRE FIGHTING - FOAMING PUMP HOUSE
75	E-4	FOA BUILDING
76	D-5	IT BUILDING
77	C-5	GATE COMPLEX
78	D-4	OPEN STORAGE YARD
79	D-5	OWNERS OFFICE
80	C-5	SAFETY PARK
81	E-5	OWNER'S STORES (CONSTRUCTION)
82	E-4	STORES (CON)
83	C-5	TIME OFFICE
84	E-3	WORKSHOP
85	-	BHEL OFFICE
86	E-7	AHP MCC-1 (SWITCHEAR CUM BCS ROOM)
87	D-7	AHP MCC-2 (SWITCHEAR CUM BCS ROOM)
88	D-7	AHP MCC-3 (SWITCHEAR CUM BCS ROOM)
89	D-6	AHP MCC-4 (SWITCHEAR CUM CONTROL ROOM)
90	H-5	AHP MCC-5 (SWITCHEAR CUM BCS ROOM)
91	H-6	CHP MCC-1 (SWITCHEAR CUM BCS ROOM)
92	G-7	CHP MCC-2 (SWITCHEAR CUM BCS ROOM)
93	G-8, G-9, H-4	BHEL CLOSED STORAGE SHEETS (TEMPORARY SITE SCOPE)
94	G-4	CHP MCC-4 (SWITCHEAR CUM CONTROL ROOM)
95	E-4	CHP MCC-5 (SWITCHEAR CUM BCS ROOM)
96	E-6	CHP MCC-6 (SWITCHEAR CUM BCS ROOM)

SPECIAL NOTE:
PLANT GRIDS ARE ROTATED AT AN ANGLE OF 44° COUNTER CLOCKWISE
AND COMMON POINT OF ROTATION IS 1000E,1000N AS PER NEW GRID SYSTEM
AND 325640E,2615460N AS PER OLD GRID SYSTEM (SURVEY GRID) AS
SHOWN IN THE DRAWING.

- LEGEND:**
- ROADS (DOUBLE LINE)
 - ROADS (SINGLE LINE)
 - OWNER'S LAND BOUNDARY LINE
 - SLOPE LINE
 - BOUNDARY WALL (2.1M HIGH BRICK WORK) FOR ISOLATION OF EXISTING STATION
 - PIPE CUM CABLE TRESTLE (PEM)
 - CABLE TRESTLE (PEM)
 - PIPE CUM CABLE TRESTLE (RAINPET)
 - CABLE TRESTLE (ISO)
 - ROAD (BY ISG)
 - CONSTRUCTION LIGHTNING MAST

PROGRESSIVE REVISION

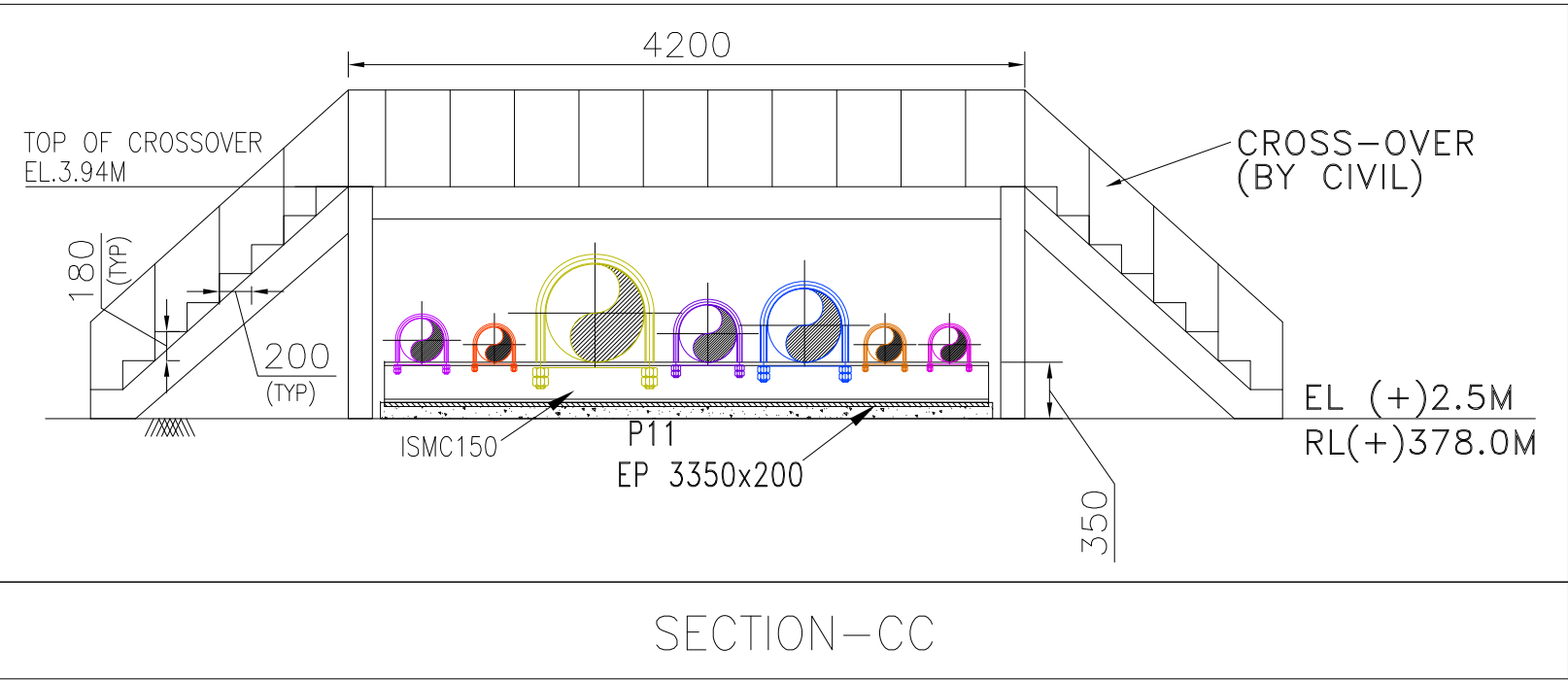
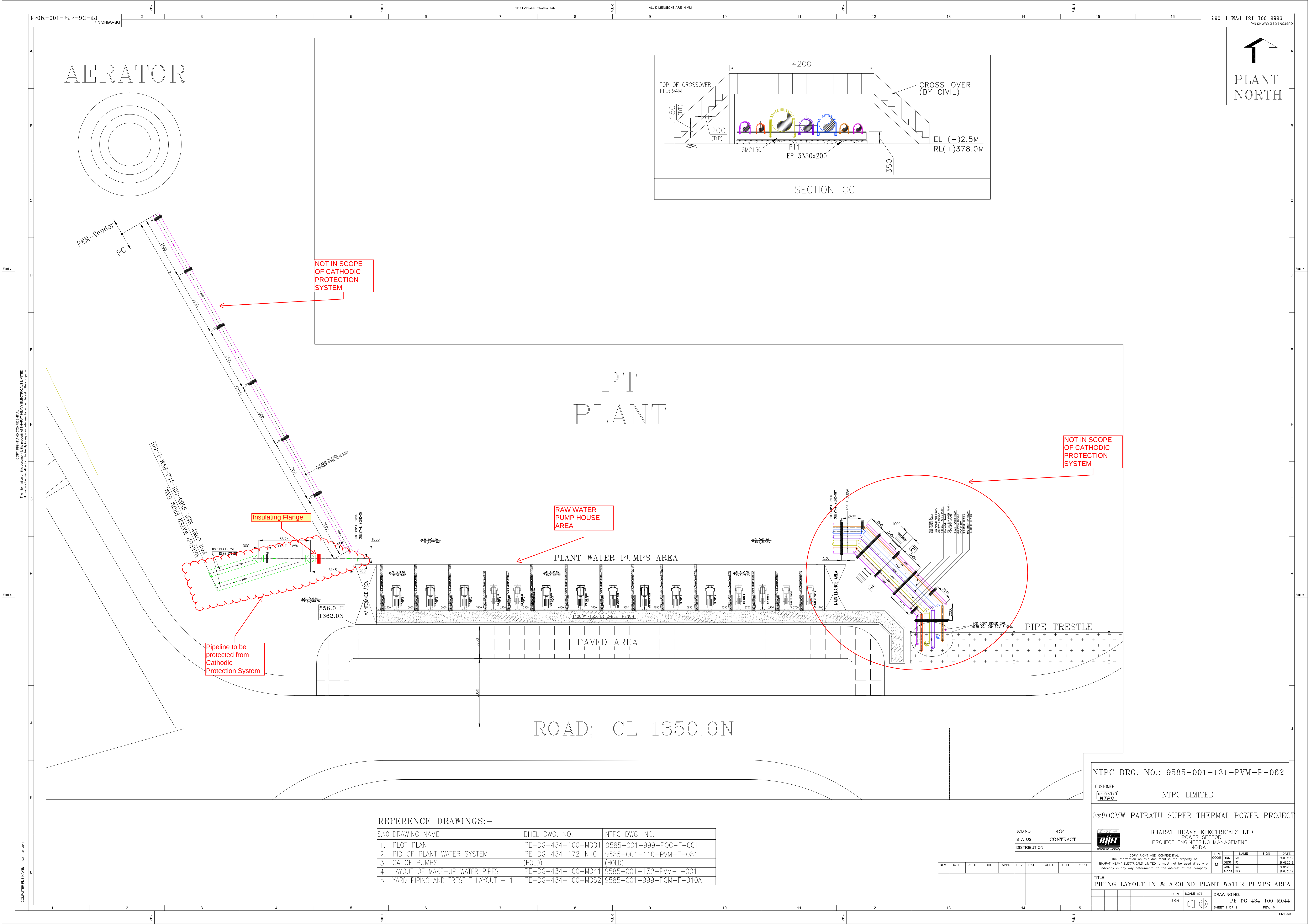


JOB NO. 434	
STATUS CONTRACT	
DISTRIBUTION	
DEPT. NAME SIGN DATE	
TITLE PLOT PLAN	
DRAWING NO. PB-DG-434-100-M001	
SHEET 1 OF 1	
REV. #02	

REV.	DATE	ALTD	CHD	APPD	REV.	DATE	ALTD	CHD	APPD	REV.	DATE	ALTD	CHD	APPD
1	2023-03-10				1	2023-03-10				1	2023-03-10			
DRAWING REVISIONS AS PER LATEST GAN OF DIFFERENT FACILITIES & NTPC COMMENTS ON REV. 1														

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COMPUTER FILE NAME: C:\A\10\A001
DRAWING NO. PB-DG-434-100-M001
SHEET 1 OF 1
REV. #02



REFERENCE DRAWINGS:-

S.NO.	DRAWING NAME	BHEL DWG. NO.	NTPC DWG. NO.
1.	PLOT PLAN	PE-DG-434-100-M001	9585-001-999-POC-F-001
2.	PID OF PLANT WATER SYSTEM	PE-DG-434-172-N101	9585-001-110-PVM-F-081
3.	GA OF PUMPS	(HOLD)	(HOLD)
4.	LAYOUT OF MAKE-UP WATER PIPES	PE-DG-434-100-M041	9585-001-132-PVM-L-001
5.	YARD PIPING AND TRESTLE LAYOUT - 1	PE-DG-434-100-M052	9585-001-999-PGM-F-010A

NTPC DRG. NO.: 9585-001-131-PVM-P-062

CUSTOMER
NTPC LIMITED

3x800MW PATRATU SUPER THERMAL POWER PROJECT

BHARAT HEAVY ELECTRICALS LTD
POWER SECTOR
PROJECT ENGINEERING MANAGEMENT
NOIDA

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TITLE
PIPING LAYOUT IN & AROUND PLANT WATER PUMPS AREA

DEPT. SCALE 1/75
SIGN
DRAWING NO.
PE-DG-434-100-M044
SHEET 2 OF 2
REV. 0