

<div> पी डी आई एल <b>PDIL</b></div> <div>PROJECTS &amp; DEVELOPMENT INDIA LTD</div>	PC0228 -PNEL-TS	P	
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## TECHNICAL SPECIFICATIONS


FOR

## SACP & ICCP CATHODIC PROTECTION SYSTEM


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B.	<b>DRAWING LIST FOR EARTHING SYSTEM</b>	<b>DRAWING NO.</b>	
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## 1.0 INTRODUCTION

This specification specifies the requirement of Basic Survey, Design, Engineering, Supply of Materials, Installation, Testing & Commissioning, Monitoring of Permanent Cathodic Protection system for mitigation of external corrosion on new underground pipelines.

## 2.0 SCOPE OF WORK :

The scope of work under this NIT shall comprise of Basic Survey, Design, Engineering, Supply of Material, inspection at works as well as at site, including packing and forwarding, transportation, loading and unloading of materials from Workshop up to Project Site, quality assurance (QA) and quality control (QC), Installation, Testing & Commissioning, Monitoring of Cathodic Protection system for mitigation of external corrosion on underground pipeline and centralized remote

For details information of pipeline, e.g. length, dia, material etc. and site piping layout shall be taken from Mechanical specification attached elsewhere in this NIT.

To access the exact quantum of work, bidder is advised to visit site(at his own expanse) before quoting for this job.

This specification defines the basic guidelines to develop -

Temporary piping cathodic protection system is required to be installed to cover the construction period of the piping until permanent cathodic protection is commissioned.

The temporary cathodic protection system is ensured by sacrificial anodes. The sacrificial anodes are high potential Magnesium type connected to the piping through the test posts installed along the piping route.


Number of anodes required, dimension and weight will be determine by the calculation note based on soil resistivity and design life. The design life for temporary cathodic protection system is considered 3 years.

After construction period, Impressed current cathodic protection system for the pipelines required to be protected. The design life for Impressed Current CP (ICCP or PCP) shall be 30 years. Temporary cathodic protection system calculation for buried piping cathodic protection using sacrificial anodes will be established for 3 years as a minimum. All data required in this regard shall be taken into consideration by the CP bidder to develop an acceptable state of the art design and properly engineered design of the CP system. Compliance with these specifications and/or approval of any of the Bidder's documents shall in no case relieve the Bidder of his contractual obligations.


The Bidder should supply materials strictly as per specifications and approved vendors list attached with. Bidder shall give performance guarantee for CP System.

## 3.0 DETAIL SCOPE OF WORK

- Carrying our Basic Surveys, Current Drainage and other topographical data collection from site.

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- Development of Detailed engineering Document on the Basic Survey Data and optimize the PCP System.
  - Site visit to decide the location of proposed Anode bed, T/R unit, Test station etc. Supply, Laying & Terminations of power cable (buried) from Owner's Substation to TR Unit and from TR Unit to anode shall be under bidder's scope. Suitable dia. GI pipe (Heavy duty) for cable protection shall be used wherever cable route crossing the road/Rail. Road cutting/damage during cable laying shall be rectified/ restore to original position by the Bidder.
  - Calculation of anode quantities and their sizes based on upon maximum current requirement and design life.
  - Sizing calculation for T/R unit, anode loop resistance and potential profile on the protected structures.
  - Submission of detailed engineering package of CP system which generally includes but not limited to formulae used, design calculations, BOQ, Technical Specifications and Post Commissioning Monitoring Methodology, Data Recording Formats, Quality Assurance Control [QA/QC] methodology, test certificates for the individual equipment , preparation of construction drawings etc for approval from owner/ his representative.
  - Procurement of Material and equipments, for complete PCP system including supply, factory inspection, transportation, loading and unloading of CP TRU, anodes, cables, junction boxes, reference cells and other material required for complete PCP work on FOT- project site basis.
  - Submission and obtaining approval of all documents (vendor documents) related to procurement of items as mentioned above.
  - Construction drawings for cable trays, fixing details, cable sizing, cable schedule, interconnection diagram, and cable tray details for complete PCP system.
  - Installation details including location and fixing details of T/R unit, junction box. Anodes and control equipments.
  - Installation details of anode bed, reference cell, junction box etc. of complete impressed current cathodic protection system.
  - Preparation of detailed factory / laboratory testing procedures for critical equipments. Submission of test certificate for equipment installed.
  - OFC cable if used shall be laid in HDPE pipe of suitable diameter.
  - Installation and erection of PCP System.
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- Development of system testing and commissioning procedures including interference testing.

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- Energizing, testing and commissioning of PCP System as defined in the tender including job procedure for field testing, pre-commissioning and commissioning.
- Preparation and submission of As-built drawings, O&M manual and handing over the entire system with reports to Owner.
- All civil works associated with the complete Cathodic Protection work shall be included in the scope of contractor. This shall include providing cable trenches, foundation for equipment etc.
- CP Monitoring for three months from the date of commissioning of PCP system with monthly progress reporting to owner/ his representative & mitigation of any anomaly required to tune up the functioning of the PCP system. This includes monthly monitoring of PCP test station with data logger and weekly monitoring of TRU parameters.
- Progress reporting to owner/ his representative.
- Coordinating with other contractors working at site as well as owner to obtain permission for PCP works.
- Handling over to client and Training of Owners Personnel.

The Intending Bidder shall be deemed to have visited the Site, pipeline ROW and familiarized before submitting his bid. Non familiarity with site conditions will not be accepted as a reason either for extra claims or for not carrying out the work in total conformity with the tender specifications.

#### **CODES AND STANDARDS**

The system design, performance and materials to be supplied shall conform to the requirements of the latest revision of following standards:

- ❖ NACE Publication No. 54276: Cathodic Protection Monitoring for Buried Pipelines.
- ❖ NACE Standard RP-0572: Standard Recommended Practice Design, Installation, Operation and of impressed Current Deep Ground Beds.
- ❖ NFPA- National Fire Protection Association
- ❖ DNV RP-B403: Recommended Practice Monitoring of Cathodic Protection Systems.
- ❖ DNV RP-B401: Recommended Practice Cathodic Protection Design.
- ❖ BS EN 15280:2013: Evaluation of AC corrosion likelihood of buried pipelines applicable to cathodically protected pipelines
- ❖ NACE Standard RP-0169: Standard Recommended Practice Submerged Metallic Piping Systems.
- ❖ NACE Standard RP-0177: Standard Recommended Practice Mitigation of Alternating Current and Lightning Effects on Metallic Structures and Corrosion Control Systems.
- ❖ NACE Standard RP-0286: Standard Recommended Practice-Electrical isolation of Cathodically Protection Pipelines.
- ❖ BS EN 50162:2004 : Protection against corrosion by stray current from direct current systems
- ❖ BS 7361 Part I: Codes of Practice for Cathodic Protection for land and marine applications.
- ❖ VDE 0150: Protection against Corrosion due to Stray Current from DC Installations.
- ❖ IS: 8062: Code of practice for cathodic protection of steel structures

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- ❖ IS: 1554 Part I: PVC insulated (heavy duty) cables.
- ❖ IS: 7098 Part-I: XLPE insulated PVC sheath cable
- ❖ Any other standard applicable for the equipment being used for CP System.
  - a) In case of imported equipments standards of the country of origin shall be applicable if these standards are equivalent or stringent than the applicable Indian Standards.
  - b) The equipment shall also confirm to the provisions of India Electricity rules and other statutory regulations currently in force in the country.
  - c) In case of any contradiction between various referred standards / specifications / datasheet and statutory regulations the following order of priority shall govern.
    - Statutory Regulations.
    - Data Sheets
    - Technical Specification.
    - Codes and Standards

#### 4.0 SYSTEM IMPLEMENTATION

All work to be performed and supplies to be effected as a part of contract shall require specific review of owner or his authorized representative. Major activities requiring review shall include but not be limited to the following:

- Corrosion survey data interpretation report and design basis for C.P. System.
- C.P. System design package.
- Basic & Detailed engineering package
- Purchase requisition for major equipment.
- Field-testing and commissioning procedure.
- Procedures for interference testing and mitigation measures.
- System monitoring procedures.
- As built documentation.


#### 5.0 CORROSION DATA

##### 6.1. GENERAL

- i) Bidder to collect soil resistivity data and other data required for CP design and completeness of the job.
- ii) Bidder shall carry out soil resistivity survey at impressed current anode ground bed locations for proper design of ground beds using Wenner's 4-pin method or equivalent method, approved by owner shall be used for such measurements. Survey instruments shall have maximum AC and DC ground current rejection feature.

##### 6.2. Soil Ionic & Microbial Analysis

Soil samples to be collected along the length of the pipeline i.e. every 500 mtr and from proposed Anode bed locations at least two or more plots at each anode bed location and soil samples for

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Semi Deep Well anode beds to be collected from 10, 15,20,25,30,35,40,45,50,60...M depending on anode bed depth. All soil samples to be analyzed for:

1. Microbial Analysis: Presence/absence of Sulphate Reducing Bacteria [SRB].
2. Ionic Loading: All soil samples to be air dried, cone and quartered and an aqueous extract of these to be analyzed for:
3. Cations: Ca, Na, K, Mg (to report in ppm)
4. Anions:  $\text{Cl}^-$ ,  $\text{SO}_4^{2-}$ ,  $\text{CO}_3^{2-}$ ,  $\text{HCO}_3^-$ ,  $\text{PO}_4^{3-}$ ,  $\text{S}^{2-}$ ,  $\text{SO}_3^{2-}$ ,  $\text{NO}_2^-$ ,  $\text{NO}_3^-$  [In ppm]
5. Others: Moisture (%), Total Dissolved Solids (ppm), pH, Redox Potential

### 6.3. Water Table

Water table for the pipeline ROW particularly at proposed anode bed locations to be recorded either from GSI [Geological Survey of India] or by recording depth of in use wells nearby.

### 6.4. Topographic Surveys

Cathodic protection stations consisting of Impressed current Anode ground bed, CP Station, etc. as applicable, along with all associated cabling up to pipeline and any other related equipment and accessories for CP Station shall be demarcated on the ground.

Ground plots so demarcated shall be surveyed for all other topographical and cadastral features and topo-sheets shall be developed by bidder, which may be available for use in designing the cathodic Protection System and land acquisition etc.

### 6.5. Additional Data to be Collected


Bidder shall conduct necessary potential gradient survey for all the existing anode ground beds of the parallel running piping and any other existing anode ground beds along the pipeline that may interfere with the CP system of the piping covered under this project.

### 6.0 Report

On completion of all fieldwork, a report incorporating all the results generated from site surveys, Type of terrain and vegetation e.g. urban areas, industrial areas, farm land, forests, deserts, rocks, marshy areas etc and details of additional data collected shall be prepared and submitted to owner for approval. The report shall also contain detailed interpretation of survey results and resistivity data, probable interference prone areas, selected locations for impressed current anode ground beds, results, etc. to form design basis for the scheme of cathodic protection.

This report shall also include various drawings prepared in connection with the above work. The soil resistivity values shall be plotted on semi-log graph sheets. The Permanent Cathodic protection system design shall be long-line continuous anode or deep well anode bed only including stepwise calculations should be part of this report. QA/QC, Erection methodology, Bill of quantity; Technical specifications, vendor list, construction drawings etc will be included in the report for review/approval of owner/owner representative.



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## 7.0 CATHODIC PROTECTION DESIGN PARAMETERS

The Design of Impressed current cathodic protection system shall be carried out based on following design parameters.

Pipe to soil potential shall not be more negative than (-) 1.2V (OFF) wrt Cu-CuSO<sub>4</sub> Reference electrode.

\*Actual current density to be adopted shall be decided based upon soil and other environmental Conditions, proximity or foreign pipe lines and structures affecting and causing interference. Where considered necessary for satisfactory protection of all pipelines the current density shall be suitably increased by bidder for pipeline.

Safety factor for Protection Current Density : 1.3

Type of Coating of Pipeline : Cold tape type coating system  
(Polyethylene backed tape with butyl rubber based adhesive system)

Anode ground bed configuration : Semi Deep well type & linear continuous anodes

Type of Anodes : MMO coated (Ti) tubular & MMO coated wire

Anode

Pipeline Natural Potential : (-) 0.45V CSE


The design life of Permanent CP System : 30 years

Total CP System Loop Resistance : 1 ohm (maximum)

(The output voltage rating of the CP TR Unit shall in minimum be adequate to drive the specified end of life Cathodic Protection current with safety factor, considering the total Anode Ground Bed loop resistance as the sum of the resistance specified in this clause and pipe to earth resistance.)

Permanent Cathodic Protection System shall be designed to meet the following criteria:

- The pipe to the soil potential measurements shall be in between (-) 0.85 V (OFF) and (-) 1.2V (OFF) with respect to a copper / copper sulphate reference electrode. At the location of Polarization coupons, coupons to soil potential measurement shall be between (-) 0.85 (OFF) minimum and (-) 1.2V (OFF) Maximum wrt.Cu-CuSO<sub>4</sub> reference electrodes (both being "OFF" potential) using a current interrupter.
- In rare circumstances a minimum polarization shift of (-) 100 mill volts w.r.t. Cu-CuSO<sub>4</sub> reference electrode shall indicate adequate levels of cathodic protection for the pipeline.
- Discretion to use any of the criteria, listed above, shall solely rest with the. Owner/his representative.
- A positive potential swing of >20 mV [P-S-P] shall be considered as the criteria for presence of an Interaction situation requiring investigation and incorporation of suitable mitigation measures by the CP Bidder.

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## 8.0 SYSTEM DETAILS

All equipment shall be new and procured from approved manufacturers. Equipment offered shall be field proven. Equipment requiring specialized maintenance or operation shall be avoided as far as possible. Prototype equipment shall not be accepted. Equipment shall conform to the relevant specifications enclosed with the tender document.

As far as possible equipment including CPTR Unit, Test Stations, Anode Junction Boxes and Cathode Junction Boxes etc. shall be located in safe non-hazardous areas. Where it is essential to install the equipment in hazardous area, such equipment shall be flameproof type and shall meet the requirement of IS: 60079-1 or equivalent International Standard and shall be suitable for gas group IIA/IIB, temperature class T3 (200°C). All Indigenous flameproof equipment shall be certified by CMIFR or any other recognized testing body and shall be approved by the concerned statutory authority. All Indigenous flameproof equipment should also be BIS marked.

### a) Sacrificial (Temporary) Cathodic Protection System

#### i. Magnesium anodes

Magnesium anodes shall be low potential type with a cast-in galvanised steel core for cable connection and be packed in cloth sacks with low resistance wetting backfill.

Nominal magnesium anode composition will be as per AZ-63 of ASTM B843 as follows:

Element	Weight in %
Manganese	0.25min
Aluminium	5.3-6.7
Zinc	2.5-3.5
Copper	0.08 max
Silicon	0.3 max
Iron	0.005 max
Lead	0.03 max
Others	0.30 max
Magnesium	Remainder

The following acceptance criteria for the anode material performance shall be applied:


Electrochemical efficiency:  $\geq 1150$  Ah/kg at 20°C

Closed circuit potential:  $1.55 \pm 0.025$  Volt (Cu/CuSO<sub>4</sub> reference electrode)

The anode core shall be a steel insert cast into the anode body. The insert shall be at least 50 % of the anode length with a 15 x 6 mm minimum dimension cross area. An insert length of at least 30 mm shall protrude from the anode. Insulation will be then ensured by epoxy resin after cable connection.

The nominal net weight of each sacrificial anode, approximate overall packaged dimensions and approximate gross weight are determined based on a 3 year design life of temporary cathodic protection system.

Each anode will be supplied fitted with a XLPE/PVC cable tail of minimum 10 meters length. The anode cable requirements and specifications will be as specified in paragraph 5.9 of this document.

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The cable will be connected to the anode core and sealed to prevent ingress of moisture. The anode to cable connection shall be guaranteed for the life of the anode, subject to normal usage.

Magnesium anodes will be pre-packaged in a cotton bag containing a backfill with the following composition:

Element	Weight in %
Powdered Gypsum	75
Granular Bentonite	20
Sodium Sulphate	5

The packaged anode will be supplied in water proof packaging to prevent dampening of the backfill before installation. A warning sign stating “BEWARE, BAG TO BE REMOVED BEFORE INSTALLATION” shall be attached to the anode packaging.

## ii. Zinc anodes

Cast zinc anodes for use inside vessels and tanks shall meet either ASTM B 418 Type II alloy composition or US MIL SPEC A-18001-K, depending on the nature of the contained fluid.

US MIL A-18001-K alloy shall be used in saline or brackish conditions.

ASTM B 418 Type II alloy shall be used in potable waters and other environments. Zinc ribbon anodes, if used, shall be to ASTM B B418 Type II alloy.

Element	ASTM B 418 Type II Content (%)	US MIL A-18001-K Content (%)
Al	0.005 max	0.1 – 0.5
Cd	0.003 max	0.025 – 0.07
Fe	0.0014 max	0.005 max
Pb	0.003 max	0.006 max
Cu	0.002 max	0.005 max
Others		0.10 max each
Zn	Remainder	Remainder

The following acceptance criteria for the anode material performance shall be applied:


Electrochemical capacity: 780 Ah/kg (mean)

Closed circuit potential: - 1.05 Volt (Ag/AgCl reference electrode)

## iii. Aluminium anodes

Aluminium sacrificial anodes for use within tank and vessel internals shall be of Galvalum III or equivalent with a cast in galvanised steel core for mounting.

The composition of the alloy shall be as follows: -

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Element	Content (%)
Fe	0.13 max
Si	0.08 – 0.02
Cu	0.006 max
In	0.01 – 0.02
Zn	2.00 -6,00
Others	0.02 max
Al	Reminder

The following acceptance criteria for the anode material performance shall be applied:

- Electrochemical capacity: 2500 Ah/kg (mean)
- Closed circuit potential: - 1.05 Volt (Ag/AgCl reference electrode)


**b) Impressed Current (Permanent) Cathodic Protection System**

The Permanent system shall include but not limited to the following major equipment/ sub-Systems unless otherwise specified in data sheet.

- Test stations
- CP TR unit with built in current interrupter and GPS based timer
- Supply, installation, testing and commissioning of Transformer Rectifier unit full compliance to technical specification, data sheets and approved drawings with built in current interrupter and GPS based Timer. This shall also includes civil foundations, structural supports, dual earthing etc. of TR unit and supply, laying & termination of incoming power cables to TR unit, Supply of recommended spares for two years operations & Maintenance.
- Factory coke backfilled MMO wire anodes and semi deep well anode ground beds with carbonaceous backfill.
- Anode & cathode junction box with shunt and resistors.
- Permanent Reference Cu-CuSO<sub>4</sub> electrodes [CSE]
- Pin Brazing for pipe to cable connection [epoxy encapsulated ]
- Interconnecting cables.
- Polarization Coupons for Corrosion monitoring (wherever required)
- Markers for cable route, anode bed etc.
- Any other equipments not mentioned specifically but required for complete and desired operation of PCP.

External CP system design philosophy for buried plant piping shall be based on the following:

- Closed bed continuous & semi-deep well anode bed system impressed current system.
- Underground piping network intended to be cathodically protected shall be considered in electrical continuity with other foreign metallic structures within plant complex such as RCC

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pavement, earthing grids, foundation bolts etc which are not intended to be protected as such no isolation joints are required.

- For CW piping network continuity of pipes shall be maintained by connecting a jumper cables between pipelines or connection in junction boxes
- At road crossings, if the piping is provided with metallic sleeve, the same is required to be treated as cased crossing and provided with zinc ribbon anodes and one test station.
- Continuous anode bed system shall be long line conductive polymeric anodes or MMO wire anodes/piggy back cable with factory pre-packed calcined coke breeze encapsulated with acid resistant fabric and protective braid.
- Semi deep well type anode bed system using MMO tubular anodes of rating 2.5 Amp (dimension of the anode: dia 16mm & length 500mm) filled with calined coke breeze shall be installed. The semi deep will shall be installed with a spacing of 25-30 mtrs from the pipeline.


The cathodic protection current requirement shall be calculated as follows:

- Coating defects / holidays for 30% shall be considered at the end of life for calculation of current.
- Earthing system shall be considered for ICCP designing of plant piping as 100% bare.
- Incidental structures like steel reinforcement, RCC paving, foundations shall be taken into consideration while designing the CP system.
- Safety margin of 30% in current calculations shall be considered while designing.
- No Insulating joints shall be installed to isolate any incidental structure from CP system within battery limit. Hence the structures intended to be cathodically protected shall be in electrical continuity with many foreign structures within the plant complex such as RCC pavements, RCC foundation, earthing grids and other underground structures which are not intended to be cathodically protected.

LOCATION	TYPE OF ANODE	DIMENSIONS OF ANODE WITH CALCINED PETROLEUM COKE BREEZE
Within Plant area and with congested incidental structures	Long line linear anode - Conductive Polymeric anode or factory pre packaged MMO wire anode	Dia: 38 mm
Around the pipeline area or Off sites with space incidental structures	Semi deep well anode bed with MMO tubular anodes	Depth: 25-30 mtr ( or as per design) Diameter: 150 mm

#### i) CP Transformer Rectifier Unit

The CP TR Units shall have Automatic/Manual control and shall be metal clad, compact, suitable for outdoor type installation type, air natural cooled, dust and vermin proof systems. The components of the units shall be designed for maximum operating efficiency.

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Transformer Rectifier unit shall have operating range of 240/415V AC and shall be natural cooled type with separate primary and secondary windings. The rating of TRU shall be selected based on actual requirement and calculation for the same shall be furnished for owner's review/ approval.

Transformer shall be vacuum impregnated with epoxy varnish and baked. The safety factor for transformer rating shall be minimum 125%. A moulded case circuit breaker of suitable rating with thermal overload relay and short circuit release shall be provided at the input of the transformer.

The rectifier shall be made of thyristor and diodes as basic components. The diode rectifier of full wave type in the secondary of the transformer and triac or back to back connected thyristor in the transformer primary AC supply circuit may be provided. The current and voltage ratings of thyristors, diodes shall be at least two times the actual maximum device current and maximum device voltage appears across the device.

The supply, Installation, Testing and Commissioning of Outdoor type CP TR Unit installed in a kiosk including the supply of kiosk shall be included in Bidder's scope.

The CP TR Unit shall be installed in non-hazardous (safe) area. The CP TR Unit shall install in a fenced location with door (if installed in outdoor area) For other details, refer attached "Technical Specification of TRU". Make of equipment & component as per vendor list attached elsewhere in NIT.

## ii) **Anode Ground Beds**


The anode ground bed shall be semi deep well anode ground bed or continuous long line anode design.

### a) **Semi deep well Type anode bed bed/system**

Semi deep well type anode bed system using MMO tubular anodes of rating 2.5 Amp (dimension of anode: dia 16mm & length 500mm) filled with calined coke breeze shall be installed. The semi deep well will be installed with a spacing of 30-50 mtrs from the pipeline and a minimum depth of 25-30 mtrs, considering the same one semi deep well can be installed every 200 mtrs(approx) .Semi deep wells can be connected to one TRU through sub anode junction box and anode junction box. All the sub anode junction boxes shall be looped to each other and connected to anode junction box.

The anode lead cable from the anode junction box to tail cables shall be of single length (no splicing) of size 1c x 16/10 Sq.mm copper HALAR/KYNAR insulated/HMWPE sheathed.The anode header cables connecting the sub anode junction box to anode junction box shall be of size 1C x 25 Sq.mm copper PVC insulated/PVC sheathed armoured cable. The main anode cable connecting to anode junction box to TRU shall be 1Cx50 Sq.mm copper PVC insulated/PVC sheathed armoured cable.Make of equipment & component as per vendor list attached elsewhere in NIT.

### a.1) **Mixed Metal Oxide [MMO] Anodes: LIDA Tubular**

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The Permanent Cathodic Protection (PCP) system will have Mixed Metal Oxide (MMO) LIDA® Tubular Anodes also known as LIDA® [Linear Distributed]. The MMO LIDA® Tubular anodes shall be centre connected scaled tubular type.


These Anodes shall be of Noble metals (group VIII) Mixed Metal Oxide coated Titanium (having Ti substrate). The LIDA [MMO] anodes shall be dimensionally stable.

The semi deep well anode-bed shall comprise of individual anodes with anode tail cable of suitable length up to anode junction box for impressed current method to protect external surface of Cold tape type coating system (Polyethylene backed tape with butyl rubber based adhesive system) coated pipeline, against corrosion as per specifications for minimum service life of 30 years by using semi deep well anode bed construction of minimum 25-30 meter deep, with minimum 6" (150 mm) Dia MS pipe filled with Petroleum Coke Breeze of resistance  $\leq 5 \Omega$ , vent pipe, dead weight & a cable string of 10/16 mm<sup>2</sup> size contains required no of mixed metal oxide coated titanium tubular anodes of size ST 1.6/50 cm with minimum of 10 nos.. Each MMO anode has current output of 2.5A respectively and other accessories like vent pipe. Calcined petroleum coke breeze, Rigid PVC pipe of 12" (300 mm) with minimum 5-7 mtrs in length (i.e. 5-7 meter inactive anode bed), Nylon Rope, etc. from the approved vendor as per specification.

The characteristics of the [MMO] LIDA Tubular anodes are as follows:

1. Current output with carbonaceous backfill: 2.5 Amp.
2. MMO coating thickness:  $\geq 6$  gms/m<sup>2</sup>
3. Anode consumption rate: 2 mg/Amp Yr.
4. Design life of anode: 30 years
5. Length of cable: as required to reach the junction box.
6. The Anodes shall be electrically remote to the pipeline (to be confirmed by calculations & site conditions). The first anode of the string should be at least more than 7m deep (as per NACE RP 0572 Standard) i.e. inactive zone and the actual depth shall be minimum 25-30 meter deep and as per Approved Design. However, for Deep well Anode bed, only MMO LIDA® anodes to be used.
7. Anode LIDA [MMO] cable string shall be of 10/16 mm<sup>2</sup> size [Kynar/ HMWPE] jointing and insulation shall be done by anode manufacturer at his shop.
8. Dimension & weight of all anodes to be checked & recorded. Negative tolerance will not be acceptable.
9. Routine & type test certificates of cable manufacturer to be furnished for anode lead cable as per IEC502-1983 or relevant BIS code. Length and identification tag to be verified by measurement.
10. Each anode to cable joint shall be tested for its electrical contact resistance & its value in ohm shall be recorded.
11. First anode to cable joint shall be subject to accelerated ageing test & destructive test to determine pullout strength of cable to anode joint as well as effectiveness of the joint insulation.
12. Manufacturer shall furnish detailed dimensioned fabrication drawing of anodes as well as details of cable connection & its insulation scaling etc. (QA/QC) to owner for approval.



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13. Manufacturing of anode will commence only after this Approval from owner.

14. Vendor shall furnish for Owner's Approval the following information;

- Type & make of Heat Shrink cap & its properties.
- Procedure for making the joint.
- Procedure for accelerated aging test.
- Vendor shall submit all test report for owner review

**b) Continuous long line anode**

Factory coke backfilled fabric jacketed conductive polymeric or MMO coated Titanium wire anode with piggy back cable shall be designed to have a single length of 150-200 meters per circuit to be fed from sub anode junction box.

The sub anode junction box will have provision for feeding 2/3 single length of continuous long-line anode through resistor and shunt to control current / voltage in each circuit.

Sub anode junction will be connected to anode junction box .Each output circuit of the anode junction box will have wire wound shunt resistor and shunt for controlling and measuring current to each sub anode junction box.

The anode lead cable connecting to sub anode junction box to conductive polymer anode or Factory pre-packaged in coke backfill MMO coated wire anode shall be size 1Cx16 mm<sup>2</sup> copper XLPE Insulated/PVC sheathed. The anode header cable connecting the sub anode junction box to anode junction box shall be of size 1Cx25 mm<sup>2</sup> copper PVC Insulated /PVC sheathed armoured cable . The main anode cable connecting the anode junction box to TRU shall be 1Cx50 mm<sup>2</sup> copper PVC insulated / PVC sheathed armoured cable.

The long line anode will have a lateral separation of minimum 0.5 meter from the outer surface of the pipe. Also the anode will be so placed that there will be no incidental structure between the anode and the piping particularly earthing strips. The anode shall be laid at a suitable depth so that there will be no damage to the anode after laying during construction.


Anode cable marker shall be provided at suitable distance indicating route of buried long line polymeric /wire anode. The In-Line splice connecting the continuous long line anode and the anode lead cable shall be provided by the anode manufacturer. Suitable marker will be installed on the top of the splice indicating the location of the splice.

The continuous long-line anode shall be factory coke backfilled fabric jacketed conductive polymeric or MMO coated Titanium wire anode with piggy back cable.

The characteristics of long line polymeric anode shall be below

S.No	Description	Requirement
1	<b>Anode type</b>	Longline Conductive Polymeric anode
2	<b>COPPER CONDUCTOR</b>	
2.1	Dimension	16 mm <sup>2</sup> /6 AWG




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2.2	Resistance	$<1.5 \times 10^{-3}$ ohm/m
3	<b>CONDUCTIVE POLYMER</b>	
3.1	Volume Resistivity	1.1 to 1.9 ohm -cm
4	<b>COKE BREEZE</b>	
4.1	Coke breeze fixed carbon content	>99%
4.2	Coke breeze resistivity	0.05 to 15 ohm-cm
5	<b>COMPLETE ASSEMBLED ANODE</b>	
5.1	Overall OD of anode string with calcined petroleum coke breeze and its nylon fabric jacket enclosure	D=35 mm min D=12.7 mm over conductive polymer
5.2	Weight including calcined petroleum coke breeze	>1.0 kg/m
5.3	Anode Current Rating	>52mA/m

#### Datasheet of Factory Coke Backfilled Fabric Jacketed MMO wire anode

Description	Detail
Anode Type	Factory coke backfilled fabric jacketed mixed metal oxide coated on titanium wire anode, piggyback connected with anode lead cable, factory pre-packed with coke
Anode shape & Dimension	Wire, 1.5 mm diameter
Anode weight	7gm/m(min)
Anode Material	Grade 1 or 2 titanium to ASTM B 863
Anode Design Life	30 years
Anode consumption rate (kg/A-yr) at 100 A/M <sup>2</sup> C. density	2 mg/ A-yr.
Metal oxide coating thickness weight (gm/M <sup>2</sup> )	6 gms /m <sup>2</sup> (min)
Optimum Recommended thickness current density ( A/M <sup>2</sup> )	
a) With carbonaceous backfill in	100 A/m <sup>2</sup>

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soil soil/sand	
Minimum rated current output in soil/sand	50mA/m( minimum)
Mechanical& Physical properties	
Electrical Resistivity of Metal oxide	<10 <sup>-5</sup> ohm cm ( max)
Contact resistance of anode to cable	0.9 milli ohms(max)
Anode fabrication	The anode assembly shall be factory coke backfilled fabric jacketed Mixed Metal oxide coated Ti wire, encapsulated in calcined petroleum coke breeze, in an acid resistant fabric jacket with nylon braid.
Spacing between consecutive anode to cable joints	3 mtr
Anode piggyback conductor metal	Copper
Anode Piggyback cable conductor size	1 C X 10 mm <sup>2</sup> , 7 strands
Anode Piggyback cable insulation	KYNAR / HALAR
Anode Piggyback cable Sheathing	HMWPE

**i) Calcined Petroleum Coke Breeze**

Lubricated Calcined petroleum coke breeze backfill material for use with LIDA single [MMO] Anodes in PCP system shall have a carbon content of 99% minimum, bulk density of 1040 kg/cubic meter and particle size of 1mm (maximum).

The calcined petroleum coke breeze material shall be tested for chemical composition, bulk density, real density, particle size and resistivity etc.


**ii) Anode Junction Box**

Depending on the size and configuration of anode beds, one or more anode junction boxes shall be provided at each new anode ground bed. The junction box shall have flameproof/ weather proof enclosure, having degree of protection IP-55 with hinged lockable shutter. Enclosure shall be made of sheet steel of at last 3 mm thickness and shall be suitable for M.S. post mounting.

They shall be designed with terminals required for permanent CP system [PCP] and shall be suitable for total life of permanent CP system.

All cable tails from individual anodes shall be terminated onto the respective anode junction boxes, which shall be further connected to the main anode junction box (where applicable). The main anode junction box shall be connected to the cable coming from CP power source.

Each outgoing circuit in main junction box (where applicable) and each anode circuit in junction box shall have provision for measurement and control of individual circuit/anode current. For

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other details, refer attached “Technical Specification of Anode Junction Box”. Make of equipment & component unit as per vendor list attached elsewhere in NIT.

### iii) Cathode Junction Box

A cathode lead junction box shall be provided at each CP stations, near the pipeline at the location of connection of the negative drainage cables to the pipelines. The junction box shall have flameproof/ weather proof enclosure, having degree of protection IP-55 with hinged lockable shutter. Enclosure shall be made of sheet steel of at last 3 mm thickness and shall be suitable for M.S. post mounting. The negative of the CP power source shall be connected to the incoming circuit of the cathode junction box. The junction box shall have separated out going circuit one for each pipeline to collect the negative drainage currents from each of the parallel pipelines. Twenty percent spare out going feeders subject to minimum one no. spare feeder shall be provided in the Cathode junction box. The incoming circuit shall have current measurement facility. Each out going circuit shall have provision for measurement and control of current through shunt and resistor respectively. The resistor shall be of strip coil type with fixed tapings. For other details, refer attached “Technical Specification of Cathode Junction Box”. Make of equipment & component unit as per vendor list attached elsewhere in NIT.

### iv) Permanent Reference Cells

High purity copper/copper sulphate Permanent Reference Electrode three (3) numbers at each CP Station shall be provided at all CP Station along the pipeline ROW for monitoring the performance of the Cathodic Protection system.

All the three reference electrodes shall be routed individually to TRU through test station.

Reference Cell tail cable length shall be sufficient enough to reach the test station and further to the TRU without any splicing or jointing.


The reference cells shall be of silver/ silver chloride type in place of copper/ copper sulphate cells, at marshy area locations, where water table is high and chloride ion concentration is more than 300 ppm.

The life of reference cells shall be minimum 30 years under burial conditions operating on measuring instrument impedance of minimum 10 Mega Ohms.

The reference Electrode Tail Cable shall be laid in HDPE Pipe extended to the Cathodic Junction Box. Watering of the Reference Electrode can be done in future to make electrical contact. For other details, refer attached “Technical Specification of Reference Electrode Cu/CuSO<sub>4</sub>”. Make of equipment & component unit as per vendor list attached elsewhere in NIT.

### v) Test Stations

Test stations shall be provided every 200 mtr along the length of the pipeline with a reference access point for placement of portable reference electrodes. The test station shall have flameproof/ weather proof enclosure, having degree of protection IP-55 with hinged lockable shutter. Enclosure shall be made of sheet steel of at last 3 mm thickness and shall be suitable for

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M.S. post mounting. The test stations shall be designed with terminals required for permanent CP system [PCP] and shall be suitable for total life of permanent CP system.

Make of equipment & component unit as per vendor list attached elsewhere in NIT.

**vi) Earthing & Lighting Protection of A/G Portion of Pipeline**

Suitable Earthing & Lightning Protection arrangement as per IS 3043 & IS/IEC:62305 for above ground cathodically unprotected pipeline section at intermediate SV stations (wherever applicable), pigging stations (wherever applicable), terminals etc shall be provided by earthing with GI earth strip & electrodes. The resistance to earth of grounding shall be limited to 5 ohm max.

The CP TR Unit shall be earthed to the station earthing system. The CP TR unit shall be earthed to the earthing system of the above ground pipeline facilities at the terminal

**vii) Polarization Coupons**

The steel coupons of pipeline material shall be provided along the length of the pipeline to monitor the adequacy of the CP system to polarize/protect coating holidays. Coupon shall be installed at every alternate test station to get an idea of the polarized potential of the pipeline in the plant environment. Coupons shall be installed at bottom 1/3rd portion of the pipeline and 250mm approx away from the pipe surface.

Coupons shall be constructed from the pipeline material and shall have uncoated surface of 100mmx100mm 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 Reference access point shall be provided at each test station and near the coupon to measure the potential accurately.


**viii) Reference Cell Access Points**

Reference cell access points shall be at each test station location flushed to the ground with a cover, for measurement of pipe to soil potentials. A perforated PVC pipe filled with native soil and buried at the location shall be provided for the purpose. The length of the PVC pipe shall be adequate to reach the native soil below the paving.

**ix) Cables**

Cables shall be with annealed high conductivity, stranded copper /Al conductor, XLPE/PVC Insulated, 1100V grade, armoured, PVC sheathed conforming to IS: 7098 except for the cables for anode tail.

The minimum size of various cables are as per following, however bidder shall recommend sizes for various type of cables which is subject to owner approval. Cable size for any other purpose subject to owner approval.

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**Header Cable:** The size of the copper conductor from TR unit to junction boxes shall be minimum 1C x 50 sq mm (Cu) and armoured.

**Anode Tail Cable:** Minimum 1Cx 10/16 sq mm (Cu), Kynar/HMWPE insulated, un armoured for anode cable from anode to junction box. The length of anodic table cable shall be sufficient enough for termination on anode junction box without any joint in between.

**Potential and Reference Measurement Cable:** The size of the conductor shall be 1C x 6 sq mm (Cu) unarmoured for potential measurement from test station to pipeline and reference electrode to test station.

**Polarization Coupon cable:** The size of cable shall be 1C x 10 sq.mm.(Cu), un armoured, PVC aluminium backed by mylar/polyester tape shielded PVC sheathed.

**Current Measurement cable:** The size of the cable shall be 1C x 10 sq.mm.(Cu), un armoured.

**Bonding cable:** The size of the conductor shall be 1Cx 25 mm<sup>2</sup> (Cu) for bonding, polarization cell/grounding cell and isolating spark gap connection purpose.

**Monitoring Cable:** The Reference electrode/measurement armoured cable from Reference electrode TLP to TRU shall be minimum 10C x 2.5 sq mm (Cu)

**AC Power Incomer Cable:** The TR/CPPSM unit incomer cable shall be minimum 16 sq. mm Cu Conductor, 650/1100 V XLPE insulated, armoured, PVC sheathed. The cable shall be of 3 core types for single phase TR units and 4 core type for 3 phase TR units.

#### x) **CP Materials**

The CP material to be procured from approved manufacturer/ vendor list enclosed with the tender. Make of item not mentioned in the enclosed vendor list shall be subjected to client /PDIL approval.

### 9.0 **DESCRIPTION OF CP CONSTRUCTION WORK**


#### a) **Cable Laying**

Cables shall be laid in accordance with the layout drawings to be prepared by the Bidder. No straight through joint shall be permitted. Cable route shall be carefully measured and cables cut to required length. Minimum half 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 0.75m. Cables outside station/ plant area shall be laid at a depth of minimum 1.5 m. 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 placed at a depth of 0.9 m. from the finished grade, to mark the route.

In case of above ground cable, all unarmoured CP cables shall be laid in GI conduits of sufficiently large size, up to accessible height for protecting against the mechanical damage.

All underground unarmored cables including Anode tail cables shall run through PE sleeves. The measurement cables and permanent reference cell cables, etc, routed along the pipeline shall be

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carried at the top of the carrier pipe by securely strapping it at intervals with adhesive tape or equivalent as required.

GI pipes for proper size shall be provided for all underground cables for road crossings. Cables shall be neatly arranged in trenches in such a manner that crossing is avoided and final take-off to equipment is facilitated.

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 CP TR 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.

The cable armour shall be insulated (by taping with insulation tape) to avoid armour carrying CP current.

Cable route marker shall be installed over ground at suitable intervals, Cables shall not be passing below the underground pipeline. Cables shall be placed above underground pipeline and tightened with tape.

**b) Permanent Reference Cells**

The permanent reference cells shall be installed in natural soil conditions as per the recommendations of the cell manufacturer. Installations in highly acidic/ alkaline soil and soil contaminated by chemicals shall be avoided.

**c) Cable to Pipe Connections**

Connections of all cables other than cathode drainage cables to the pipeline or to charged pipelines shall be made by pin brazing/ Thermit welding.


Pin brazing connection shall have extremely low resistance ( $\leq 1$  ohm). The Pin Brazing connection shall have life not less than 30 years and suitable for all weather condition. Further cable connection through pin brazing to be field tested for contact resistance & temperature etc.

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 metal plate shall be same as that of the material of the pipeline.

Pipe coating shall be repaired after connection of cable to pipeline. At cathode drainage point the cable joint including the bolt, metal plate and exposed portion of the pipeline shall be covered by the coating repair material against ingress of water / moisture.

The coating repair material shall be compatible with the original coating and shall prevent ingress of water along the cable surface and at the interface of coating repair with the original pipe coating.

**d) Electrical Bonding of Flanged Joints**

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All flanged joints located in buried pipeline section that are cathodically protected must be electrically bonded. Connection shall be done with minimum 16 mm<sup>2</sup> cable.

## 10.0 Civil Works

All civil works associated with the complete cathodic protection work shall be included in the scope of CP contractor. This shall include providing cable trenches, foundation for equipment and all junction boxes etc.

## 11.0 Painting

The sheet steel used for fabrication shall be thoroughly cleaned and degreased to remove mill scale, rust, grease and dirt. Fabricated structures shall be pickled and then rinsed to remove any trace of acid. The under surfaces shall be prepared by applying a coat of phosphate paint and a coat of yellow zinc chromate primer. The under surfaces shall be free from all imperfections before undertaking the finished coat. After preparation of the under surface, spray painting with two coats of final paint shall be done. The finished panel shall be dried in oven in dust free atmosphere. Panel finish shall be free from imperfections like pin holes, orange peels, run off paint etc.

All unpainted steel parts shall be cadmium plated to prevent rust formation.

## 12.0 Quality Plan

The following documents are to be submitted for fulfillment requirement of quality plan for impressed current Cathodic protection system.

- Site Quality Plan
- Bought Out Item Quality Plan
- Indicative inspection and test plan with check list.
- Site organization chart
- Manufacturers QA Plan for major items.

## 13.0 MATERIAL INSPECTION AND TESTING


Owner or his representative will visit the works during manufacture of various equipment to assess the progress of work as well as to ascertain the quality of raw materials used. All necessary assistance shall be provided by Bidder and vendor during such inspection.

The minimum testing and inspection requirements for all components/ equipment shall confirm to requirements as defined in the relevant codes and standards. Detailed inspection and testing procedure along with acceptance criteria shall be prepared by Bidder for Owner's approval.

Test certificates including test records, performance curves etc., shall be furnished. All test certificates shall be endorsed with sufficient information to identify the equipment to which certificates refer and must carry project title, owner name and purchase order details etc.

Owner reserves the right to ask for inspection of all or any item under the contract and witness all tests and carryout inspection or authorize his representative to witness tests and carryout



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inspection. Bidder shall notify the Owner / Owner's representative at least 20 days in advance giving exact details of tests dates and address of locations where the tests would be carried out.

The following minimum tests must be carried out and recorded for all equipments.

Checking: Visual inspection comparison with drawings and specifications.

Inspection: Detailed physical inspection & Dimensions measurement

Testing : Simulation tests of equipment to determine its operational fitness.

#### 14.0 PACKING AND TRANSPORT

All equipment/material shall be protected for inland/ marine Transport, carriage at site and outdoor storage during transit and at site. All packages shall be clearly, legibly and durably marked with uniform block letters giving the relevant equipment/material details. Each package shall contain a packing list in a water proof envelope. Copies of the packing list, in triplicate, shall be forwarded to owner prior to dispatch. All items of material shall be clearly marked for easy identification against the packing list.

#### 15.0 FIELD TESTING AND COMMISSIONING

##### System Testing at Site

The system testing at site described below shall be applicable both for Sacrificial Anode CP system and Impressed Current CP system.

Field tests as per the owner reviewed/ approved field testing and commissioning procedures prepared by the Bidder shall be carried out on the equipment/ systems before these are put into service. Acceptance of the complete installation shall contingent upon inspection and test results.

All site tests & performance test shall be carried out by bidder.

All tools, equipment and instruments required for testing shall be provided by Bidder. Generally, the following minimum tests must be carried out and results should be recorded:

- Visual Inspection: Comparison with drawings, specifications, detailed physical inspection and, if necessary; by taking apart the component parts.
- Testing: Simulation tests of equipment to determine its operational fitness.


##### (i) Cables

- Cable No.
- Voltage grade
- Conductor cross section
- Continuity check
- Insulation resistance values between each core & earth, between cores.
- All cables shall be tested by 500 V megger.

##### (ii) Anode Ground Bed

- Location / Station
- Vertical / Horizontal/ Semi Deep Well/MMO wire Anode
- Check for actual layout and compliance with drawings.



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- Resistance of each individual anode and total resistance of anode bed.
- Current output of ground bed.
- Current output of each anode
- Mutual interference

### (iii) Reference Cell

- Location
- Type of cell
- Potential reading
- Installed on top / bottom level of pipeline.

### (iv) Test Stations

- Location / Identification number.
- Check for wiring as per schematics.
- Type of reference cell
- Check the healthiness of reference cell.

### (v) Grounding cell

- Location
- Type (no. of anodes)
- Ratings
- Surge diverter
- Location/ Identification number
- Ratings
- Check for healthiness


### (vi) Polarization coupons

- Location
- Exposed area/ size of coupons.
- Coupon to soil 'ON' and 'OFF' potential
- Type of reference cell
- Magnetic reed switch rating
- Operation of magnetic reed switch rating with magnet

## 16.0 PRE COMMISSIONING

Bidder shall carry out pre-commissioning operations after completion of installation of the system including all pre-commissioning checks, setting of all equipment, control and protective devices. All site tests reliability and performance tests shall be carried out by Bidder.

Before the electrical facilities are put into operation, necessary tests shall be carried out to establish that all equipment, devices, wiring and connection have been correctly installed, connected and are in good working condition as intended for the required operation.

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Owner / Owner's representative may witness all tests. At least one week's notice shall be given before commencing the tests.

All tools, equipment and instrument and instruments required for testing shall be provided by bidder.

a) **Anode Bed Resistance Logging**

Resistance Logging of anode beds shall be done after completion of installation of anode bed and during commissioning of CP System. The procedure for same shall be given by Bidder as a part of commissioning procedure during commissioning of CP system.

b) **Holiday Detection of Anode Leads**

To ensure the integrity of the insulation, the Bidder shall detect holiday of all anode lead cables. This test shall be conducted at the time of lowering anodes in the deep anode ground beds or trench. In case anode bed is located in hazardous area then the holiday detection test shall be conducted in the safe area before installation, after conducting test in the safe area anodes with lead wires to be shifted in anode bed location. The Bidder shall provide an approved holiday detection instrument complete with all accessories for testing of cables at the specified voltage. The actual procedures for the holiday detection testing shall be in accordance with the recommendation of the manufacturer of the holiday detection instrument.

No repair will be allowed on the down hole anode lead wires. Should holiday be detected, the entire cable and anode assembly shall be replaced.

c) **Energization of T/R Unit**

After installation of each CP Station is complete, the Bidder shall energize the T/R unit in the presence of the owner/ his representative to check the functioning of the CP System.


## 17.0 COMMISSIONING

Bidder shall furnish detailed CP commissioning procedure for approval. The CP commissioning shall be carried out as per approved procedure. The measurement carried out during CP commissioning shall be recorded. Interference situation shall be identified and necessary mitigation measures shall be taken by bidder. Interference situation shall also be identified and mitigated by comparing different sets of readings taken a same test station at different intervals of time under identical conditions.

## 18.0 SYSTEM MONITORING

CP Bidder has to monitor the- Permanent Cathodic Protection [PCP] system monthly after successful commissioning of the entire PCP system as per scope of work for three months period and submits the monitoring report to the owner/ owner representative for review.

CP Bidder to augment any deficiency observed during monthly monitoring the PCP system so as to ensure adequate levels of protection as specified in CP Acceptance criteria.

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## 19.0 GUARANTEE

Bidder shall guarantee the proper performance of the complete impressed current cathodic protection system and equipment provided by him for a period of 12 months from the date of commissioning of the PCP System.

The Bidder will monitor the CP System for one year from the date of commissioning and any defects arising shall be rectified at no extra cost.

## 20.0 INSTRUMENTS, TOOLS AND SPARES

Bidder shall provide a list of all instruments, tools and tackles necessary for proper operation and maintenance of complete cathodic protection system and associated equipment along with prices.

As a minimum following Instrument, tools and tackles required for proper operation and maintenance & monitoring of complete PCP shall be provided by Bidder. Cost of these shall also be included in the quoted price -

- a) Digital Multimeter
- b) Digital AC-DC Clamp meter
- c) Soil resistivity meter
- d) Portable Cu-CuSO<sub>4</sub> reference electrode

Bidder shall provide a spares and consumables along with prices, required for proper operation and maintenance of complete cathodic protection system for two (2) years.


## 21.0 DRAWINGS AND DOCUMENTS

### 22.1 GENERAL

- a) Within two week from the date of issue of Purchase Order, Bidder shall submit the list of all drawings/ data manuals/ procedures for approval, identifying each by a number and descriptive title and giving the schedule date. This list shall be revised and extended, as necessary, during the progress of work.
- b) All drawings and document shall be in English and shall follow metric system, with identification on each document by a number and descriptive title with project name, owner and consultant name.

Drawings and documents shall be furnished by bidder shall include but not limited to the following :

- i. Report on corrosion survey.
- ii. Basis of system design, design and sizing calculations of the equipments, equipment selection criteria, and data sheets of materials.
- iii. Bills of materials, material requisitions and purchase requisitions.
- iv. Quality assurance/ Quality control Procedures.

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- v. Fabrication and installation details of AJB, CJB, test station, grounding cell etc with its enclosure and housing.
- vi. TRU Erection/ Installation Details drawing.
- vii. Connection scheme drawing for different type of test station used in the cathodic protection of pipeline.
- viii. Permanent Cu-CuSO<sub>4</sub> reference electrode installation drawing.
- ix. Cable- to-pipe joint details for charged and non charged pipelines.
- x. Grounding Cell (Zn/ Mg anode) fabrication drawings.
- xi. Incorporation of anode beds, polarization cell, , test stations, etc. and other relevant features of CP system-design in Pipeline alignment sheet and other related drawings.
- xii. Detailed commissioning report including various measurement data at test stations etc.
- xiii. Equipment inspection and testing procedure.
- xiv. Construction, installation procedures.
- xv. Procedure for monitoring of cathodic protection after commissioning.
- xvi. Field testing and commissioning procedures.
- xvii. Post Commissioning Testing, Monitoring Periodicity/ Methodology.
- xviii. Layout drawings showing anode ground bed location, test station, AJB, CJB, TR unit cased crossing, permanent reference cell location etc.
- xix. Cable schedule and cable layout.
- xx. Report comprises of details regarding interference affected sections along pipeline ROW, sources of interference, interference mitigation arrangement etc.
- xxi. Vendor drawings and catalogues, test certificates.
- xxii. Operation and maintenance manual.
- xxiii. Miscellaneous

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**TECHNICAL SPECIFICATION**  
**OF**  
**ANODE JUNCTION BOX**  
**FOR**  
**PERMANENT CATHODIC PROTECTION SYSTEM**

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## 1.0 SCOPE

This specification covers the minimum technical requirements for the design, manufacturer and Supply of anode Junction Boxes for CP system.

The junction boxes should be a standard product of the manufacturer regularly used for impressed current cathodic protection system.

Junction box shall have provision of termination of cable tails from individual anodes of the ground bed and provision of connection of from CP station power source.

This specification confers requirement for type, rating, manufacture and testing of Anode junction boxes. The weatherproof junction boxes shall be supplied in accordance with the following specifications and data sheets.

## 2.0 CODES AND STANDARDS

The Weatherproof Junction boxes shall be in accordance with the latest revisions of the following Indian standards, wherever applicable. Where appropriate Indian standard are not available, the relevant IEC standards shall apply.

- Indian standards institution (ISI)
- International electro technical commission (IEC)
- American standards institution (ANSI)
- British standards institution (BS)
- NACE standards
- OISD standards

## 3.0 DATA SHEET:

Output circuit Configuration	: Anode Bus output distributed into outgoing circuits and spare circuit in line with Current Measuring Shunt & Resister with minimum 30% spare outgoing circuits.
Shunt type	: Maganin Alloy
Shunt Rating	: 25A/25mv (To be calculated by CP contractor subject to approval by owner)
Resistor Rating	: Cressol Type (To be calculated by CP contractor subject to approval by owner)
Insulation Level in between	: 2 KV for 1 minute at 50 HZ.
Terminals & body	
Busbar	: Tinned Copper Bus Bar- 25mm x 6mm
Input terminals	: Stainless Steel Stud with nut, spring

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and plain washer.

Output terminals	: As required
Enclosure	: Minimum 3 mm thickness Completely enclosed, outdoor type, Wall/ Structure Mounted, Natural Air Cooled, IP-55 Construction. The cabinet is made from LM-6, Die cast construction, The cabinet has hinged front doors with Neoprene gasket and weather proof single compression cable gland and is Pad lockable.
Dimension	: To be specified by bidder
Cable entries	: Cable entries are through pipe and gland
Painting	: One Coat of Zinc Primer  Two Coat of Epoxy Paint Shade 631 of IS: 5
Name plates and Labels	: All internal component identification labelling is done using permanent Screening / marker Name plate shall be Engraved white lettering in black Manufacturer's name, address, date of manufacture, model number, serial number, weight etc. Provided on front door

#### 4.0 CONSTRUCTIONAL FEATURES

Anode lead cable from anode ground beds are terminated to the junction box and further extended to T/R Units. The junction box should have a tinned copper bus bar 25mmx6mm for connection of positive header cable from the transformer rectifier unit. The anode lead cable is feed from output circuit through a shunt of suitable rating and an adjustable strip wound CRESSOL type resistor of suitable rating.

All terminals should be SS-304 material and size M-8 (08mm) nut, bolts, spring washer. The termination boards should be Fabric reinforced Polyester of minimum 08 mm thickness.

The enclosure should be fabricated from LM-6. The construction should be Weather proof. Air-cooled, Dust and Vermin proof. Junction box should have a card pocket inside the door. Degree of protection should be IP55 as per IS/IEC-60529.

The enclosure should be stand alone / wall mounted type with canopy for rainwater protection. The gasket should be of neoprene rubber. The enclosure should be provided with front excess door with pad and panel key locking arrangement. Contractor needs to take prior approval of GA drg, data sheet of AJB before proceeding with fabrication/manufacturing.

The junction box should be provided with stainless steel nameplate with details.


#### 5.0 TESTING & INSPECTION:

Weather Proof Junction Boxes shall be inspected by owner before dispatch. Testing shall be conducted in accordance with codes and standards specified in this document and also as per enclosed technical specifications.

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**TECHNICAL SPECIFICATION**  
**OF**  
**CATHODE JUNCTION BOX**  
**FOR**  
**PERMANENT CATHODIC PROTECTION SYSTEM**



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## 1.0 SCOPE

This specification covers the minimum technical requirements for the design, manufacturer and Supply of Cathode Junction Boxes for CP System.

The junction boxes should be a standard product of the manufacturer regularly used for impressed current cathodic protection system. This specification confers requirement for type, rating, manufacture and testing of different types of junction boxes. The junction boxes shall be supplied in accordance with the following specifications and data sheets.


## 2.0 CODES AND STANDARDS

The Weatherproof Junction boxes shall be in accordance with the latest revisions of the following Indian standards, wherever applicable. Where appropriate Indian standard are not available, the relevant IEC standards shall apply.

- Indian standards institution (ISI)
- International electro technical commission (IEC)
- American standards institution (ANSI)
- British standards institution (BS)

## 3.0 DATA SHEET:

Output circuit Configuration	: Cathode Bus output distributed into required no. of outgoing & incoming circuit (1 incoming & minimum 2 outgoing with 1 spare). The incoming circuit shall have a current measurement shunt. while out going circuits shall have isolation link, variable resistance of grid coil type and a current measurement shunt.
Shunt type	: Maganin Alloy
Shunt Rating	: 25A/ 25mv (To be checked and confirmed by the contractor)
Resistor Rating	: Cressol Type – Strip Wound (To be indicated by the contractor with calculations)
Insulation Level in between terminals & body	: 2 KV for 1 minute at 50Hz.
Busbar	: Tinned Copper Bus Bar- 25mm x 6mm
Input /output terminals	: Stainless Steel Stud with nut, spring and Plain washer.
Enclosure	: Completely enclosed, Outdoor type, Wall / Structure Mounted, Natural Air Cooled, dust and vermin proof IP55 Construction. The cabinet is made from LM-6, Die cast construction. The cabinet has bolted front doors open able with Allen key neoprene gasket and is Pad lockable.
Dimension	: To be specified by bidder
Cable entries	: Cable entries are through pipe.
Painting	: Surface preparation One Coat of Zinc Primer Two Coat of Epoxy Paint Shade 631 of IS: 5
Name plates and Labels	: All internal component identification

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Labelling is done using anodised aluminium plate with black back ground and white letters.

#### 4.0 Cathode/ Bonding junction Boxes:

Drainage, measurement, and reference electrode cable from the pipelines are terminated to the junction box and further extended to T/R Units. The junction box should have a Ni-Cd plated copper bus bar 25mm x 6mm for connection of negative header cable from the transformer Rectifier unit. The number of cathode circuits should be 02+01 including spare. The cathode lead cables feed from output circuit through a suitable shunt of 25 A/ 25 mV and adjustable strip wound Reputed make type ZO resistor of suitable rating.

All terminals should be SS-304 material and size M-8 (08mm) nut, bolts, spring washer.

The enclosure should be fabricated from LM-6. The construction should be Weather proof. Air-cooled, Dust and Vermin proof. Junction box should have a card pocket inside the door. Degree of protection should be IP55 as per IS/IEC-60529.

The termination boards should be Fabric reinforced Polyster of minimum 06 mm thickness.

The enclosure should be standalone / wall mounted type with canopy for rainwater protection. The gasket should be of neoprene rubber. The enclosure shall be provided with front excess door with bolted arrangement openable with Allen key. Contractor needs to take prior approval for GA drg & data sheet before proceeding with fabrication works/ manufacturing.


The junction box shall be provided with stainless steel nameplate with minimum information viz chainage in Km, connection scheme, distance from the nearest pipeline & other CJB.

#### 5.0 TESTING & INSPECTION:

Weather Proof Junction Boxes shall be inspected by purchaser before dispatch. Testing shall be conducted in accordance with latest codes, standards specified in this documents and also as per enclosed technical specifications.

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**TECHNICAL SPECIFICATION**  
**OF**  
**REFERENCE ELECTRODE – Cu-CuSO<sub>4</sub>**  
**FOR**  
**PERMANENT CATHODIC PROTECTION SYSTEM**

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## 1.0 SCOPE

This specification covers the minimum technical requirements for supply of permanent reference electrode for cathodic protection system.

The permanent reference electrode shall be a standard product of a manufacture regularly engaged in production. Reference Cell tail cable length shall be sufficient enough to reach the test station and further to the TR unit without any splicing or jointing.

The reference electrode shall be supplied in accordance with the following specification and data sheets & drawing attached elsewhere in ITB.

## 2.0 CODES AND STANDARDS

The permanent reference electrode shall be in accordance with the latest revisions of the following Indian standards, wherever applicable. Where appropriate Indian standard are not available, the relevant IEC standards shall apply.

- Indian standards institution (ISI)
- International electro technical commission (IEC)
- American standards institution (ANSI)
- British standards institution (BS)

## 3.0 DATA SHEET:

Type	: Cu-CuSO <sub>4</sub>
Application	: Direct Buried
Design life	: more than 30 years
Dimensions	: To be Specified by bidder
Type	: Copper/Copper Sulphate (Cu/CuSO <sub>4</sub> )
Make	: As per vendor list attached
Model	: To be specified by bidder
Dimensions	: To be specified by bidder
Lead wire	: 2.5 sq.mm, Cu cable, Lead wire, 1.5" long
Temperature	: 0 to 55 Deg C
Stability	: +/- 10 mV with 3.0 micro amps load
Tube Material	: Space age ceramic tube with cap
Application	: For External CP only

## 4.0 TEST CERTIFICATES:

The testing shall be conducted in accordance with codes and standards specified in this document and also as per enclosed technical specifications. Test certificate shall be furnished as per routine test done by manufacturer.

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**TECHNICAL SPECIFICATION**  
**OF**  
**TRANSFORMER RECTIFIER UNIT**  
**FOR**  
**PERMANENT CATHODIC PROTECTION SYSTEM**

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## 1.0 SCOPE

This specification covers the minimum Technical requirements for the Design, Manufacture, Performance, Supply, Inspection, Testing and commissioning of AC operated Air natural Cooled, dust and vermin proof Transformers Rectifier Unit for CP System.

The Transformer Rectifier units shall be a standard product of a manufacturer regularly engaged in production of Cathodic Protection Power Supplies. Apart from the derating for site conditions an additional derating of 20% shall be considered for the specific use. The components of the units shall be designed for maximum operating efficiency.

The units shall be supplied in accordance with the following specifications.

## 2.0 CODES AND STANDARDS

The Design, Manufacturing, Testing of Air natural Cooled Transformer Rectifier Unit and their components shall be in accordance with the latest revisions of the following Indian standards, wherever applicable. Where appropriate Indian Standards are not available, the relevant IEC Standard shall apply:

- a) Indian Standards Institution (ISI)
- b) Indian electricity Rules (IE rule)
- c) International Electro Technical Commission (IEC)
- d) NACE standards & recommended practice
- e) American Standards Institution (ANSI)
- f) British Standards Institution (BS)
- g) OISD standard & CCOE norms

Which shall include but not limited to the followings:

- |               |   |  |
|---------------|---|--|
| IS: 2026      | - | Power Transformer  |
| IS: 3700      | - | Essential rating and characteristics of semi-Conductor devices.  |
| IS: 4400      | - | Methods of measurements on semiconductor Devices (General)   |
| IS: 60898     | - | Electrical accessories-Circuit breakers for over current Protection for household and similar installation |
| IS: 13703     | - | Specification for Low voltages fuses for voltage not exceeding 1000V AC or 1500V DC                        |
| IS/IEC: 60947 | - | Specification for Low voltage Switchgear & control gear  |
| IS: 3070      | - | Lightning arrestors for AC systems.  |
| IS: 11548     | - | Capacitors for surge protection for use in   |

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Voltage system above 650V and up to 33kV.

IS: 694	-	PVC insulated unsheathed and sheathed cables/ cords for working voltages up to and including 450/ 750 volts
IS: 3961	-	Recommended current rating for cables
IS: 4800	-	Enameled round winding wires
IS: 11222	-	Dial, scales and indexes for indicating analogue Measuring instruments.
IS: 1248	-	Direct acting indicating analogue electrical measuring instruments and their accessories
IS: 6236	-	Direct recording electrical measuring instrument
IS: 2419	-	Dimension for panel mounted indicating and recording electrical instrument
IS: 8573	-	Digital electronic DC voltmeters and DC Electronic analogue to digital convertors
IS: 3715	-	Letter symbols of semiconductor devices
IS: 4411	-	Code of designation of semiconductor devices
IS: 5469	-	Code of practice for the use of semiconductor junction Devices
IS: 6619	-	Safety code for semiconductor rectifier equipment
IS: 7204	-	Stabilized power supplies DC output
IS/IEC: 60529	-	Classification of degree of protection provided by enclosure
IS: 3043	-	Code of practice for earthing

In case of conflicting requirements amongst any of the above standards, the most stringent requirement shall be followed.

### 3.0 GENERAL REQUIREMENTS

- The CPTR unit shall be suitable for installation in non air-conditioned room with restricted ventilation or in outdoor kiosk (as specified in data sheet), in locations having generally corrosive, warm, humid and dusty atmosphere.
- Design ambient temperature of 50°C and an altitude not exceeding 1000 m above mean sea Level shall be considered.
- TR unit shall be housed in sheet steel enclosure. The front, rear and doors shall be made by using minimum 2.64 mm thick sheet steel and side walls shall be made of minimum 1.6 mm thick sheet steel, suitable stiffeners shall be provided wherever required.

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- iv. The Unit shall be freestanding type. Hinged doors shall be provided at the front and back as required. The unit shall be natural cooled type. Louvered openings with wire mesh for natural ventilation may be provided.
- v. Minimum Degree of protection for the panel shall be IP-41.
- vi. Suitable hooks shall be provided for lifting the panel.
- vii. All instruments shall preferably have panel mounted type. All fuses shall be provided inside the panel and shall be of link type.
- viii. Power & auxiliary wiring shall be carried out by 660 V grade PVC insulated BIS approved wires with stranded copper conductor of size minimum 2.5 mm<sup>2</sup>. Control wiring for electronic circuits shall be through flat ribbon cable or through copper wire of minimum 0.5 mm diameter.
- ix. All wirings shall be ferruled with PVC ferrules at both ends for ease of identification.
- x. Clamp type terminals suitable for termination up to 10 mm<sup>2</sup> conductor shall be provided for all control cable connection. Suitable power terminals shall be provided for power cables. Minimum 20% spare terminals shall be provided. The terminal blocks shall be mounted minimum 300 mm above the gland plate.
- xi. All live parts shall be properly shrouded. This shall ensure complete safety to personnel intending routine maintenance by opening the panel doors.
- xii. TR unit shall be suitable for bottom cable entry unless otherwise specified in the data sheet and shall be supplied complete with crimping type cable termination lugs and cable glands. Cable glands shall be of brass, nickel plated, single compression type for indoor installations and double compression type for outdoor installations. The space in the terminal chamber shall be adequate for termination of required number and sizes of cables.
- xiii. The input power factor of the unit at rated load shall be 0.8 lag or better.
- xiv. All the control equipment like switches, push buttons, potentiometers etc. shall be located at a convenient height of minimum 300 mm and maximum 1800 mm from the bottom of the panel.
- xv. The printed circuit boards (PCBs) shall be of copper clad glass epoxy laminate. PCB tracks shall be tinned and solder masked. The PCB shall be coated with suitable lacquer to make it immune to dust, moisture and fungal growth. Where plug in type of PCBs are used gold plated male-female connectors shall be used for the purpose.
- xvi. The panel shall be provided with suitable space heater to prevent moisture condensation. The space heaters shall be located at the bottom of the panel and shall be provided with a manually operated switch, HRC fuse and link for phase and neutral respectively.
- xvii. Panel shall be provided with integral base frame channel. The integral base frame of panel shall be suitable for directly bolting with the help of foundation bolts and shall also be suitable for tack welding to purchaser's insert plate/ flat/ channel embedded in the floor. Amply dimensioned oblong holes shall be provided at the bottom of the panel for its bolting to the embedded insert plate/ channel.
- xviii. An earth bus bar of minimum (25x3) mm<sup>2</sup> copper or equivalent aluminium shall be provided throughout the length of the panel. Provision shall be made for connecting this earth bus at two ends with the plant earth grid by means of (50x6) mm<sup>2</sup> GI flat. All non-current carrying metallic parts of the panel and mounted equipment shall be connected to the panel earth bus. All doors and movable parts shall be connected to the earth bus by flexible copper cables.



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- xix. All panel mounted equipments (e.g. lamps, push buttons, switches, meters, PCBs, etc.) shall be provided with suitable nameplates. Nameplates shall be engraved out of 3-ply (black-white-black) lamicoide sheets or anodised aluminium. Back-engraved Perspex sheet nameplates may also be acceptable. Engraving shall be done with groove cutters. Hard paper or self-adhesive plastic tape nameplates shall not be acceptable. Nameplates shall be fastened by screws and not by adhesive. Labels shall be provided for every component on the cards, connecting wires as well as for the terminals in the terminal strip inside the panel.

#### 4.0 TRANSFORMER

The Main Transformer will be the air natural cooled, dry type with input operating range of 230V or 415V AC 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, for this purpose a visible lead should be brought out from the copper foil which shall be connected to any of the mounting stud of the transformer core. Insulation class of winding shall be class F type with temperature rise limited to class B.

Transformer shall be vacuum impregnated with epoxy varnish and baked. The safety factor for transformer rating shall be minimum 125%. A moulded case circuit breaker with thermal overload relay and short circuit release shall be provided at the input of the transformer.

The winding assembly shall be dipped in the thermo-setting varnish and backed. The Cabinet air temperature will not exceed 70°C at 110% full load current at ambient temperature of up to 45°C. Transformer full load efficiency will not be less than 95%. The autotransformer shall be similar to main transformer except it will have single winding and tapping for manual mode of control.

#### 5.0 RECTIFYING ELEMENT

Rectifier shall be Silicon type made of thyristors and diodes as basic components with adequate cooling arrangement with moisture and humidity resistant finish. It shall be mounted on spindles or other suitable supports. The Power Rectification shall be through Diodes/SCRs which shall be properly selected to have adequate Safety Margin. It shall have 3 phase full wave controlled type configuration.

The thyristors/diodes shall be mounted on heat sinks which shall preferably be made of extruded aluminum. The diodes shall be connected in Bridge circuitry for full wave rectification. Adequate filtering in the form of L-C filtering circuit shall be provided on the output side to limit the ripple content to less than 5% at rated output. The input & output of the Rectifier shall be protected by HRC fuses of suitable rating. Transient surge suppressors shall also be provided across DC output terminals and AC input terminals to protect the rectifier against surges. Each diode and SCR shall be provided with suitable surge suppressors, and also with suitably designed snubber circuits.

The current and voltage ratings of thyristors, diodes shall be at least two times the actual maximum device current and minimum two times the actual maximum voltage coming across the device respectively. The thyristors/ triac/ rectifier elements shall be protected against voltage surges coming from the incoming power supply and from output side from the pipeline. Required shunt zeners / MOV shall be provided across the rectifier elements for protection.

#### 5.0 A.C. INPUT

The transformer rectifier units shall be designed to operate on 240V/415V $\pm$  10% single/three phase AC, 50Hz $\pm$ 5% power supply. Inrush current limiting reactor of suitable rating to be provided at input line of the Main Transformer to avoid possibility of nuisance tripping of MCB while closing circuit using MCB.

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## 6.0 D.C. OUTPUT

The Transformer rectifier shall be designed to operate continuously at 110% rated output current and 110% rated output voltage at input supply voltage 240V/415V, single/three phase AC without damaging any components.

Two pole moulded case circuit breaker or miniature circuit breaker (if available) rated for the DC output current, short circuit current and having thermal over load, short circuit release shall be provided in the output. A lightning arrestor rated for minimum 10KA impulse current discharge capacity and rated voltage & maximum spark over voltage rating suitable to protect the TR unit components against lightning and switching surges shall be provided at the output.

## 7.0 D.C. OUTPUT ADJUSTMENTS

The D.C. output control shall be available in any of the following modes, with the help of a selector switch.

## 8.0 MODES OF OPERATION

### 8.1 MANUAL MODE

Output voltage at 36 equal steps up to 110% rated voltage shall be available by means of coarse and fine tap changing switches for rated input supply voltage and 110% rated output current.

Tapping for output voltage control shall be taken from a separate Auto transformer. The controlled output voltage of the auto transformer shall be fed to main transformer input. The output of the Main Transformer shall be rectified for D.C load supply.

### 8.2 AUTO MODE

Either Automatic voltage-current control mode or Automatic reference mode to be provided in Auto mode.

#### 8.2.1 AUTOMATIC VOLTAGE-CURRENT CONTROL MODE

The output voltage of the unit shall be adjustable to any value from 0V to rated voltage by means of a step less voltage setter potentiometer. The voltage regulation shall be better than  $\pm 0.25V$ .

The output current of the unit shall also be adjustable to any value from 0A to rated current by means of a step less current setter potentiometer. The current regulation shall be better than  $\pm 0.5A$ . The response of both current controller and voltage controller shall be ultra fast, instantaneous type.

The independent current limit circuit capable of protecting the unit even under dead short circuit across output shall be provided. The unit will be suitable of sustaining dead short circuit across output indefinitely without degrading or damaging any internal components in this mode.

The working of this mode shall be totally independent of the Auto reference mode and failure of unit in Auto reference mode shall not affect operation in this mode.

#### 8.2.2 AUTOMATIC REFERENCE MODE

The TR Unit shall normally be working in this mode. The operation of the unit in this mode shall be controlled by a reference signal and shall be instantaneous to suppress extremely fast acting external stray currents if present. The output D.C. voltage of the unit in this mode shall vary right

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from 0V to rated voltage and from 0A to rated current to maintain the reference signal within  $\pm 15$  mV of the set value under all operating conditions.

Suitable monitoring arrangement shall be provided to monitor all the external reference signals as well as internal reference signals independently. Fully solid state Automatic Reference Selector logic shall be provided to select the lowest of the three Reference Inputs automatically.

Facility shall also be provided for Manual selection of anyone out of the three reference inputs for control.

In the event of failure of the reference signals, the unit will provide alarm – “All Reference Fail” and the output of the unit shall get adjusted to a preset value which will be manually adjustable from 0V to rated voltage.

Independent ultra fast acting electronic current limit circuit shall be provided to limit the output Current of the unit in Auto mode to any value from 0 A to rated value as desired by the operator. The current limit circuit will be capable of protecting the unit even under dead short circuit across output. The unit will be suitable of sustaining dead short circuit across output indefinitely without degrading or damaging any internal components in this mode.

## 9.0 REMOTE MONITORING & CONTROL FACILITY

T/R Units should be provided with transducers for providing 4-20 mA output signals required for remote monitoring unit (RMU) interface for remote monitoring of T/R Unit output voltage and current. Necessary terminals are to be provided at suitable locations of the T/R unit panel for easy termination of onward wiring by others for remote monitoring purpose.

Facility will be provided for remote monitoring of following signals;

1. Analog Parameters
  - a) PSP
  - b) DC O/P Voltage
  - c) DC O/P Current
  - d) AC Supply Voltage
  - e) AC Supply time Totaliser
2. Alarm Parameters
  - a) Under Protection
  - b) Over Protection
  - c) Reference fail
  - d) AC Supply Fail
  - e) TR unit Door open

## 10.0 T/R UNIT CONTROL

The Transformer / Rectifier unit's electronic control circuitry should be able to accept remotes as well as local reference control signal for setting of output current / output voltage. The control

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signal for setting should be selected using a selector switch for remote or local control. At selector switch in local position, the potentiometer provided in T/R Units for continuous current and voltage adjustment in auto mode should provide local control reference signal by manual adjustment to the potentiometer. At selector switch in remote position the electronic circuitry should be suitable to accept digital reference control signals from central control room computer for remote setting of output current / voltage / PSP. In this case if communication links fails the set points should be maintained to the preset values stored in memory till communication resumes and new values are programmed.

#### 11.0 T/R UNIT IN INTERRUPTION

Current interruption facility will be provided by means of a built-in contactor & microprocessor based synchronisable digital timer with real time clock & ON/OFF time display. The timer will have facility for adjusting the ON time & OFF time from 0 to 9999 sec. by means of digital setting facility. Timer will have START, STOP facility through local keypad or through remote potential free contacts. The timer will have facility for Synchronization to Master Timer or similar Timer in another unit. The current interrupter should have membrane keypad and LCD display for programming of day, date, time, ON/OFF Time, Synchronization Signal etc.

#### 12.0 DC OUTPUT RIPPLE

The filter circuit shall be designed in such a manner that Ripple Factor does not exceed 5% at rated load both in auto and manual mode.

#### 13.0 INPUT OVERLOAD PROTECTION

Protection from overloads on the input shall be provided by Miniature circuit breaker of suitable rating on the input side. The trip point shall be unaffected by ambient temperature. The trip handles of individual poles of circuit breaker shall be mechanically linked so that all lines are opened when an overload occurs. In addition to above MCB, HRC fuse of suitable rating shall be connected before MCB so that A.C. input current is limited to max. 10% excess rated input current.

#### 14.0 OUTPUT OVERLOAD PROTECTION

Two pole moulded case circuit breaker or miniature circuit breaker (if available) rated for the DC output current, short circuit current and having thermal overload, short circuit release shall be provided in the output. A lightning arrestor rated for minimum 5 KA impulse current discharge capacity and rated voltage & maximum spark over voltage rating suitable to protect the CP TR unit components against lightning and switching surges shall be provided at the output. For CP TR units with multiple output circuits, each output circuit shall be provided with circuit breaker and lightning arrestor.

#### 15.0 VOLTAGE SURGE PROTECTION

Each silicon controlled rectifier (SCR) and Diodes shall be protected from Voltage Surges by means of R-C circuitry. These R-C circuits will be rated as recommended by the manufacturer of the SCR/Diodes so that they will conduct heavily before the Peak Inverse Voltage ratings of the SCR / Diodes are reached.

In addition, Lightning Arrestors and Zener barrier type or MOV type Surge Diverters shall be provided in the A.C. input and D.C. output circuit of the Transformer Rectifier.

#### 16.0 COOLING

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The Transformer/Rectifier will be natural air cooled, completely enclosed IP55 construction. The temperature of the transformer shall not be more than 85°C for ambient temperature of up to 50°C.

## 17.0 INPUT AND OUT PUT TERMINALS

DC terminals made of tinned plated copper shall be located convenient to the cable entrance. The terminals shall be suitable for required cable sizes. Two negative and two positive output terminals shall be provided.

AC terminals shall be insulated to withstand 2000 volts, 50 Hz for 1 minute to the enclosure, shall be shielded to prevent accidental contact and shall be sized to take required cable sizes.

## 18.0 METERS

The transformer rectifier units shall be equipped with separate continuous reading Voltmeter and Ammeter for the D.C output and the A.C input voltage, current and PSP measurement. All meters shall be electronic digital type with LED display arrangement and should be able to indicate the current and voltage up to full ranges and have a resolution of one decimal place for DC Ammeter & Voltmeter and 3 decimal places for PSP meter. Digit size should be 12.5 mm (minimum). All meters shall be square in shape and accurate to within 2% at full load at ambient temp. They shall be Temperatures compensated to vary no more than 1% per 10% temperature changes.

All AC & DC voltmeters shall be provided with separate fuse and toggle switch where as all Ammeters shall be provided with only toggle switch.

Following Digital meters shall be provided:

- a) AC Voltage : 0 to 300V/500V AC
- b) AC Current : 0 to 50 A AC with CT
- c) DC Voltage : 0 to 60V DC
- d) DC Current : 0 to 60A DC with shunt
- e) PSP : 0 to  $\pm 19.99$  V DC

## 19.0 ENCLOSURE

The enclosure of T/R unit shall be suitable for Floor mounting, outdoor type having one compartments contain Main Transformer, Auto-Transformer, DC choke. Panel shall be of free standing type and all cable entries shall be from the bottom only.

The SCRs, Diodes, indicating meters, protective devices, electronic control circuits/control cords etc. and shall be provided with a plexiglass viewing window. Both the compartments shall be completely enclosed type having IP 55 construction.

The enclosure shall be made of minimum 2.64mm sheet steel. Size of enclosure should be specified by Vendor. An integrated sun/rain shade of suitable size to be provided by vendor (if installed in outdoor)

The transformer rectifier shall be provided with the following accessories.

- Steel channel under the base for plinth mounting.

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- Lifting lugs of size suitable for lifting complete transformer rectifier unit.
- Sunshade / rain shade (if installed in outdoor)
- Lockable control cabinet with viewing windows to IP55 as a minimum.
- Lockable doors shall be provided in the front and back

Accessibility shall be provided by hinged and removable front and back doors. A Plexiglas viewing windows shall be provided at the front door to allow the meters to be read without opening the front door. One drawing pocket shall made at inner side of the front door. One holder for 60 watt CFL connection shall be provided at a strategic point inside the cabinet to facilitate proper illumination during operation and maintenance.

The enclosure shall be supplied with an engraved warning label with the word "DANGER". Two junction boxes one for A.C cable entries and other for D.C cable entries shall be provided. Gland plate should be provided against each junction box for fixing single compression cable glands for AC/DC control / monitoring cables. Two 240 V, 6A Socket shall be provided at a strategic point inside the cabinet to facilitate connection of soldering iron during maintenance. After fabrication the entire enclosure shall be epoxy paint/Powder Coating of shade 631 of IS-5 with proper pre-treatment and primer application as per standard Industrial Practice.

## 20.0 ENCLOSURE EARTHING

Earthing terminals shall be suitable for 50x6 mm GI strip connections to power supply earthing and two earthing terminals shall be made for earthing connection to the local earthing pits.

The earth connection points shall be protected against corrosion. It shall not be necessary to scrap the paint away in order to make an effective earth connection. Provision shall also be made adjacent to each gland plate for cable gland earthing connection. Enclosure earthing connection stud size shall not less than 12mm.

## 21.0 Cable Terminations

- i. Cable glanding and terminating facilities and terminals shall be suitable for the cable type and conductor size used in PCP system. Suitable size Cable glands & lugs shall also be in the scope of bidder.
- ii. Terminal blocks shall be arranged and positioned to afford easy access for carrying out external cable termination, testing, inspection and maintenance. There shall be ample clear space allowed between the terminal block and gland plate for the spreading and termination of external conductors.
- iii. All terminal blocks shall be shrouded or provided with transparent covers. Pinch screw type terminals are not acceptable.
- iv. Three positive and three negative post types D.C output terminals shall be provided for rectifier transformers. Each post shall be fitted with double nuts and washers.
- v. Terminals for different voltages shall be separated by partitions.
- vi. A terminal box or chamber with underline gland plate or entry panel of sufficient dimensions to terminate the specified incoming and outgoing cables shall be provided. Direction of cable entry shall be from bottom.
- vii. Termination of single core cables shall through a non-magnetic gland plate and provision made for bonding and earthing any armour and/or concentric ground conductors.



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- viii. Cable terminal arrangements for power and control cables may be integrated provided that a barrier separates the two.
- ix. Auxiliary wiring shall have copper conductors of the manufacturer's standards sizing (subject to buyer's approval).
- x. Suitable terminals for two nos. ref. cell cables, one no. measurement cables and a selector switch for permanent ref. cell to be provided for T/R unit panel for connection to PSP meter.

Wiring shall be crimped using self-insulated compression type terminal blocks which shall be suitably identified. Conductors shall be fitted with sleeve ferrules bearing the same identification as the terminal to which they are connected. Minimum conductor size shall be 1.5 mm<sup>2</sup>.

## 22.0 NAME PLATE

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

- a. Manufacturer's name
- b. AC input voltage & current rating
- c. AC frequency / Phase
- d. Output DC volts and Amps. Rating
- e. Weight in Kg of T/R unit
- f. Model number / Serial number
- g. Year of Manufacture

## 23.0 RECOMMENDED LIST OF SPARE PARTS

The Bidder shall supply the following spares for T/R units along with inspection test reports, certificates as applicable.

- D.C Voltmeter	Nos.	1
- D.C Ammeter	Nos.	1
- A.C Voltmeter	Nos.	1
- A.C Ammeter	Nos.	1
- Corrosion voltmeter	Nos.	1
- Diodes	Set	1
- SCR's	Set	1
- D.C. Fuses for output side	Set.	1
- HRC fuses for Diodes	Set	1
- A.C fuses for input side	Set	1
- D.C lighting arrestor	Nos.	1

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- MCB of each rating	Nos.	1
- Electronic Control Cards each type	Nos.	1
- Filter Circuit Capacitor	Nos.	1
- Signal Light assembly for annunciation	Nos.	1
- R.C. Surge Diverter	Nos.	1
- Control transformer	Nos.	1
- Coarse & Fine Control Switch	Set.	1
- Auto Manual Mode Selector Switch	Nos.	1
- Toggle Switches	Nos.	2
- Assorted Glass Cartridge Fuses	Set	5

#### 24.0 DATA SHEET OF T/R UNIT

A.C Input Voltage	: <b>240V/415V<math>\pm</math> 10%</b> Volt, 1/3 phase 50Hz $\pm$ 5 % Hz
A.C Input Current	: *
D.C Power Output	: *
KVA Rating of transformer.	: *
D.C Output Voltage	: *
D.C Output Current	: *
Reference cell	: Copper / Copper Sulphate Saturated
Number of reference cell for control	: 3
Reference EMF Setting	: -0.8V to -2.5V
Regulation of Reference	: better than $\pm$ 15 mv
Derating Factor for Transformer	: 30% excess current capacity
Derating Factor for Diodes / SCRs	: 300% factor of safety for voltage & 300% to 500% factor of safety for current
Full Load Efficiency of transformer	: Not less than 95%
Full Load Efficiency of rectifier	: More than 80%
Power Factor	: Not less than 0.85 (lagging)
Insulation Level	: 2 KV for 1 minute at 50Hz
Peak Inverse Voltage Diodes & SCRs	: 1500 V (minimum)
Filtering Circuit	: LC Filter



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Ripple and Hum	: Less than 5% at rated load
Surge Diverters for	
Diodes / SCRs	: Metal oxide varistors/Zener Diodes/ R-C networks
Lightening Arrestors	: At input & output side of the TR unit.
	Voltage rating 500V RMS
	Impulse discharge current rating 5 KA
Protection	: MCB having thermal overload and short circuit protection with backup HRC fuses for input and output. Input MCB trip alarm shall be extended to facilitate for remote indication of unit fail.
	Glass cartridge fuses in lamp circuit and auxiliary power supply line of control circuit.
	Fast acting electronic over current limits circuit & short circuit Protection for output.
Meters / Instruments	: Digital Panel Meters (96 mm x 96 mm), Accuracy – <b>2% ±1</b> Digit of Full Scale, 1 No. AC Voltmeter, 0-300/500 Volts, Resolution <b>1 V</b> . 1 No. AC Ammeter, Current Transducer Operated, <b>0 – 50 A</b> , Resolution <b>.1 A</b> , 1 No. DC Voltmeter, <b>0-25 V</b> , Resolution <b>0.1 V</b> with built in 4-20 mA transducer
	1 No. DC Ammeter, <b>0-25 A</b> with shunt <b>25A / 25 mV</b> , Resolution <b>0.1A</b> with built in 4-20 mA transducers. 1 No. Corrosion Voltmeter, 19.9-0-19.9V, <b>0.001V</b> Resolution with built in <b>4-20mA</b> transducer.
Visual indications/Annunciation	: The following Visual signal light Indicators shall be provided.
	AC Mains ON
	Auto Mode
	Manual Mode
	Unit in AVCC mode
	Over Current Alarm
	Over Voltage Alarm
	Over Temperature
	TR output voltage
	TR output current
	Input/output MCB trip

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Pipe to Soil potential

High temperature of instrument chamber

All reference fail

Reference cell 1 lowest

Reference cell 2 lowest

Reference cell 3 lowest

Reference 1 fail

Reference 2 fail

Reference 3fail

Individual Fuse failure LED indication

Identifying failure of each Diode and

DC Output Fuse with audio alarm.

Other Accessories

(a) Integral Sun and Rain shade

(b) One holder for 60 Watt CFL

(c) Two 240V, 5A socket for Maintenance

(d) Glass Viewing Window

Cooling

The cabinet is natural air cooled and the temperature rise not exceeding 45°C above the ambient.

Measurement and control terminals

Shrouded terminal blocks of proper size shall be provided in the control junction box.

Climate Conditions

: 6°C to 45°C with moderate to heavy rainfall during Monsoon and relative humidity of 97%.

Enclosure

: Completely enclosed. Plinth Mounted, IP55 construction . The top cabinet is made from 12SWG (2.64mm) mild steel. The control cabinet has hinged front and rear doors and are pad lockable. A glass viewing window is provided for front door for reading of all the meters without opening the door.

The enclosure is also provided with lifting lugs of size and location suitable for lifting the complete rectifier unit.

Dimension of TR Unit:

.\*

Weight of TR Unit:

.\*

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#### Input and Output Terminals

: Three Positive and three negative DC Post type terminals made of tinned plated copper with double nuts and washers are provided in the DC junction box.

AC terminals insulated from the enclosure to withstand 2000 volts 50Hz are provided in the AC junction box.

Remote Control Terminals are ELMEX/TOSHA Make Multiple Terminals, Shrouded Type

#### Cable entries

For Anode, Cathode, Power, Control and measurement cables through cable gland plate at the bottom of the T/R unit.

#### Surface Coating and Painting

Epoxy paint/Powder Coating of shade 631 of IS-5 with proper pre-treatment and primer application.

#### Name Plates and Labels

All component identification Labels shall be aluminum anodized.

A stainless steel rating plate along with manufacturer's name, address, date of manufacture, model number, serial number, weight etc. will be provided.

-A DANGER label on the Rear Door.

#### Voltage Setting

: 0-rated DC O/P Voltage in steps of 1V each with

Two selector switches with an accuracy of  $\pm 10\%$  in AUTO Mode.

COARSE : 0,5V, 10V, 15V, 20V, 25V...up to rated DC o/p voltage in steps of 5V

FINE : 0,1V, 2V, 3V, 4V, 5V... up to rated DC o/p voltage in steps of 1V

The two switches are algebraically additive but maximum does not exceed rated DC o/p Voltage.

#### Current Setting

0-rated DC O/P Current in of 1A each with two selector switches with an accuracy of  $\pm 10\%$  in AUTO Mode.

COARSE: 0,5A, 10A, 15A, 20A, 25A...up to rated DC o/p current in steps of 5A.

FINE: 0, 1A, 2A, 3A, 4A, 5A. Up to rated DC o/p current in steps of 1A

The two switches are algebraically additive but maximum does not exceed rated DC o/p Current.

#### Modes of Auto Operation

##### (i) AUTO Ref Mode

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In this mode of operation “Auto Protected structure to soil potential” is sensed with respect to Cu-CuSO<sub>4</sub> (Saturated) reference to electrodes. The electronic control circuit scans up to three reference electrodes for actual PSP and automatically selects the minimum negative value of actual PSP obtained from any of the three reference electrodes.

The desired Set PSP reference is compared with the minimum selected value of actual PSP and the output power of the CP TR is set automatically so that the measured value always remains close to the Set PSP value.

#### **(ii) AUTO AVCC MODE:**

In this mode of operation Output voltage & current can be varied continuously by a potentiometer depending upon the Coarse and Fine switch settings. Control of output voltage and current through SCRs and Electronic Control circuitry so that output of the unit is maintained constant irrespective of current drain and supply line voltage variations.

Output voltage variable by a potentiometer in the range 0-rated DC o/p Voltage depending on “COARSE” & “FINE” limit settings.

Output voltage adjustable in steps of 1V by “COARSE” & “FINE” voltage limit switches. Two switches are algebraically additive, with a maximum of rated DC output voltage.

Output current adjustable in steps of 1A by “COARSE” & “FINE” current limit switches. Two switches are algebraically additive with a maximum of rated DC o/p Current.

\* - Bidder to specify.

#### **25.0 TESTING OF T/R UNIT:**

All T/R units shall be tested by bidder and inspected by purchaser/his representative before dispatch. Testing shall be conducted in accordance with codes, standards, approved QAP and enclosed specifications.

Bidder /vendor shall provide all the necessary facilities to carry out all tests of CP TR unit in his premises at his expenses.

#### **26.0 DRAWINGS / DOCUMENTS:**

Following drawings / documents shall be furnished by bidder for approval before starting of fabrication/manufacturing. Approved drawing after incorporation of comments, if any from OWNER shall be furnished in 4 copies along with reproducible during the delivery of T/R units.

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- Fabrication drawings, GA drawings and data sheet of T/R unit giving dimensions, rating, weight, including installation / foundation arrangement details.
- Front view and typical sections 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 rating.
- Schematic and wiring diagram of T/R unit circuitry giving auto / manual mode of control including circuit details of all control cards.

## 27.0 INSTRUCTION BOOK

The instruction book/ operational manual in 4 hard copies+ 2 soft copy in CD shall be presented in such manner as to enable it to be used by personnel who are unfamiliar with the operation and maintenance of the T/R unit. The instruction book/ operational manual to be furnished along with supply of T/R unit.

The instruction book/ operational manual shall contain the following:

- A description of the T/R unit.
- Instruction for the installation, testing commissioning and safe operation and maintenance.

The information shall be presented as follows:

1. Index of contents
2. General description giving brief description of the T/R and its use.
3. Detailed description of T/R unit, This description shall include the technical characteristics, physical and mechanical limitations, and item wise the components, accessories and spare parts.
4. Description of the operation of the T/R unit. This description shall be clear, concise and in a logical sequence, using schematic diagram, wiring diagram and fabrication drawing.
5. Procedures for testing and adjusting the T/R unit. The complete procedure for testing and adjusting the T/R unit during operation, periodic maintenance and overhaul shall be covered.
6. Maintenance instructions :

This sections shall be divided into Two parts:

- a. Preventive maintenance which shall indicate the periodic inspection required the inspection procedure and clearing procedures.
- b. Break down maintenance which shall include instruction for trouble shooting of the removal and replacement of all parts listed as spares shall be given.

7. Spare Parts.

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The instruction books shall be given all the necessary details so as to procure all the spare parts from the manufacture or from open market.

8. Each instruction book shall be accompanied with one set of final approved Drawing / Documents.


## 28.0 COVERING OF THE INSTRUCTION BOOKS/ OPERATIONAL MANUALS

The instruction book/ operational manuals shall be presented in a stiff covered binder with the following information printed on the cover:

- The client's name
- The location of the installation
- The name of the installation
- The title of the instruction book

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**TECHNICAL SPECIFICATION**  
**OF**  
**INSTRUMENTS FOR O&M**  
**FOR**  
**CATHODIC PROTECTION SYSTEM**

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## 1.0 SCOPE

This specification covers the requirements for instruments for carrying out Monitoring, Operation and Maintenance of Cathodic Protection System.

## 2.0 CODES AND STANDARDS

The Instruments shall be in accordance with the latest revisions of the following Indian standards, wherever applicable. Where appropriate Indian standard are not available, the relevant IEC standards shall apply.

- Indian standards institution (ISI)
- International electro technical commission (IEC)
- American standards institution (ANSI)
- British standards institution (BS)

## 3.0 BASIC INSTRUMENTS:

The Basic instruments shall be supplied by the contractor for Monitoring, Operation and Maintenance of cathodic protection System which are listed as follows with their detail description.

### ❑ **Portable Reference Electrode**

The portable Reference Electrode shall be Cu-CuSO<sub>4</sub> type with PVC Body and ceramic Sensing plug. The Copper Electrode should be Electrolytic Grade and the copper Sulphate should be of purity of Analytical Grade. The Reference Electrode should be of Approved make.

### ❑ **3-½ digit Multi meter**

The Multimeter should have input impedance of minimum 20MΩ. The Multimeter should measure AC / DC Volts, AC/DC A, Resistance, Continuity etc.


### ❑ **AC/ DC Clamp Meter**

The clamp Meter shall be 3-½ Digit suitable for measuring AC/ DC Current.

### ❑ **Portable Current interrupter with GPS Antenna**

A Portable Current interrupter shall be microprocessor based with LCD Display and Membrane Keypad. The interrupter shall be suitable for interrupting AC/DC supply. The continuous DC interruption capacity should be 25A at 25V whereas the AC interruption capacity should be 50A at 240V. the time synchronisation between interrupter should be maintained by GPS clock update every 10 seconds.



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The GPS Antenna should be suitable for external outdoor mounting with tail cable. The interrupter shall be programmable for Date, day, time, Start Time, Start Date, Stop date, and stop Time, ON/OFF time from 99 sec to 0.5 Sec. The interrupter should be suitable for operation from AC input supply of 240V or DC input supply of 24V. Make of Portable current Interrupter shall be subject to owner approval.

❑ **Pipeline Locator, Current Mapper with Transmitter and Receiver:**

The pipeline Locator, Current Mapper shall be supplied with transmitter and Receiver. The Transmitter should be operated on AC as well as DC Power Supply. The receiver should operate on Battery Backup supply. The receiver should be supplied with Magneto Foot and A- frame for Current Mapping Facility. The make of Instrument subject to owner approval.

#### 4.0 TEST CERTIFICATES

The instruments shall supplied along with Test certificates for testing conducted in accordance with codes and standards enclosed in this document, as per routine tests done by manufacturer and additional tests done by manufacturer. The testing shall be conducted in accordance with codes and standards enclosed in this document. Test certificate shall furnish. The Manufacturer shall carry out NDT on weld Joints – DP, XRAY, MPT etc. After manufacturing dielectric test and Hydro Test shall be carried out and results shall be Indicated in Test Reports.



ARRANGEMENT OF CONNECTIONS  
OF EARTH CONDUCTORS  
(T-JOINT AL STRIP & GI STRIP TO ROUND AL CONDUCTOR)

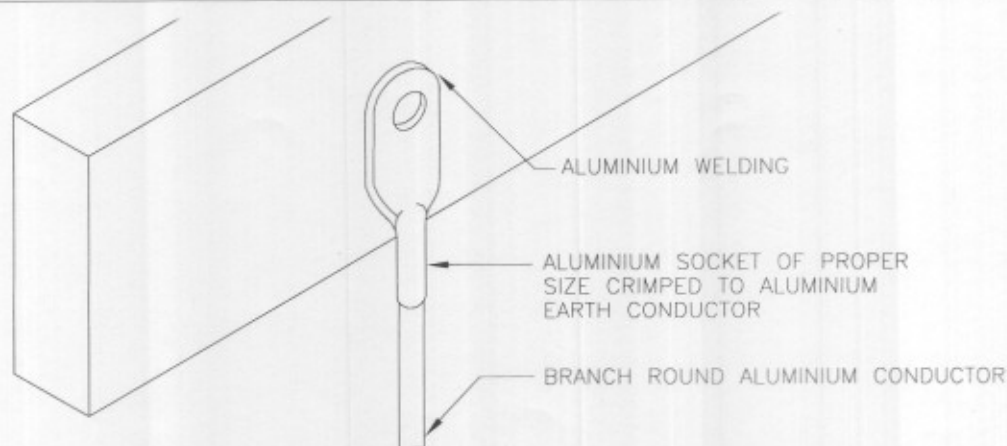
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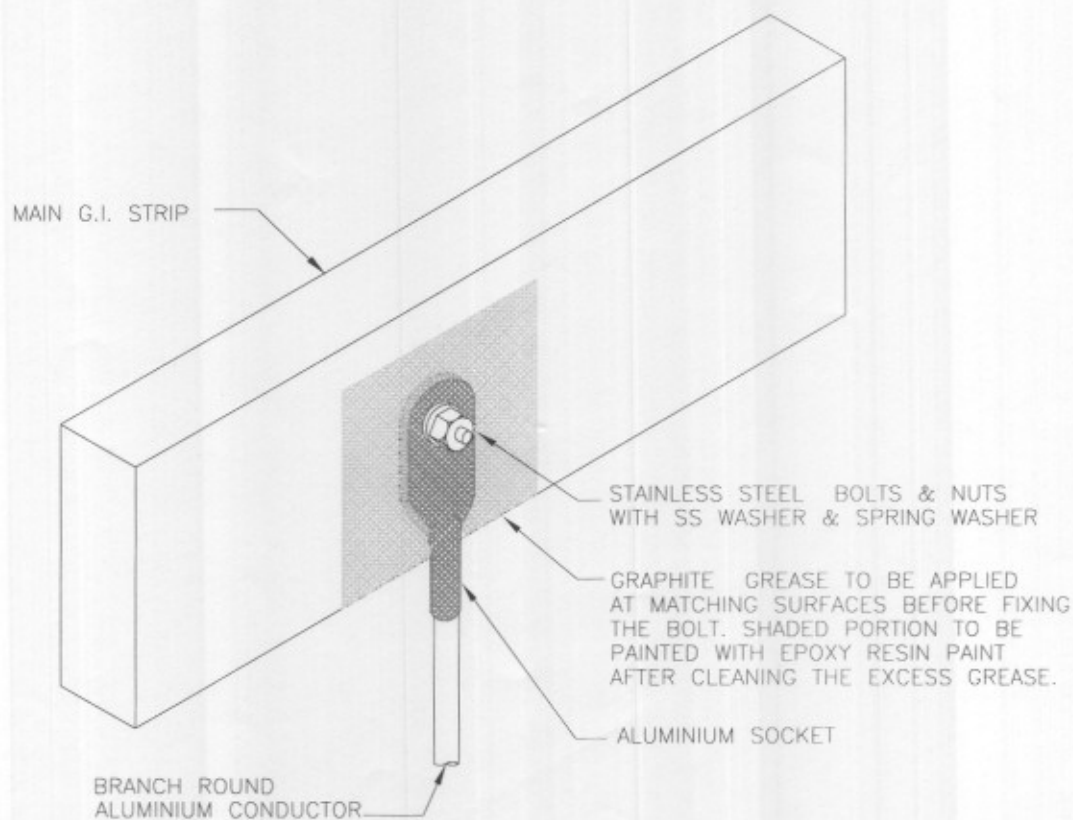
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' T ' JOINT ALUMINIUM STRIP TO ROUND ALUMINIUM CONDUCTOR



' T ' JOINT G.I. STRIP TO ROUND ALUMINIUM CONDUCTOR

0	03.01.07	15.01.07	ISSUED FOR IMPLEMENTATION	<i>GNR</i> NKR	<i>AV</i> AV	<i>BB</i> BB
REV	REV.DATE	EFF.DATE	PURPOSE	PREPD	REVWD	APPD



# ARRANGEMENT OF CONNECTIONS OF EARTH CONDUCTORS

( TERMINATION OF ROUND EARTH CONDUCTOR AT EQUIPMENT)

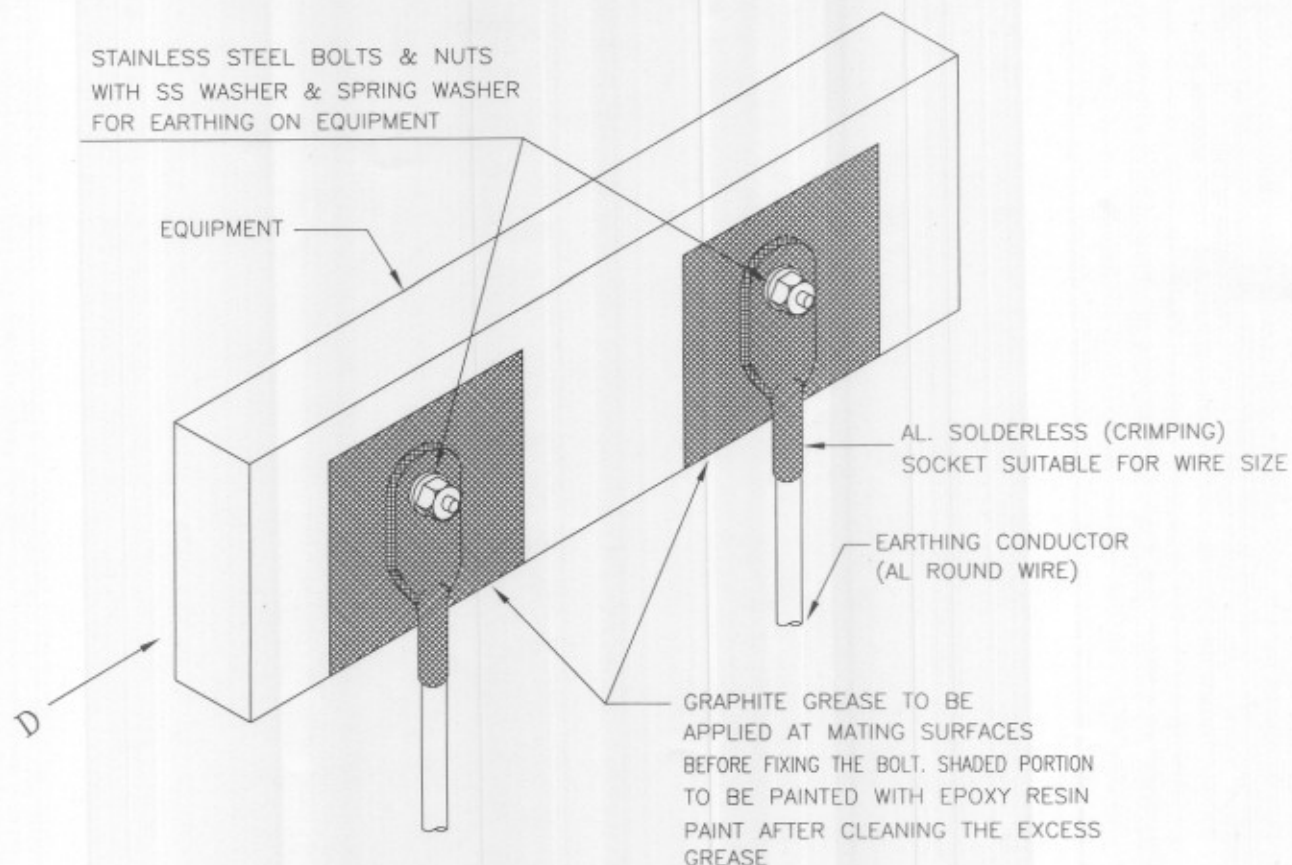
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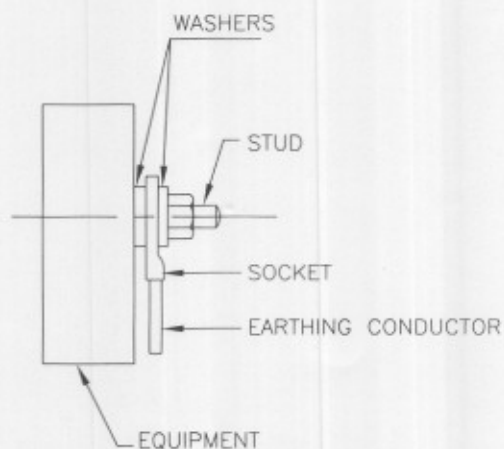
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## ARRANGEMENT OF DOUBLE EARTH CONNECTIONS TO EQUIPMENT



VIEW FROM - D

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REV	REV.DATE	EFF.DATE	PURPOSE	PREPD	REVWD	APPD



ARRANGEMENT OF CONNECTIONS OF EARTH CONDUCTORS  
(STRAIGHT & T - JOINT G.I. & AL. STRIP)

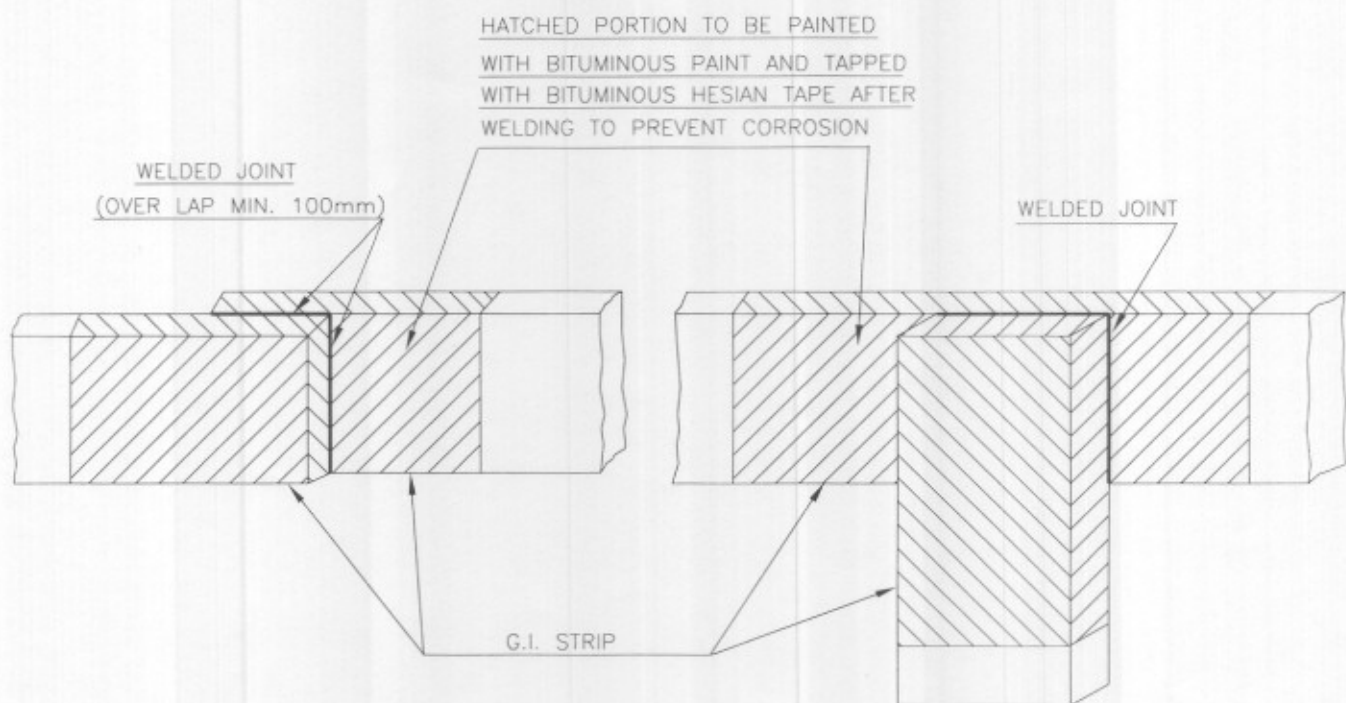
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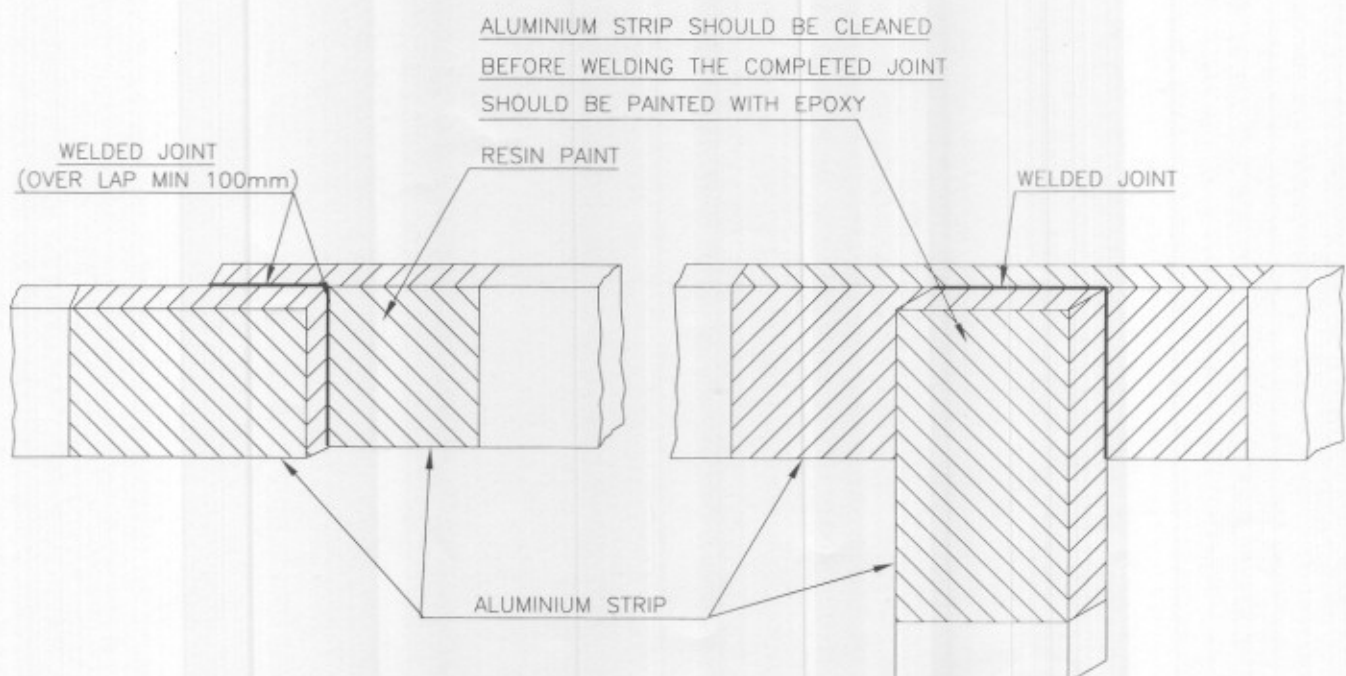
REV

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STRAIGHT JOINT G.I TO G.I. STRIP

" T " JOINT G.I. TO G.I. STRIP



STRAIGHT JOINT AL. TO AL. STRIP

" T " JOINT AL TO AL STRIP

0	03.01.07	15.01.07	ISSUED FOR IMPLEMENTATION	NKR	RV	BB
REV	REV.DATE	EFF.DATE	PURPOSE	PREPD	REVWD	APPD



ARRANGEMENT OF CONNECTIONS OF EARTH CONDUCTORS

STRAIGHT JOINT GI TO AL STRIP

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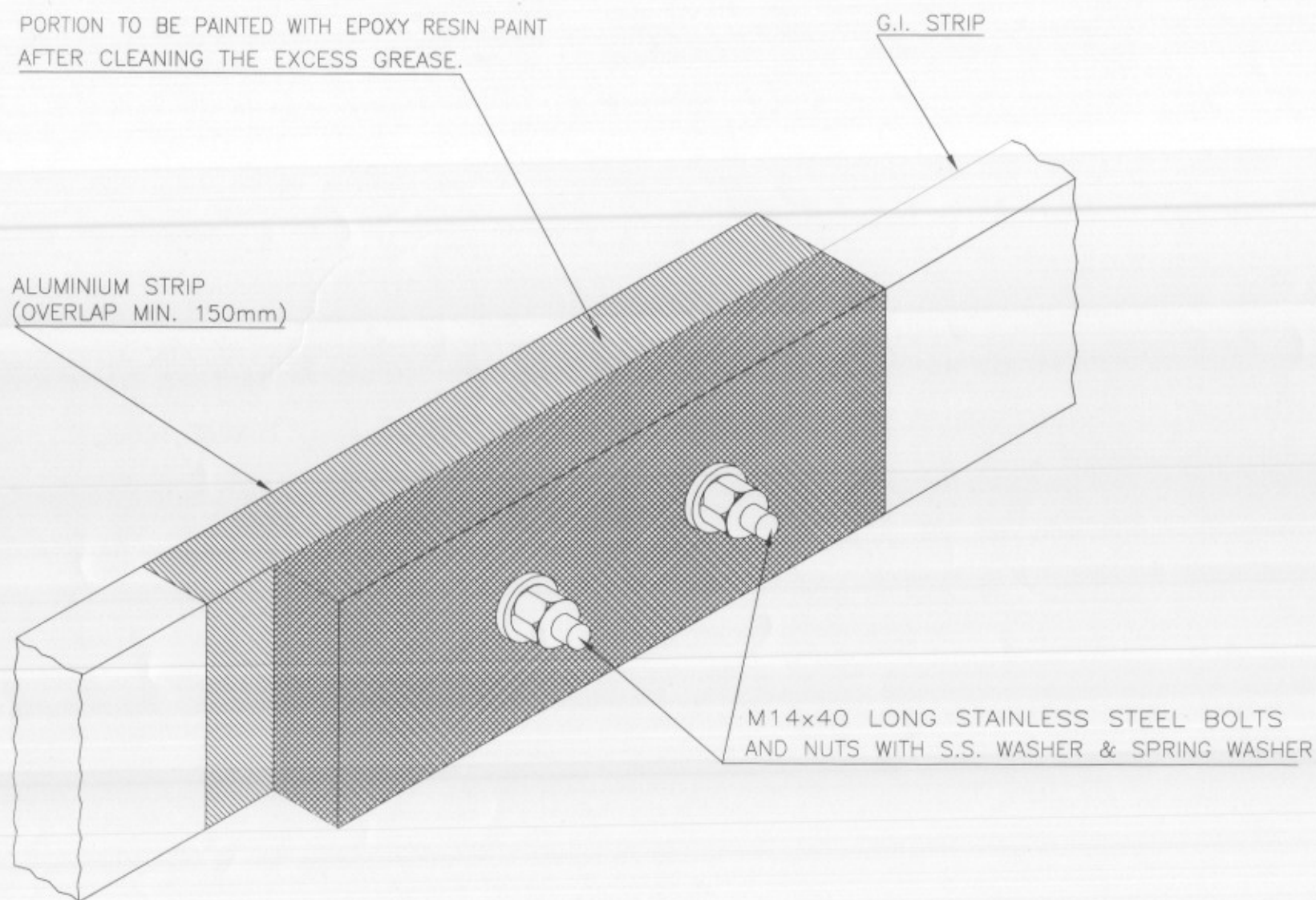
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REV

GRAFITE GREASE TO BE APPLIED AT MATCHING SURFACES BEFORE FIXING THE BOLT. SHADED PORTION TO BE PAINTED WITH EPOXY RESIN PAINT AFTER CLEANING THE EXCESS GREASE.



ARRANGEMENT OF LAP JOINT BETWEEN  
AL. EARTH STRIP TO G.I. EARTH STRIP

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REV	REV/DATE	EFF/DATE	PURPOSE	PREP	REWD	APP
				NKR	Chunghy	BB
						APPD





## ARRANGEMENT OF CONNECTIONS OF EARTH CONDUCTORS

TERMINATION OF AL / GI STRIP AT EQUIPMENT

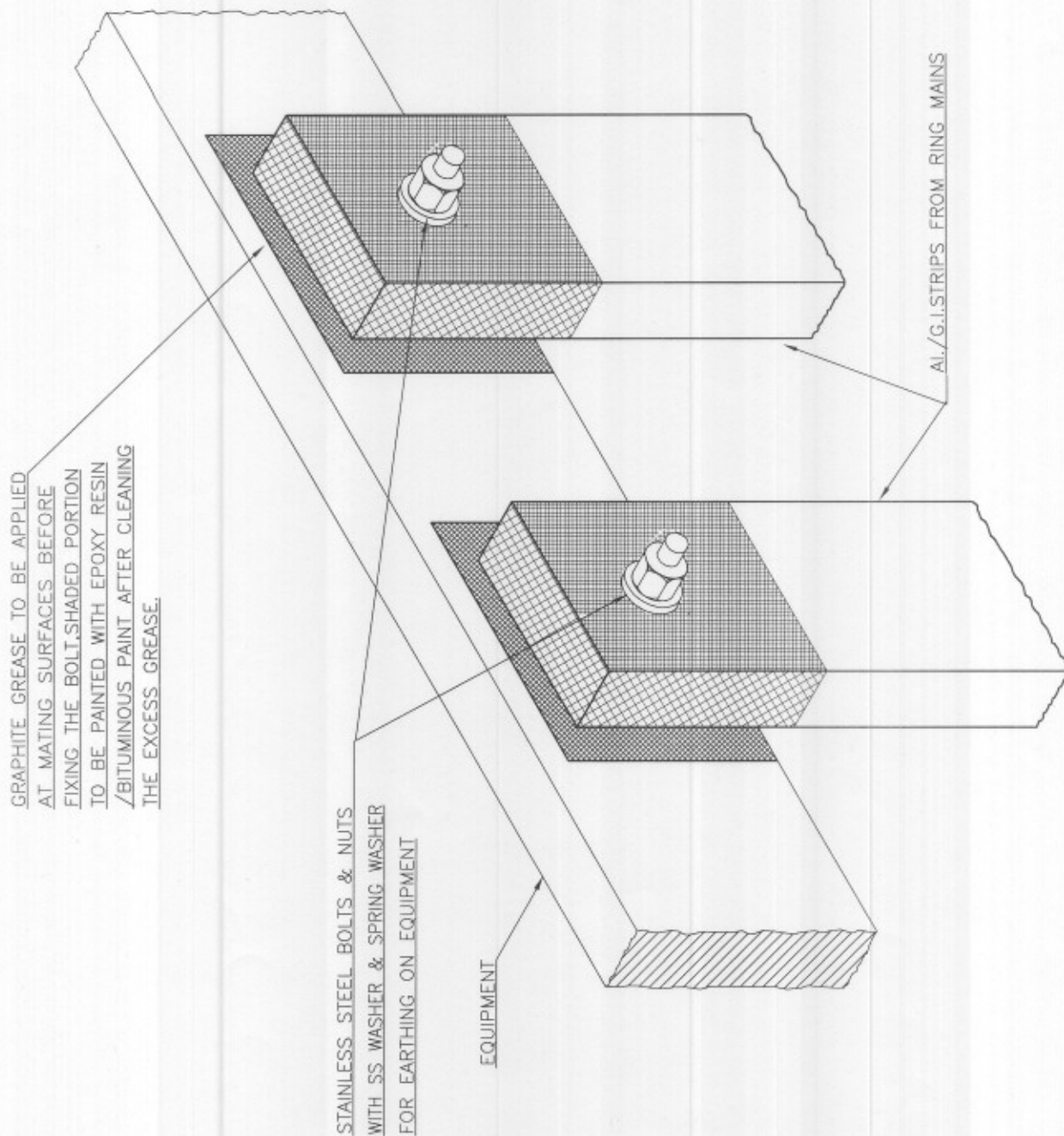
PDS:E 603

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DOCUMENT NO.

REV

SHEET 5 OF 6



ARRANGEMENT OF DOUBLE EARTH CONNECTION ON EQUIPMENT

NOTE:—

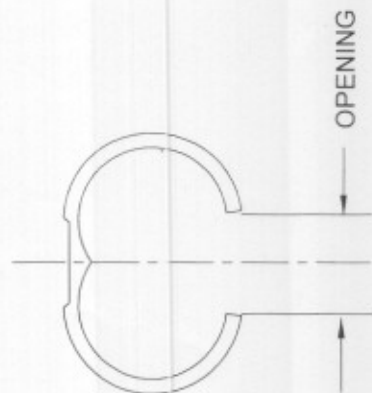
EPOXY RESIN PAINT SHALL BE USED FOR  
AL STRIP AND BITUMINOUS PAINT FOR  
G.I. STRIP.

0	03.01.07	15.01.07	ISSUED FOR IMPLEMENTATION	NKR	AV	BB
REV	REV.DATE	EFF.DATE	PURPOSE	PREPD	REVWD	APPD

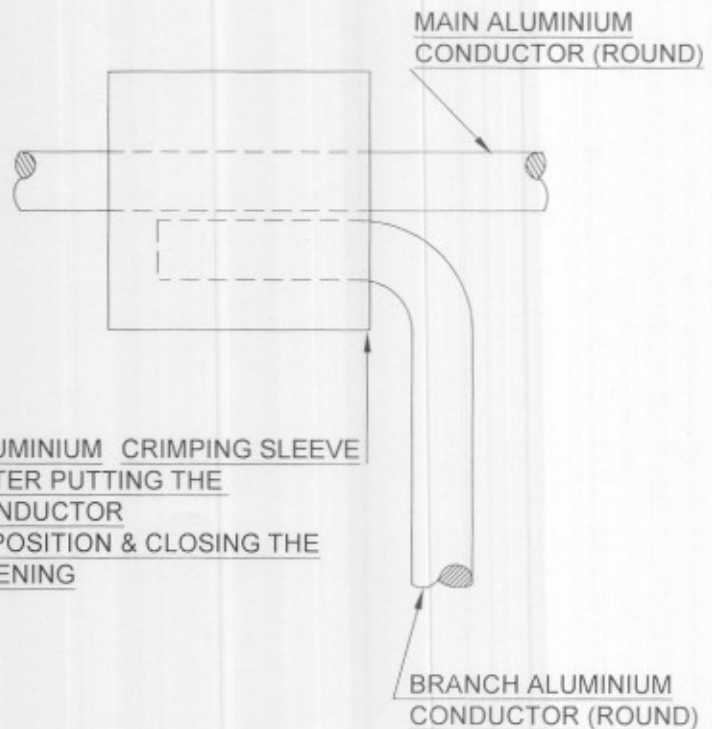


ARRANGEMENT OF CONNECTIONS OF EARTH CONDUCTORS  
(CRIMPING OF ROUND TO ROUND ALUMINIUM CONDUCTORS)

PDS:E 603	0
DOCUMENT NO.	REV
SHEET 6 OF 6	



END VIEW OF THE  
ALUMINIUM CRIMPING  
SLEEVE BEFORE  
CRIMPING



ALUMINIUM CRIMPING SLEEVE  
AFTER PUTTING THE  
CONDUCTOR  
IN POSITION & CLOSING THE  
OPENING

"T" JOINT ROUND ALUMINIUM CONDUCTOR TO ROUND ALUMINIUM  
CONDUCTOR ( CRIMPING TYPE )

NOTE :-

USE CORRECT SIZE OF COMPRESSION DIES.

0	03.01.07	15.01.07	ISSUED FOR IMPLEMENTATION	NKR	APPD	BB
REV	REV.DATE	EFF.DATE	PURPOSE	PREPD	REVWD	APPD



# TYPICAL DETAILS OF CONNECTIONS IN EARTH PIT

PDS:E 604

DOCUMENT NO.

SHEET 1 OF 1

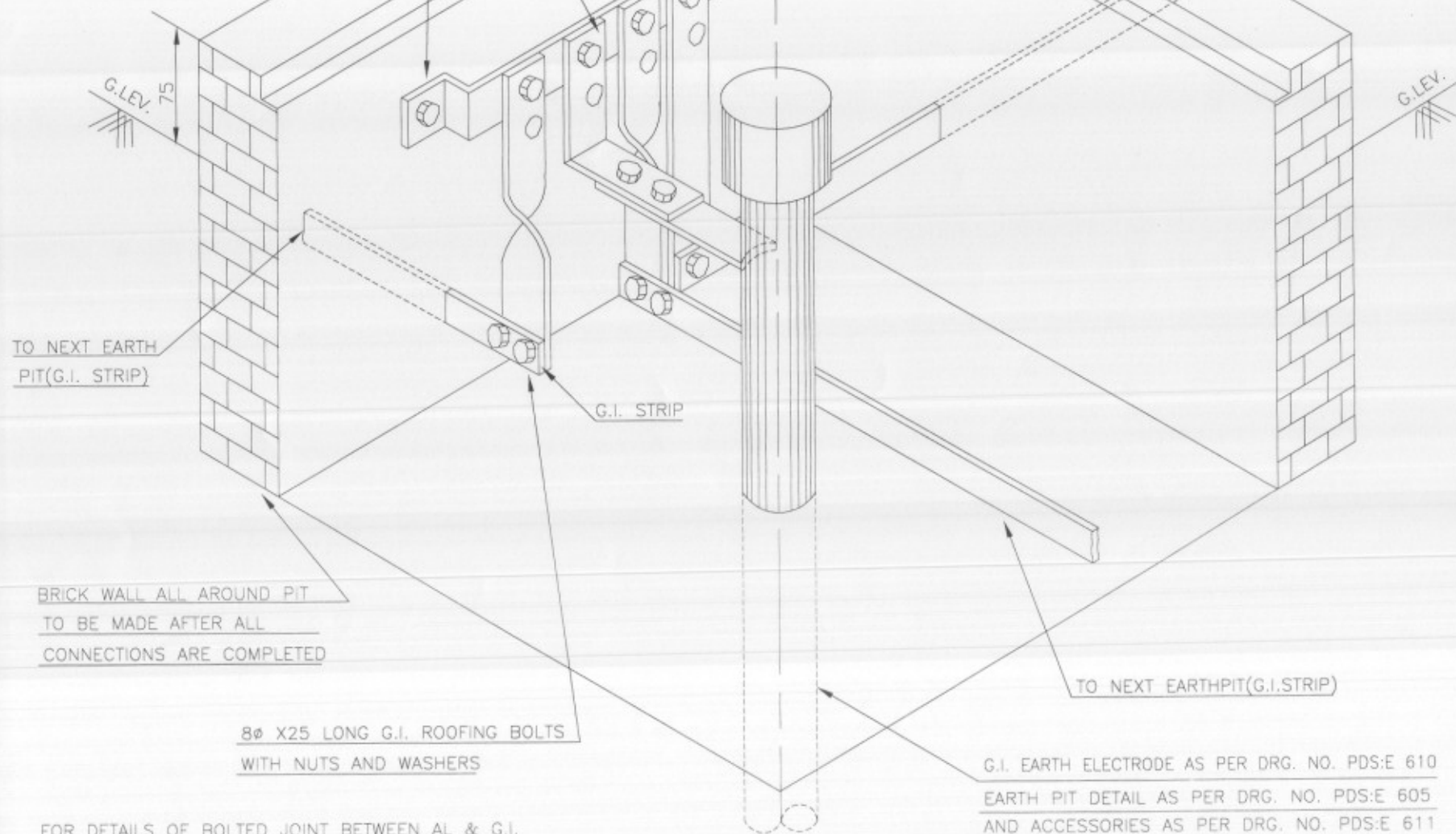
0

REV

GROOVE FOR PLACING R.C.C. COVER ON EARTHPIT  
G.I. "L" SHAPED CONNECTING TEST LINK WITH BOLTS  
FOR CONNECTING TO EARTH PIPE

G.I. BRACKET FOR TEST LINK TO BE GROUTED  
TO THE WALL WITH RAG BOLTS & NUTS

TO EQUIPMENT / SYSTEM EARTH BUS  
(G.I. STRIP). INSTEAD OF G.I. STRIP, PVC  
INSULATED CABLE MAY ALSO BE USED &  
CONNECTED TO THE G.I. BRACKET BY  
USING AL. CABLE SOCKET.



FOR DETAILS OF BOLTED JOINT BETWEEN AL & G.I.  
REFER PDS:E 603 (SHEET 4 OF 6 )

G.I. EARTH ELECTRODE AS PER DRG. NO. PDS:E 610  
EARTH PIT DETAIL AS PER DRG. NO. PDS:E 605  
AND ACCESSORIES AS PER DRG. NO. PDS:E 611

0	03.01.07	15.01.07	ISSUED FOR IMPLEMENTATION			
REV	REV/DATE	EFF. DATE	PURPOSE	PREP'D	REV'D	APP'D
				AKR	Chand	BB





# EARTH PIT DETAILS

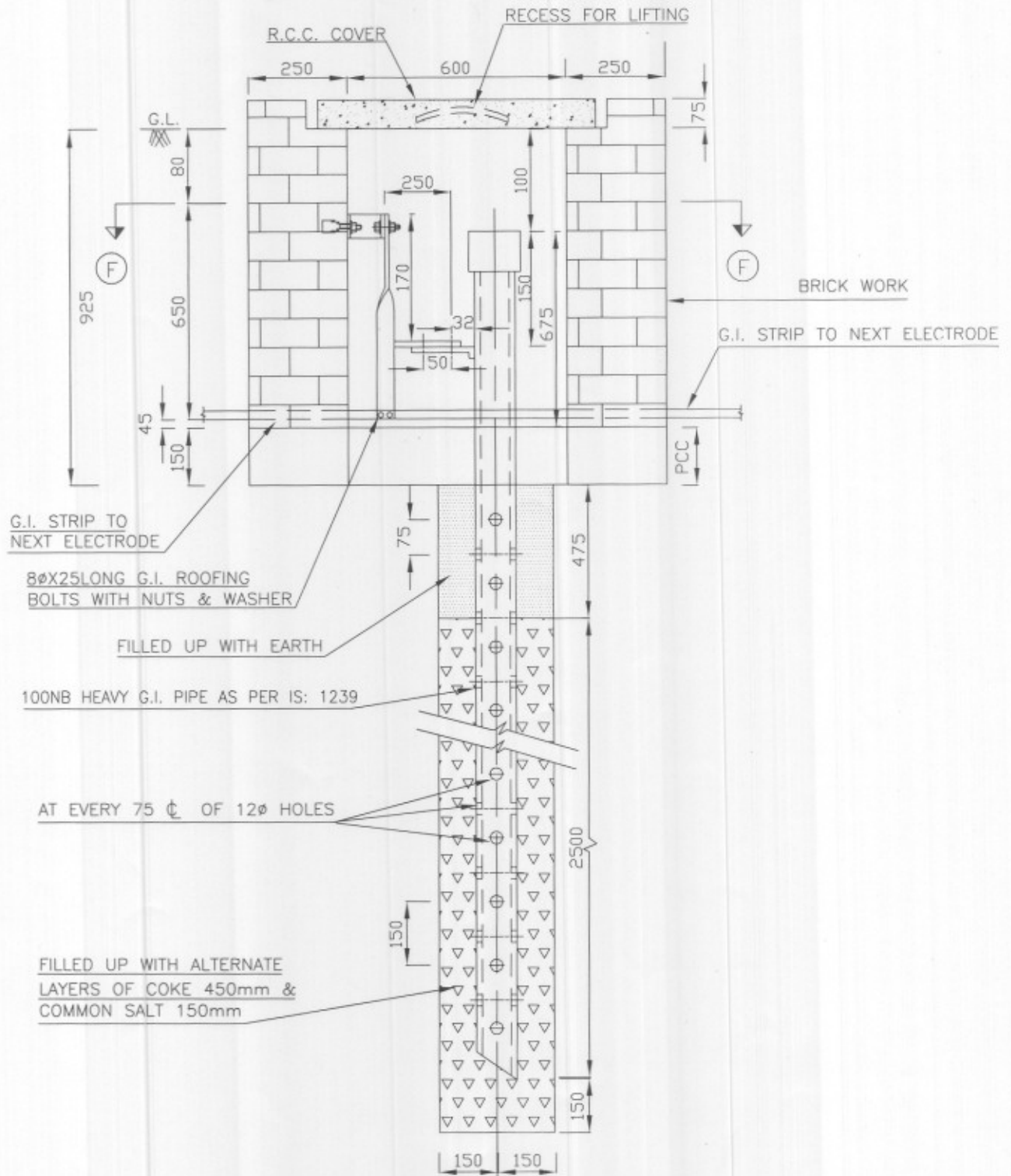
PDS:E 605

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DOCUMENT NO.

REV

SHEET 1 OF 2



SECTIONAL ELEVATION OF EARTH PIT

0	03.01.07	15.01.07	ISSUED FOR IMPLEMENTATION	NKR	AV	BB
REV	REV.DATE	EFF.DATE	PURPOSE	PREPD	REVWD	APPD



# EARTH PIT DETAILS

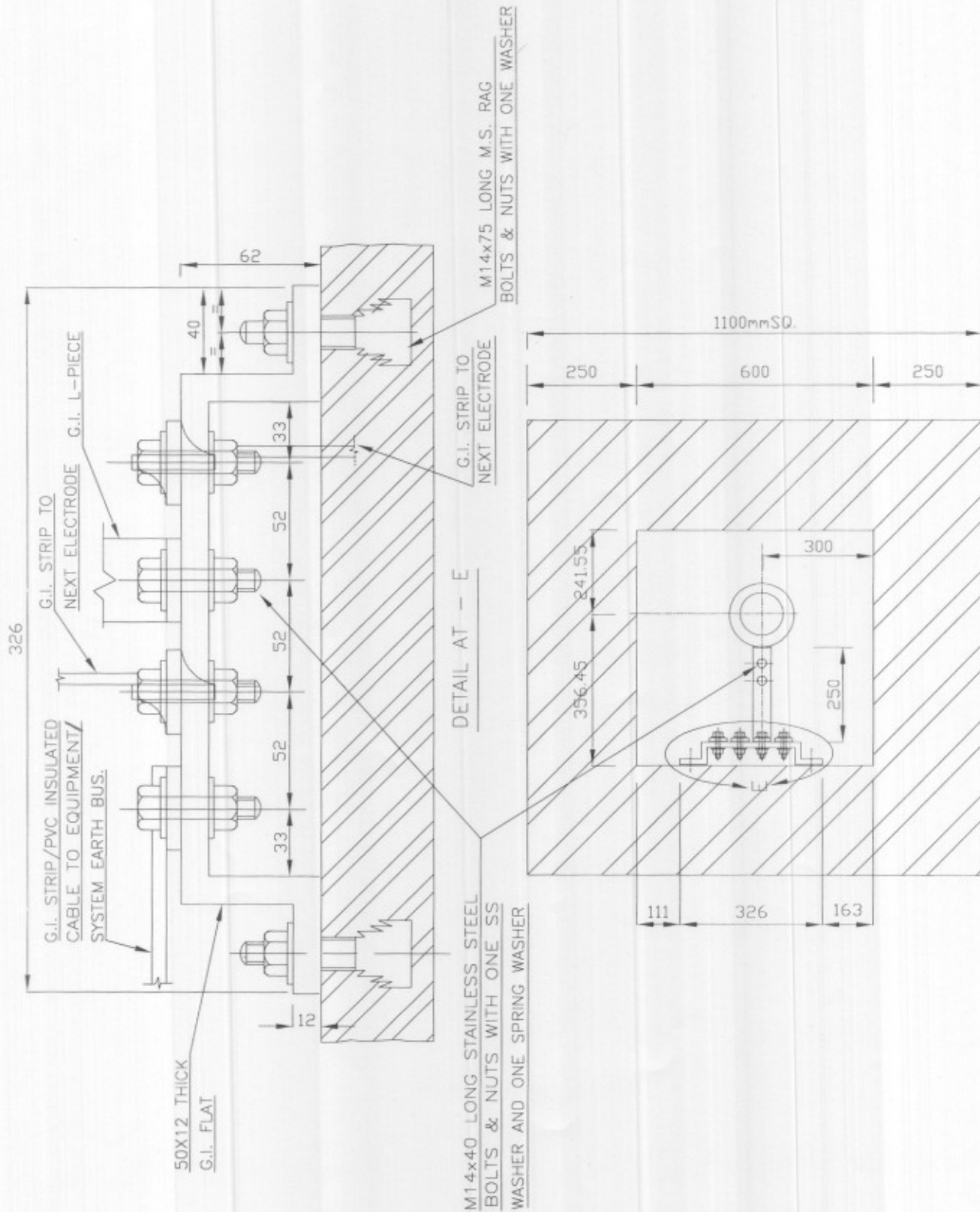
PDS:E 605

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DOCUMENT NO.

REV

SHEET 2 OF 2



0	03.01.07	15.01.07	ISSUED FOR IMPLEMENTATION	<i>Reddy</i> NKR	<i>Amrith</i> AV	<i>BR</i> BB
REV	REV.DATE	EFF.DATE	PURPOSE	PREPD	REVWD	APPD



# 3.8M G.I. ELECTRODE FOR EARTHING

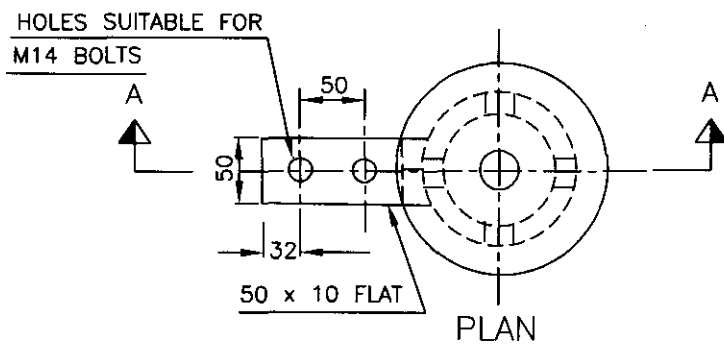
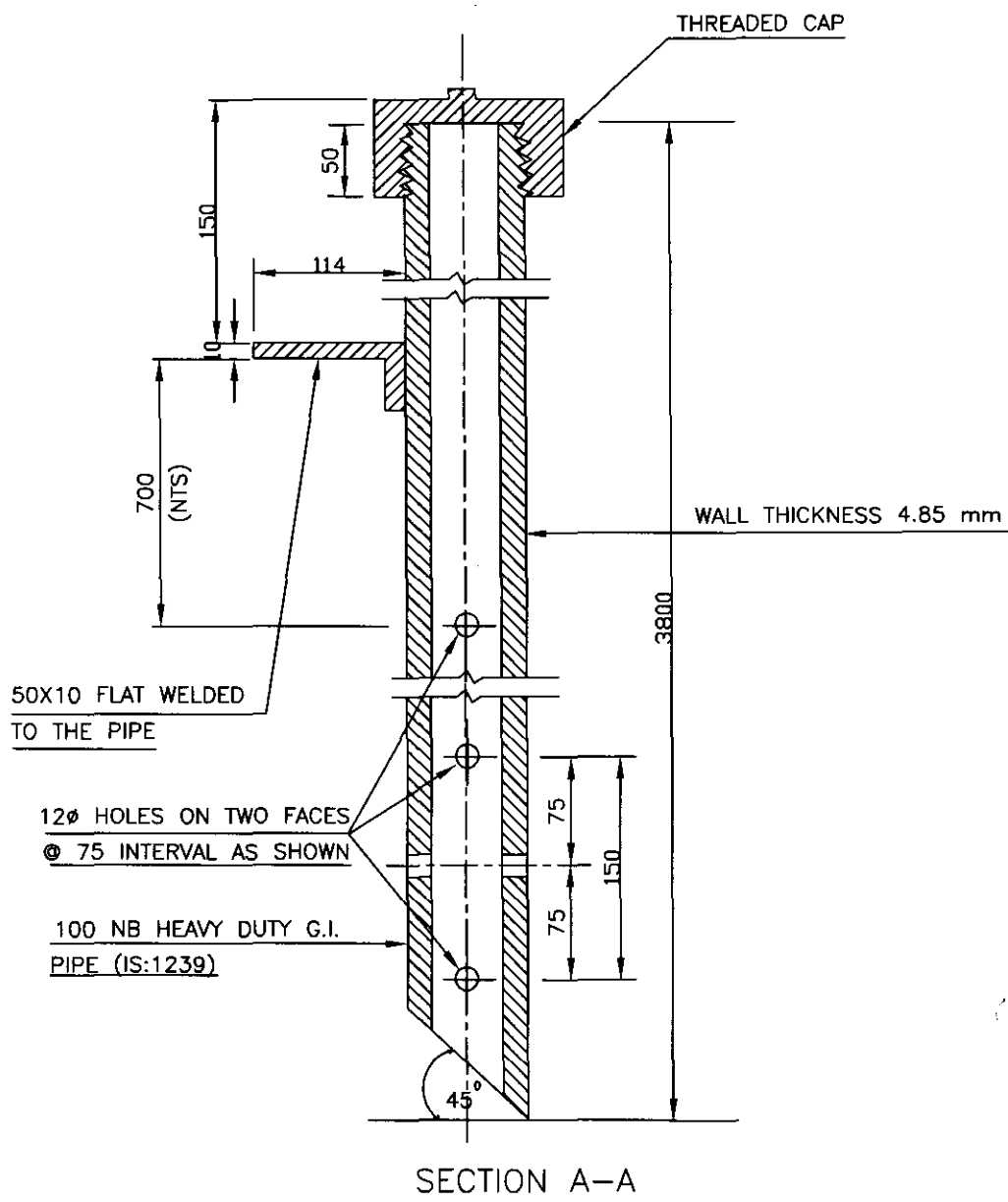
PDS:E 610

1

DOCUMENT NO.

REV

SHEET 1 OF 1



## NOTE:-

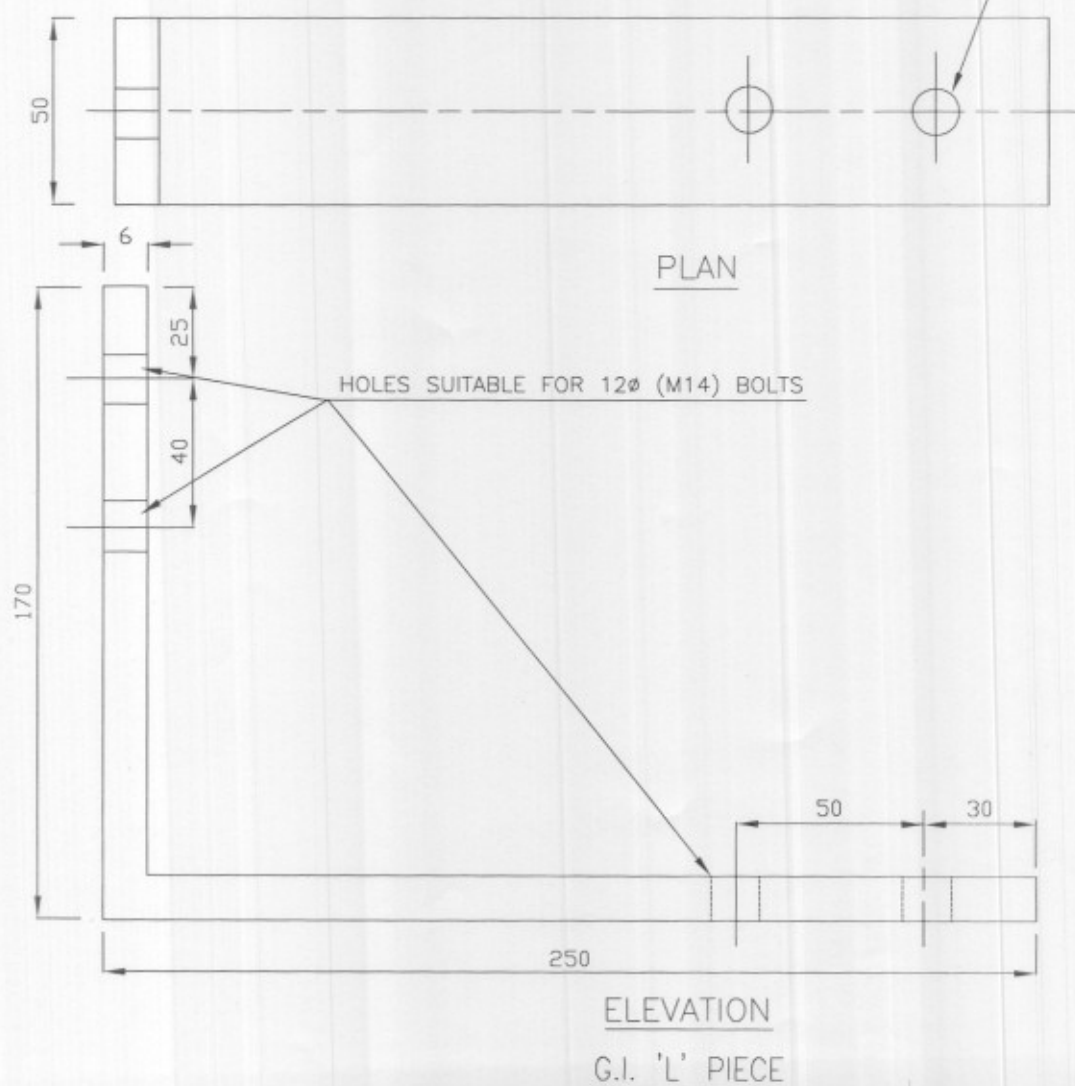
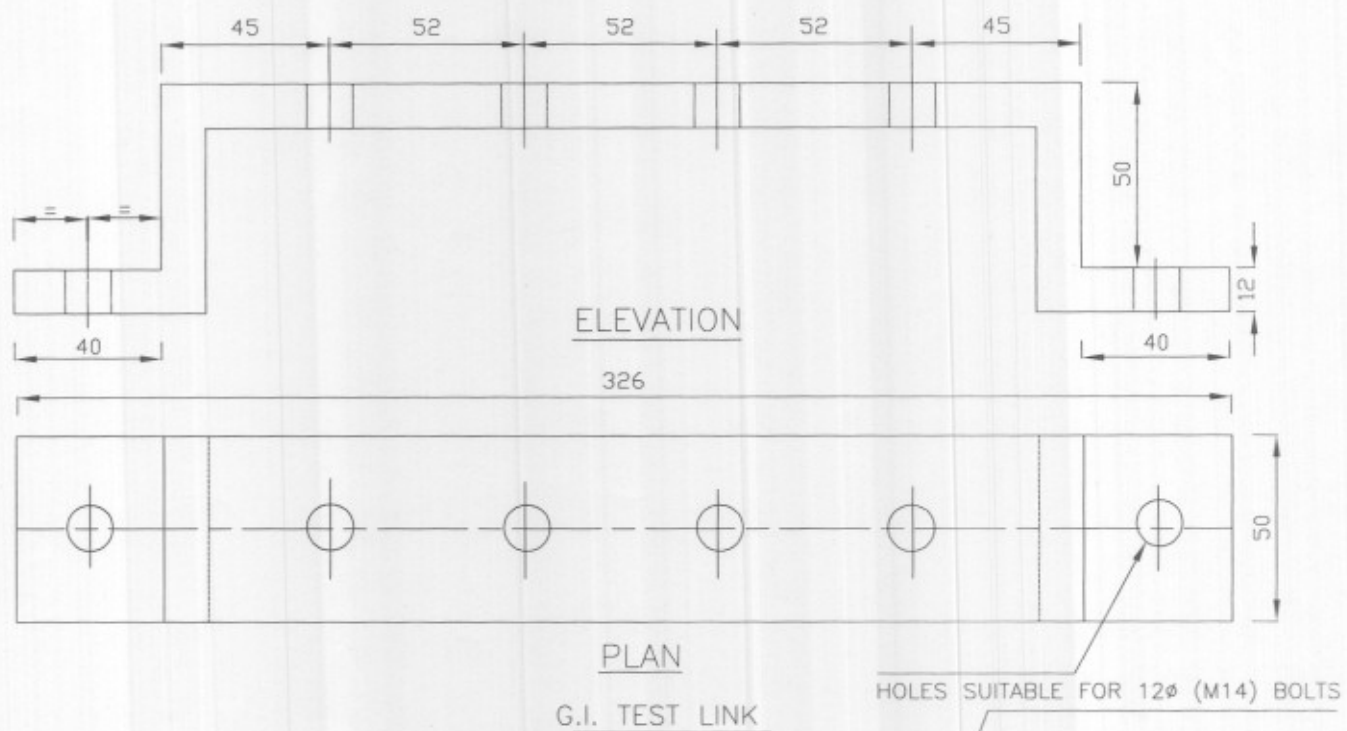
1. 12 $\phi$  HOLES WILL BE PROVIDED AT 75mm INTERVAL ON TWO FACES THROUGHOUT THE LENGTH OF PIPE. THE FIRST ONE SHALL START 700mm BELOW THE WELDED FLAT.
2. ALL DIMENSIONS ARE IN mm.

1	16.01.06	30.01.06	ISSUED FOR IMPLEMENTATION	RUNDA	AV	BB
REV	REV.DATE	EFF.DATE	PURPOSE	PREPD	REVWD	APPD



GI / AL. ACCESSORIES FOR  
EARTH PIT

PDS:E 611	0
DOCUMENT NO.	REV
SHEET 1 OF 2	



0	03.01.07	15.01.07	ISSUED FOR IMPLEMENTATION	NKR	AV	BB
REV	REV.DATE	EFF.DATE	PURPOSE	PREPD	REVWD	APPD



GI/AL. ACCESSORIES FOR  
EARTH PIT

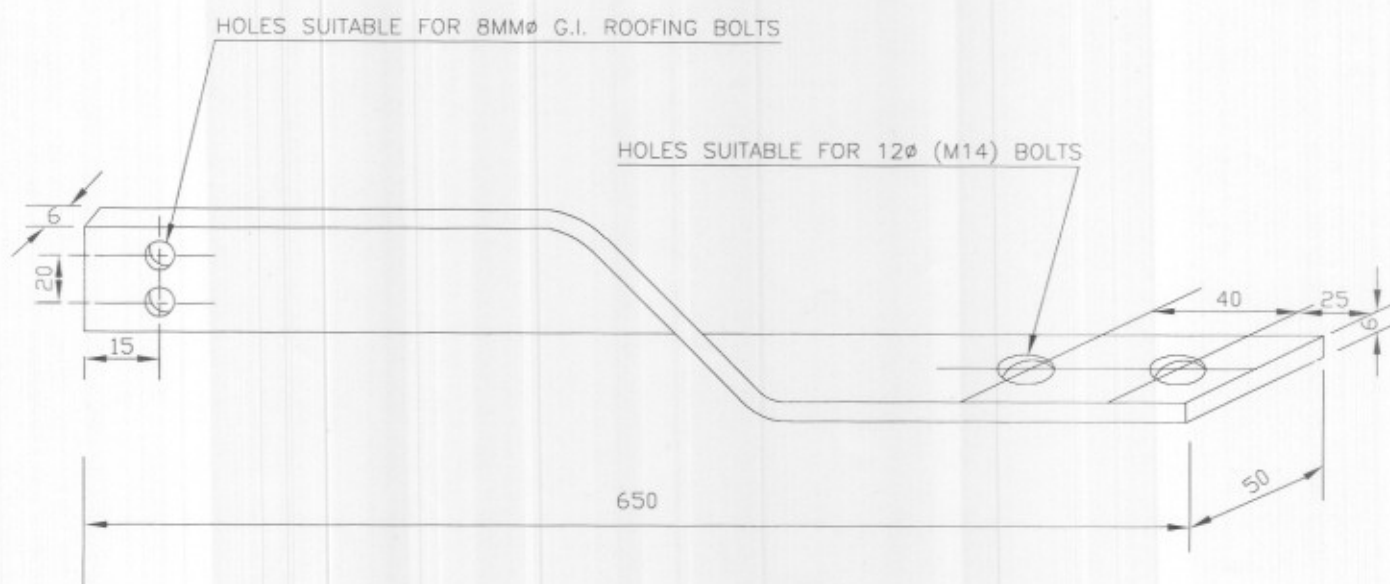
PDS:E 611

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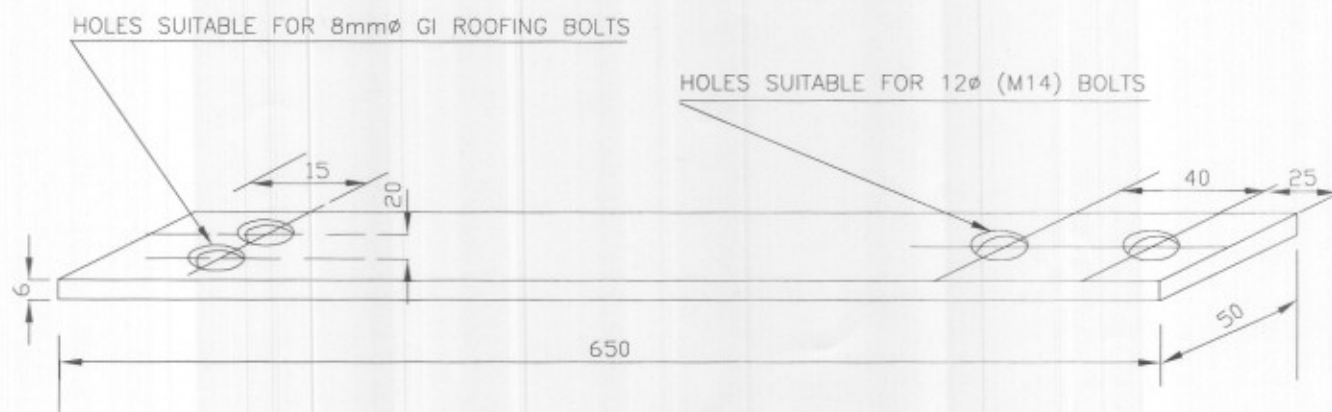
DOCUMENT NO.

REV

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CONNECTING TWISTED ALUMINIUM FLAT PIECE



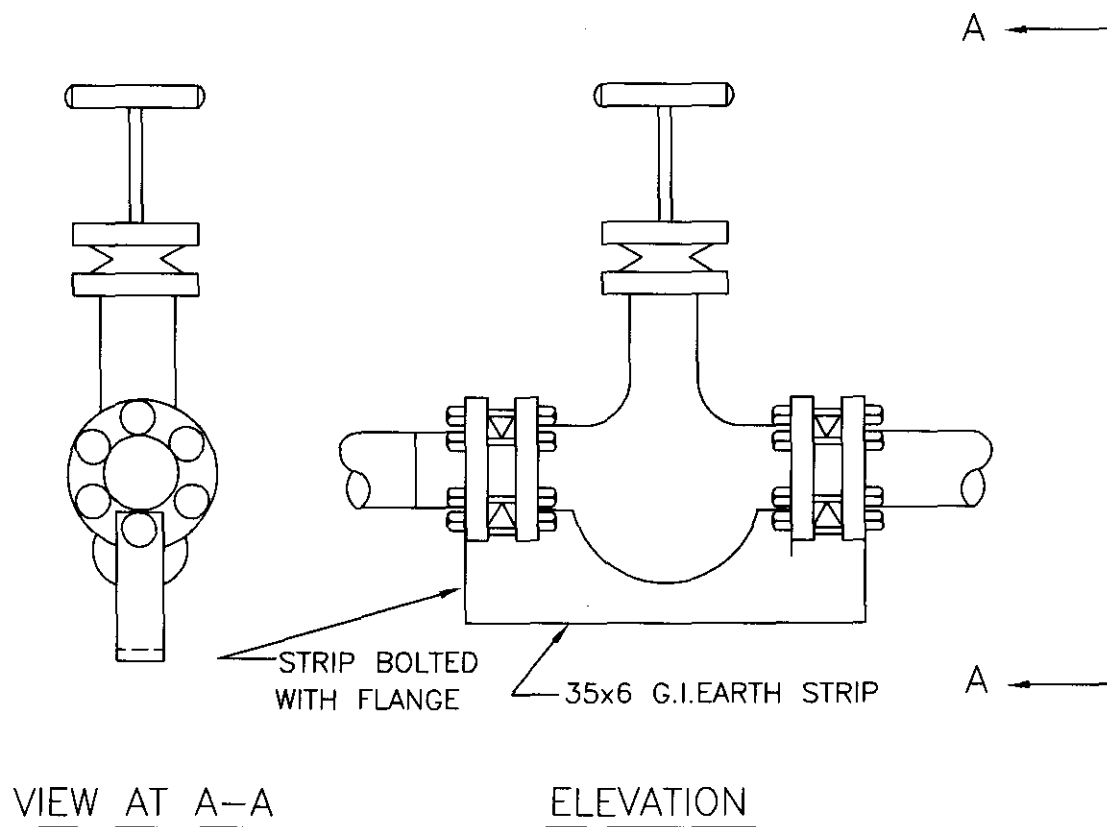
CONNECTING ALUMINIUM / G.I. FLAT PIECE

0	03.01.07	15.01.07	ISSUED FOR IMPLEMENTATION	NKR	AV	BB
REV	REV.DATE	EFF.DATE	PURPOSE	PREPD	REVWD	APPD



TYPICAL EARTHING ARRANGEMENT  
ACROSS PIPE JOINT/VALVES

PDS:E 612	1
DOCUMENT NO.	REV
SHEET 1 OF 1	



ALL DIMENSIONS ARE IN mm.

1	16.01.06	30.01.06	ISSUED FOR IMPLEMENTATION	RUNDA	AV	BB
REV	REV.DATE	EFF.DATE	PURPOSE	PREPD	REVWD	APPD