GAIL (INDIA) LIMITED

VIJAYPUR – DADRI – BAWANA PIPELINE PROJECT
(VIJAIPUR-DADRI SECTION)

LIST OF ATTACHMENTS
FOR
CP SYSTEM
(SMMS)

0 31.07.08  Issued with Tender

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1.0 LIST OF ATTACHMENTS

CONTRACTOR shall carry out all works strictly in accordance with the drawings/documents/specifications indicated in subsequent paragraphs.

2.0 SCOPE OF WORK

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GAIL (INDIA) LIMITED

VIJAYPUR – DADRI – BAWANA PIPELINE PROJECT
(VIJAIPUR-DADRI SECTION)

SCOPE OF WORK
FOR
CP SYSTEM
(SMMS)
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9.0 TENTATIVE MINIMUM BILL OF MATERIALS

ANNEXURE-1: TENTATIVE MINIMUM BILL OF MATERIALS FOR TCP & PCP SYSTEM WORKS
1. SCOPE OF WORK FOR CP SYSTEM FOR COMPLETE 497.79 KM VIJAIPUR-DADRI PIPELINE

1.1 SCOPE OF WORK (GENERAL)

M/s GAIL (India) Ltd is implementing laying of one 48” OD, approximately approx. 498 km long gas pipeline from Vijaipur (M.P.) to Dadri (U.P.). The complete pipe laying work from Vijaipur to Dadri has been divided into three sections (Section-A, B & C) as indicated below:

Section-A: 169.500 km: Vijaipur despatch terminal (Chainage 0.000 km) to Ch. 169.500 km.

Section-B: 165.500 km: Chainage 169.500 km to Ch. 335.00 km.

Section-C: 163.000 km: Ch. 335.000 km to receipt terminal at Dadri (Ch. 497.79 km).

Temporary and Permanent Cathodic Protection works for all the three sections shall be carried out by the same CP System contractor while the pipeline laying works are going on. The CP System contractor shall be responsible for coordination with pipeline laying contractor to ensure the following:

- The works related to TCP/PCP such as connection to the pipeline for cables for cathodic protection system (for sacrificial anodes of TCP/PCP, measurement cables, etc.), laying of reference cell, ER probes, polarization coupon etc. can be completed by CP System contractor before backfilling of the trench by pipeline contractor.
- The works related to pipeline contractor for pipeline crossings, so that the CP protection is provided to carrier pipe before laying of carrier pipe inside the cased crossing, sacrificial anodes are installed connected to pipe for river crossings, HT overhead line crossings, pipeline crossings etc.before backfilling of pipes.
- The works related to close interval potential logging (CPL) survey longitudinally along the pipeline and lateral potential measurement survey and when conducting other tests as may be required for identification of coating defects/holidays and for current drainage survey. The CP System contractor shall be responsible for physical verification and repair of all coating defects that may be detected during such surveys at no extra cost to Company.
- The works related to collection of approximately 10-12 m of pipeline material (may be in pieces of 500 to 1000 mm length) for fabrication of polarization coupons and ER probes.

One 36” OD, approx. 498 km long gas pipeline of M/s GAIL (India) Ltd. Exists in the common ROW of the proposed Vijaipur to Dadri 48” OD pipeline. The existing line is already having impressed current CP System with 13 No. of CP Stations. For the proposed Vijaipur to Dadri 48” OD pipeline CP System, one new temporary CP System need to be installed and operated until its permanent CP System is installed and hooked up with the existing impressed current CP System. The permanent CP System shall compose of the following major item / works:

- Installation of one new CP Station at intermediate pigging station IP-1, at KULWARA.
• The Existing CPPSM at IP-3 (BAJHERA) needs to be replaced with new CPPSM of same rating.
• Installation of additional 15 No. new anode ground beds (one each at existing and proposed CP Station & two at Vijaipur CP Station).
• Separate drainage connections are to be made to each 36" OD & 48" OD pipeline from the common CPPSM/CPTR at each of the 14 No. CP Station (13 existing and one new)
• Direct/resistance bonding connection shall also be made between the two pipelines at the test stations along the pipeline route at an average interval 1Km and at additional locations wherever required.
• Installation of permanent Cu/CuSO₄ reference cell at 48" / 36"outside diameter pipeline as detailed elsewhere and its connection to SCADA through CPPSM/CPTR at the 14 No. CP Station (13 existing and one new)

1.2 SCOPE OF WORK FOR TEMPORARY CP SYSTEM (TCP):

1.2 (a) Corrosion survey, Design, detailed engineering, Supply, installation, testing and commissioning of the temporary cathodic protection system using galvanic anodes to protect the external surface of the 48" outside diameter, 497.79 KM (approx.) long pipeline from VIJAIPUR (Chainage 0.000KM) to DADRI (Chainage 497.79 KM) Receipt Terminal, against corrosion for minimum 1 year or till commissioning of permanent CP system whichever is later and C.P. activities which are common for TCP and PCP (viz. protection of carrier pipe using zinc ribbon anodes for a design life of 35 years at all cased crossings) are to be included in the scope of this contract, including measurement of soil resistivity along the ROW and at anode ground beds for PCP, collection of cathodic protection related data along right of way as per specifications, detection using data logger and mitigation of DC interference on pipeline and CP System due to proximity of foreign DC source, detection using data logger and mitigation of high induced voltage at pipeline due to proximity of HT line, maintaining and safe keeping of test stations and monitoring at monthly basis of the temporary cathodic protection system till commissioning of the permanent cathodic protection system. All work shall be carried out conforming to the Scope of work, Design Basis, Data Sheets, specification, standard and vendor list as per the SMMS list of attachments vide document No. 6921-060-06-45-LL-01 and provisions of GCC, SCC including specification no. 6-51-0026, 6-51-0027 & 6-51-0029.

1.2 (b) The following need to be considered in specification no.6-51-0027/28:

(i) At saline soil Ag/Agcl reference electrode should be used and not Zinc electrode.
(ii) Carrier pipe inside the casing pipe need to be protected with zinc ribbon anode irrespective of casing pipe is coated / painted or not

Note:- For chainages refer Schematic Arrangement of Pipeline facilities for VIJAIPUR to DADRI Pipeline project drg.no.6921-060-16-71-3001.

1.3 SCOPE OF WORK FOR PERMANENT CP SYSTEM (PCP):
a) Corrosion survey, Supply, Design, detailed engineering, installation, testing and commissioning of the permanent cathodic protection system by impressed current method to protect the external surface of the 48” outside diameter, 497.79 KM (approx.) long pipeline from VIJAIPUR (Chainage 0.000 KM) to DADRI (Chainage 497.79 KM) Receipt Terminal, against corrosion for minimum for 35 years. The scope shall include complete permanent cathodic protection system, including carrying out the soil resistivity measurement for anode ground beds, design of anode ground beds considering size / rating of anode bed not less than the minimum requirements of the anode ground bed specified, detection using data logger and mitigation of DC interference on pipeline and CP System due to proximity of foreign DC source, detection using data logger and mitigation of high induced voltage at pipeline due to proximity of HT line, close interval potential logging survey for entire length of both 36” OD & 48” OD pipeline and additional survey CAT, DCVG etc. at selected locations which shall be decided from the abnormality areas of close interval potential logging survey results to identify coating defects/holiday, conducting pipelineline current & coating resistance test at selected locations where current measurement test stations shall be installed, preparation of commissioning report and as built drawings etc. All work shall be carried out conforming to the Scope of work, Design Basis, Data Sheets, specification, standard and vendor list as per the SMMS list of attachments vide document No.6921-060-06-45-LL-01 and provisions of GCC, SCC including specification no.6-51-0024, 6-51-0025, 6-51-0028, 6-51-0029.

b) The scope shall include acquisition of land for anode ground bed and anode junction box and for laying of cables from anode ground bed to CP station. The scope shall also include disconnection of temporary cathodic protection system wherever it is not the part of PCP before commissioning and reconnect it after commissioning, laying and termination of all the cables of C P system, including all the CP cables incoming and outgoing from CPTR/CPPSM units and permanent reference cable/measurement cables, from Vijaipur dispatch terminal CP station, Intermediate SV cum CP stations (SV-2, SV-4, SV-5, SV-8, SV-9, SV-11, SV-13 and SV-15), intermediate pigging station (IP1, IP3, IP4), existing CP Station at BURDHA (Chainage 170.00 KM) & receipt terminal at Dadri (Chainage 497.79 KM) to 48” & 36”OD pipeline / new anode beds as required. In additions to separate drainage connections at each CP Station, direct/resistance bonding connection shall be made between the 48” / 36”outside diameter pipelines at the test stations along the pipeline route at an average interval 1Km and at additional locations wherever required. At all possible locations, the test stations for 48” OD pipeline need to be installed matching with the test station of existing 36”OD pipeline, for bonding purpose. Installation, testing and commissioning of CPPSM unit at new CP Station (IP1) and existing CP Station (IP3). The CPPSM unit to be installed at intermediate pigging station (IP1) and (IP3) shall be provided with facilities for sending and receiving digital and analogue input/output signals for remote SCADA monitoring/controlling system. The permanent reference cell and measurement cables for all the permanent reference cells to be installed at 48” / 36”outside diameter pipeline at 13 No. existing CP Stations & one new CP Station at (IP1) need to be terminated to CPPSM/CPTR terminal for monitoring/controlling.
purpose. Supply and installation of 8 pair, 1.5 mm², copper conductor PVC insulated screened cable for sending analogue signals and 14 core, 2.5 mm², copper conductor YFY cable for sending digital signals between CPTR/CPPSM & SCADA system I/O rack shall be in the contractor’s scope of work.

c) The contractor shall include the services of specialist agencies, (like PLE Germany, Vender Velde Holland, Nippon Japan, SSS India, IACS of UK or equivalent) for doing interference survey and implementing mitigation measures against DC interference on pipeline and CP system due to proximity of foreign DC source, high induced voltage at pipeline due to proximity of HT line detection and mitigation, in case contractor on his own do not possess the adequate experience for the same, also refer Design Basis, Data sheet & 6-51-0028 for scope.

d) The contractor should consider the vendor, manufacturer as mentioned vide 6921-060-06-45-VN-01 for the CP System supply/installation work. In case contractor proposes to include additional names in the vendor list, it shall be subject to approval by EIL/OWNER.

e) Anode ground bed shall preferably be horizontal type of plot size 100mx10m (minimum) for the anode bed consisting of solid Hi-Si-Cr-cast iron anode and 60mx5m (minimum) for the anode bed consisting of MMO tubular anode. Irrespective of the life of anode bed or anode bed resistance worked out by the design calculations, each anode bed should contain minimum 20 No. solid Hi-Si-Cr-cast iron anode (51mm dia.x1524mm long, 20 kg weight) or 10 No. MMO tubular anode (25mm dia.x1000mm long). In case design calculations based on soil resistivity of the anode bed or the life of anode bed or anode bed resistance worked out to be of higher plot size or higher No. of anodes than the minimum requirement specified above, the same need to be considered.

f) Anode lead cable in between each cast iron anode or MMO tubular anode and AJB for shallow depth horizontal anode bed shall be PVDF insulated and HMWPE sheathed cable, 7 strands, 10mm² stranded copper conductor, single core, unarmoured cable, with a double insulation system. The primary insulation shall be 0.04 inch thick poly vinyl dyne fluoride (PVDF) 1100 Volt grade. The secondary insulation shall be 0.065 inch thick high molecular weight poly ethylene (HMWPE) sheathing jacket over the primary insulation, in place of 1x10 sq.mm PVC insulated and sheathed cable mentioned in spec.6-51-0029.

g) Specific approval need to be taken from OWNER/EIL by the CP vendor for installation of deep/semi-deep anode bed with the supporting bore-log data for the soil strata / permanent water table depth and the soil resistivity values taken both by soil box method and using Wenner’s 4-pin method up to 50m depth. In case deep/semi-deep well anode bed with MMO tubular single string anode with single dead weight is accepted by EIL/OWNER, minimum 10 No. MMO tubular anode (25mm dia.x1000mm long) need to be considered in the anode string, anode lead cable shall be 1x50 sq.mm EPR/CSPE insulated cable or PVDF insulated and HMWPE sheathed cable. In case deep/semi-deep well anode
bed with MMO tubular multiple string anode with dead weight for each string is accepted by EIL/OWNER, minimum 10 No. MMO tubular anode (25mm dia. X1000mm long) need to be considered, one in each anode string, anode lead cable shall be 1x10 sq.mm EPR/CSPE insulated cable or PVDF insulated and HMWPE sheathed cable between each anode and AJB. Minimum depth of deep/semi-deep well anode bed shall be 50m & minimum diameter of anode bed shall be 250mm. For installation of the anodes in the permanent water table, higher than 50m (minimum) depth specified above need to be considered in case the permanent water table is at lower depth. In case design calculations based on soil resistivity of the anode bed or the life of anode bed or anode bed resistance worked out to be of higher depth or higher No. of anodes than the minimum requirement specified above, the same need to be considered.

h) Anode ground bed resistance should be ideally 1 ohm (max) as mentioned in spec.6-51-0028. However, in case of very high soil resistivity at anode ground bed location, the upper acceptance limit of anode bed resistance may be increased at the sole discretion of EIL/OWNER.

i) Current measurement test station needs to be installed at all the intermediate CP Station for measurement of the upstream and downstream pipeline current as well as coating resistance. The current measurement test station needs to be installed also at the beginning and end CP Station for measurement of the upstream or downstream (one leg only) pipeline current as well as coating resistance.

j) In case anode ground bed for foreign pipeline is existing within 100m of the proposed pipeline ROW and cause interference to proposed pipeline, CP CONTRACTOR need to relocate the anode bed with the consent of the OWNER of the foreign pipeline.

k) Each CPPSM/CPTR units shall have GPS synchronised current interrupter with 0-999 second programmable timer and antenna for synchronised current interruption.

l) For observing various parameters/indications without opening the door, the transparent glass cover shall be provided at each CPPSM/CPTR units.

m) Necessary measures shall be adopted to mitigate the stray current interference due to crossings of high tension line, electrified railway track, existing pipeline in the close vicinity etc. by providing sacrificial anodes, grounding cells, diodes etc.

n) Surge diverter across insulation joints shall be solid state type.

o) Minimum distance between the horizontal shallow depth or vertical deep/semi-deep anode ground bed and the pipeline to be protected shall be considered 100m. In case design calculations based on soil resistivity of the anode bed
and anode bed current indicates that remoteness of the anode bed shall be more than 100m, the same need to be considered.

p) Two permanent reference cells need to be installed on 48” line at each of the 13 No. existing CP Stations, three permanent reference cells on 36” line & two permanent reference cells on 48“ line need to be installed at new intermediate CP Station cum pigging station (IP1), for monitoring and control of CP System through CPPSM/CPTR as well as SCADA/RTU.

q) Supply and installation of the power supply cable from switch fuse unit/ MCC/PDB of OWNER’S Electrical substation to CPPSM/CPTR shall be CP CONTRACTOR’s scope of work.

r) Sacrificial type CP System needs to be installed at all river crossings for 35 years design life in addition to the ICCP system.

s) Colour code identification scheme need to be provided for the CP System cables of 36” OD & 48” OD pipeline.

Note:- For chainages refer Schematic Arrangement of Pipeline facilities for VIJAIPUR to DADRI Pipeline project drg.no.6921-060-16-71-3001.

2.0 SCOPE OF DESIGN & ENGINEERING

2.1 Preparation of specification for procurement of CP System equipment/materials in contractor's scope of supply, submission of CP System equipment drawing/document to the Engineer-in-charge for their review, preparation of site engineering drawings and details for installation work wherever applicable or required by the Engineer-in-charge, and submit to the Engineer-in-charge for approval and comments.

3.0 SCOPE OF SUPPLY

Following CP System equipments and material are in the contractor's scope of supply in this tender:-

3.1 Cathodic protection system

a) All equipment and materials including cables as required for Temporary cathodic protection of pipeline as per Cl. 1.1, 1.2(a), (b) and in line with specification no. 6-51-0026, 6-51-0027, 6-51-0029, standard specification, design basis and data sheets.

b) All equipment and materials including cables, CPTR/CPPSM units as required for Permanent cathodic protection of pipeline as per Cl. 1.1,1.3 (a), (b), (c), (d), (e), (f), (g), (h), (i), (j), (k), (m), (n), (o), (p), (q), (r) & (s) and in line with specification nos.6-51-0024, 651-0025, 651-0028, 651-0029, standard specification, design basis and data sheets.

4.0 AS BUILD DRAWING & DOCUMENT
After completion of work contractor should prepare commissioning report as well as hard and soft copy of as build drawings & documents both for TCP & PCP. Six copy of the commissioning report and as build drawings & documents shall be submitted to OWNER and one copy to EIL for record.

5.0 OTHER MISCELLANEOUS WORKS

5.1 Preparation of buried cable trenches including excavation, back filling, compacting, providing of brick protection by second-class bricks, spreading of fine river sand, including all supplies.

5.2 The job includes repairing of all civil works damaged during installation of electrical facilities.

5.3 The scope of work under this contract shall be inclusive of breaking of walls and floors, and chipping of concrete foundations necessary for the installation of equipment, materials, and making good of the same.

5.4 Minor modifications wherever required to be done in the owner free supplied equipments or devices to enable cable entry, termination, etc.

5.5 Sealing of openings made in the walls / floors for cable trays, cables, bus ducts, etc. suitably using acceptable practice and standards.

5.6 Supply and installation of all other accessories not specifically mentioned herein, but nevertheless necessary for completion of the job.

5.7 Miscellaneous works (civil works, co-ordination, etc.) : All related civil works shall be included in the scope of the contractor.

6.0 OWNER’S SCOPE OF SUPPLY

Supply, installation, testing and commissioning of all the equipment covered in this package are included in the scope of the contractor. No equipment will be free issued by the owner to the contractor except CPTR/CPPSM units at Vijaipur dispatch terminal CP station, Intermediate SV cum CP stations (SV-2, SV-4, SV-5, SV-8, SV-9, SV-11, SV-13 and SV-15) & intermediate pigging station (IP4), existing CP Station at BURDHA (Chainage 170.00 KM) & receipt terminal at Dadri (Chainage 497.79 KM) which shall be provided to CP CONTRACTOR by OWNER in as is where basis for power supply to PCP.

7.0 OPTIONAL ITEMS

The rates for the following optional item need to be furnished by the bidder along with the bid. The rate for the optional item shall not form the part of the evaluation or the
lump sum price. OWNER as per need may take any part or all optional item from the CP CONTRACTOR:

- 02 Year O&M CP Spares/ Tool / Tackles for CP system like Multimeter, Clamp meter, ER Meter, Portable reference cell, UT meter, Tool box Complete for each maintenance base etc.
- 02 Year O&M CP Spares for TR /CPPSM unit
- Provision for new TS at 36” OD pipeline if existing TS are not available.
  - Provision of plates & terminals/ doors, Cable laying & connections in existing TS of 36” OD pipeline, in case the same is missing or broken.
- Effectiveness/ checking and remedial measures of the existing CPPSM/CPTR

8.0 LIST OF ATTACHMENTS
For List of attachment, refer document no. 6921-060-06-45-LL-01 attached elsewhere in this tender document

9.0 TENTATIVE MINIMUM BILL OF MATERIALS
The bidders should consider the bill of materials as per the Annexure-1 attached to this SOW as the minimum requirements for their quotation.

NOTES:

1. Contractor to note that the exact cable routing shall be decided at site based on actual site conditions. Exact cable quantities/sizes shall be based on actual measured route lengths at site/load by Contractor in coordination with Engineer-in-Charge/Client. Contractor shall ensure that there is no surplus or shortage of cables at site and procure cables accordingly. Contractor shall note that payment for supply of cables shall be made as per actual laid cables at site.
2. Contractor to note that all cabling (including supply & laying) & other electrics for the CP System shall be supplied along with the package and no separate payment shall be admissible for the same. Owner shall provide only single point power supply for the same.

ANNEXURE-1

VIJAIPUR- DADRI PIPELINE PROJECT OF M/S. GAIL

TENTATIVE MINIMUM BILL OF MATERIALS FOR TCP & PCP SYSTEM WORKS

48" DIA X 498 KMS. LONG

<table>
<thead>
<tr>
<th>S.N.</th>
<th>Description</th>
<th>Unit</th>
<th>Total Qty</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Temporary Cathodic Protection System (TCP)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Description</td>
<td>Kms</td>
<td>LS</td>
</tr>
<tr>
<td>---</td>
<td>-----------------------------------------------------------------------------</td>
<td>------</td>
<td>-----</td>
</tr>
<tr>
<td>1</td>
<td>Soil resistivity survey at every 500Mtr and additional data collection along ROW</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Design, Detailed Engineering for Temporary Cathodic Protection system</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>Sacrificial anodes</td>
<td>Nos.</td>
<td>498</td>
</tr>
<tr>
<td></td>
<td>5 Kg Prepacked Magnesium anode (Low potential -1.55V) for Carrier Pipe protection along the pipeline route</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>10 Kg Prepacked Magnesium anode for Casing Pipe Protection at Coated casings only</td>
<td></td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>Zinc Ribbon anode for carrier pipe inside the casings</td>
<td>Mtr</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Zinc Ribbon anode to Pipe connection by thermit weld</td>
<td>Nos.</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>TCP - Cables shall be annealed high conductivity, stranded copper conductor, 650/1100V grade</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1c x 6 mm² - Anode tail cable -PVC/PVC, unarmoured</td>
<td>Mtr</td>
<td>as reqd.</td>
</tr>
<tr>
<td></td>
<td>1 core x 4 mm² - Potential Measurement.-PVC, PVC sheathed, armoured</td>
<td>Mtrs.</td>
<td>as reqd.</td>
</tr>
<tr>
<td></td>
<td>1 core x 6 mm² - current measurement cable-PVC/PVC, armoured</td>
<td>Mtrs.</td>
<td>as reqd.</td>
</tr>
<tr>
<td></td>
<td>1 core x 10 mm² - Pipeline to Test station-PVC/PVC, armoured</td>
<td>Mtrs.</td>
<td>as reqd.</td>
</tr>
<tr>
<td></td>
<td>1 core x 25 mm² -Bonding, Earthing, Surge divertor, HT line, etc-PVC/PVC, armoured</td>
<td>Mtrs.</td>
<td>as reqd.</td>
</tr>
<tr>
<td>5</td>
<td>Test Station (Weather Proof with IP-55)</td>
<td>Nos.</td>
<td>620</td>
</tr>
<tr>
<td>6</td>
<td>Normal Size</td>
<td>Nos.</td>
<td>60</td>
</tr>
<tr>
<td>7</td>
<td>Cable to pipe connections by Exothermic Process or Pin Brazing for all sizes (Upto 1C x 25mm²)</td>
<td>Nos.</td>
<td>2000</td>
</tr>
<tr>
<td>8</td>
<td>Electrolytic type Polorisation cells for HT power line crossings</td>
<td>Nos.</td>
<td>60</td>
</tr>
<tr>
<td>9</td>
<td>20 Kg Sacrificial Zinc anode for HT line crossing</td>
<td>Nos.</td>
<td>105</td>
</tr>
<tr>
<td>10</td>
<td>20 Kg Sacrificial Zinc anode for earthing of MOV on Cathodically protected portion of pipeline.</td>
<td>Nos.</td>
<td>15</td>
</tr>
<tr>
<td>11</td>
<td>Computerised test station</td>
<td>Nos.</td>
<td>6</td>
</tr>
<tr>
<td>12</td>
<td>Computerised test station reader</td>
<td>Nos.</td>
<td>3</td>
</tr>
<tr>
<td>13</td>
<td>Solid state Surge Divertors rating 100 kA for Insulating Joints</td>
<td>Nos.</td>
<td>10</td>
</tr>
<tr>
<td>14</td>
<td>Polarisation coupons</td>
<td>Nos.</td>
<td>50</td>
</tr>
<tr>
<td>15</td>
<td>ER probe</td>
<td>Nos.</td>
<td>6</td>
</tr>
<tr>
<td>16</td>
<td>ER probe Reader</td>
<td>Nos.</td>
<td>3</td>
</tr>
<tr>
<td>17</td>
<td>Earthing of above ground unprotected Pipeline at Terminals by installing 100mm dia x 3mtr long GI pipe</td>
<td>Loc.</td>
<td>20</td>
</tr>
<tr>
<td>18</td>
<td>Testing and Commissioning of Temporary Cathodic Protection System.</td>
<td>LS</td>
<td>1</td>
</tr>
<tr>
<td>19</td>
<td>Monitoring of TCP System</td>
<td>Months</td>
<td>12</td>
</tr>
<tr>
<td>20</td>
<td>Permanent Cathodic Protection System</td>
<td></td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>Soil Resistivity Survey at PCP anode ground bed Locations</td>
<td>Location</td>
<td>15</td>
</tr>
<tr>
<td>22</td>
<td>Design, Detailed Engineering for Permanent Cathodic Protection system</td>
<td>LS</td>
<td>1</td>
</tr>
<tr>
<td>23</td>
<td>CPPSM Units - 24V/25A with remote monitoring and control through SCADA facility Excluding battery bank for DC power supply</td>
<td>Nos.</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Anode Ground bed</td>
<td>Location</td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---------------------------------------------------------------------------------</td>
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<td>---</td>
</tr>
<tr>
<td>4.1</td>
<td>Shallow type Anode bed using MMO LIDA tubular anode (1&quot; dia. x 1m long) of each 8.0 A Output, total 10 Nos. including GI cannister with petroleum coke breez. Excluding anode tail cable.</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>4.2</td>
<td>Land acquisition for anode ground bed (60mx 5m plot), Anode Junction Box and anode ground bed cable laying (100m x 1m plot).</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>4.3</td>
<td>Chainlink fencing for anode ground Bed</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>4.4</td>
<td>20 Kg Sacrificial Zinc anode for river crossing</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Anode Junction Box</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Cathode Junction box</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>PCP - Cables shall be annealed high conductivity, stranded copper conductor, 650/1100V grade</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.1</td>
<td>1 core x 4 mm² - Ref. Cell, PSP Measurement &amp; Pol. Coupon cable-PVC, aluminium backed by mylar/polyester tape shielded, PVC sheathed, armoured</td>
<td>Mtrs. as reqd.</td>
<td></td>
</tr>
<tr>
<td>7.2</td>
<td>1-pair x 2.5sq.mm- reference signals from Per. Ref. cell &amp; Pipeline to CPTR/CPPSM units</td>
<td>Mtrs. as reqd.</td>
<td></td>
</tr>
<tr>
<td>7.3</td>
<td>1 core x 35 mm² - Anode &amp; Cathode header Cable-PVC/PVC, armoured</td>
<td>Mtrs. as reqd.</td>
<td></td>
</tr>
<tr>
<td>7.4</td>
<td>1C x 10mm² - PCP anode tail cables-PVDF/HMPE (KYNER), unarmoured</td>
<td>Mtr as reqd.</td>
<td></td>
</tr>
<tr>
<td>7.5</td>
<td>1 core x 6 mm² - Drainage connection at Intermediate CP stn.</td>
<td>Mtr as reqd.</td>
<td></td>
</tr>
<tr>
<td>7.6</td>
<td>2C x 10mm² - CPPSM power supply cable-PVC/PVC, armoured</td>
<td>Mtr as reqd.</td>
<td></td>
</tr>
<tr>
<td>7.7</td>
<td>Supply and installation of 8 pair, 1.5 mm², copper conductor PVC insulated screened cable for sending analogue signals between CPTR/CPPSM &amp; SCADA system I/O rack</td>
<td>Mtr as reqd.</td>
<td></td>
</tr>
<tr>
<td>7.8</td>
<td>Supply and installation of 14 core, 2.5 mm², copper conductor YFY cable for sending digital signals between CPTR/CPPSM &amp; SCADA system I/O rack</td>
<td>Mtr as reqd.</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Cable to pipe connections by Pin brazing method for all sizes (Upto 1C x 35mm²) for existing/operating pipeline</td>
<td>Nos. 200</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Permanent Cu/CuSO4 Reference cell</td>
<td>Nos. 60</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Testing and Commissioning of Permanent Cathodic Protection System.</td>
<td>LS 1</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Post commissioning surveys</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11.1</td>
<td>Interference Survey &amp; Mitigation measure (Foreign backup)</td>
<td>Kms. 1000</td>
<td></td>
</tr>
<tr>
<td>11.2</td>
<td>CPL Survey</td>
<td>Kms. 1000</td>
<td></td>
</tr>
<tr>
<td>11.3</td>
<td>CAT with ‘A’ Frame Survey</td>
<td>Kms. 250</td>
<td></td>
</tr>
<tr>
<td>11.4</td>
<td>DCVG Survey</td>
<td>Kms. 200</td>
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</tr>
</tbody>
</table>
GAIL (INDIA) LIMITED

VIJAIOPUR – DADRI - BAWANA PIPELINE PROJECT
(VIJAIPUR-DADRI SECTION)

DESIGN BASIS
FOR
CP SYSTEM
(SMMS)

0 31.07.08 Issued for bid

<table>
<thead>
<tr>
<th>Rev. No</th>
<th>Date</th>
<th>Purpose</th>
<th>NB Prepared by</th>
<th>BC Checked by</th>
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Format No. EIL 1641-1924 Rev. 1
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2. Power Source Details:
3. Utilisation voltage & Operating philosophy
4. CP power supply
5. Monitoring and control signal through SCADA
6. Cabling System
7. Electrical Equipment for Hazardous Areas
8. Statutory Approval
9. CP System
10. Special requirements for SCADA input
This design data defines the design requirements applicable for this project in addition to the Specification for Sacrificial anode cathodic protection system 651-0027, specification for impressed current cathodic protection system 6-51-0028. (Data marked ‘*’ shall be furnished/confirmed by client).

1. **Site Conditions**
   
   A. Equipment design temperature (IS 9676) : 50°C
   
   B. Soil Resistivity : As per Soil Analysis report
   
   C. Min. temp. for battery sizing : 10°C
   
   D. Altitude above mean sea level : Less than 1000M above
   
   E. Weather : Dry, dust storms in summer, humid / heavy rain fall during monsoon

2. **Power Source Details:**
   
   - The following power source details
     are for information to CP CONTRACTOR
   
     i) Vijaipur Despatch Terminal : Existing system (*)
   
     ii) At IP-1 : Power generation by 24V DC Solar system Battery back-up of 72 hours to be provided at all unmanned stations. 415V grid power supply through auto healthy phase selection for A/C, ventilation and outdoor/normal indoor lighting.
   
     iii) At all other remote operated SV/IP stations (SV-2, SV-4, SV-5, SV-8, IP-2, SV-9, SV-11, IP-3, SV-13, SV-15, IP-4) : From existing 24V/48V system through suitable panel/feeder modification as required
   
     iv) & Dadri Despatch Terminal : Covered in Dadri-Bawana Pipeline tender

3. **Utilisation voltage & Operating philosophy:** The following Utilisation voltage details are for information to CP CONTRACTOR

   3.1 Telecom :
      
      For IP-1 :- (-) 48V DC (+VE earthed)
      
      For manned Terminals :- NA

   SCADA :
      
      For IP-1 :- 24V DC (Floating)
      
      For manned Terminals :- NA
3.2 Electrical System

For IP-1 :-
24V DC (Floating) & 240V (normal), 1-Ph AC power supply

For manned Terminals : NA

4.0 CP power supply :
- Type : Existing (*)
- Output voltage : Existing (*)
- Number/configuration : Existing (*)

5.0 Monitoring and control signal through SCADA

Digital and analogue monitoring and control signals as required for CP system, shall be provided in various electrical equipment for connection to SCADA system.

6.0 Cabling System

6.1 Cable laying philosophy

A. Paved area : Cable tray/RCC trench
B. Unpaved area : RCC trench/Directly buried
C. Type of cable trays : Galvanized prefabricated /
And painted

7.0 Electrical Equipment for Hazardous Areas

All the electrical equipment for hazardous areas shall be of Ex-d type suitable for temp classification T3.

8.0 Statutory Approval

From CEA : Not in CP System contractor’s scope of work

9.0 CP System

9.1 Temporary cathodic protection system : Required
A. Type  :  Sacrificial magnesium anode
B. Design life  :  1 Year or till commissioning of PCP whichever is later
C. Pipeline coating  :  Three Layer Polyethylene
D. Protective current density  :  As per Cl.5.1(iii) of spec.6-51-0027
E. Anode material (for sacrificial CP System)  :  Zinc / low potential (1.55 V) Magnesium
F. Electrical resistance probes (ER Probes)  :  Shall be provided as per Cl.7.4 of spec.6-51-0027
   a. Quantity of E/R probes  :  2 nos. per section, location in consultation with OWNER/EIL by CP Contractor based on Cl.7.4.1 of spec.6-51-0027
   b. No. of E/R probe reading instrument  :  One per Section
G. Polarisation coupons  :  Shall be provided as per Cl.7.8 of spec.6-51-0027
   a. Size of exposed area of coupon  :  100mm x 100mm
   b. No. of coupons  :  To be decided by CP contractor based on Cl.7.8.1 of spec.6-51-0027 & in consultation with OWNER/EIL
   c. No. of magnet devices for operation of magnetic reed switch  :  -DO-
H. Polarisation cell  :  Electrolytic type
I. Additional tests to evaluate the coating defects  :  Shall not be conducted
K. CPL survey  :  Shall not be conducted during TCP.
L. DC interference & AC induced voltage survey  :  Shall be conducted during TCP stage for DC interference areas and HT crossings (11kV and above), foreign pipelines and GAIL pipelines in the common ROW, reading shall be taken after every 24 hrs or at hourly interval.

9.2 Permanent Cathodic Protection System

A. Type  :  Impressed current type
B. Design life of protection  :  35 Years
C. Pipeline coating  :  Three Layer Polyethylene
D. Design protection current density  :  As per Cl.5.1(iii) of spec.6-51-0028
E. Current drainage & coating resistance measurement survey  :  Shall be carried out
F. Type of Anodes for anode ground bed  :  Solid high silicon iron / tubular mixed metal oxide titanium.
G. Electrical resistance probes  :  Shall be provided as per Cl.7.8.1 of spec.6-51-0028(Also refer Cl.12.1F)
H. Computerised test stations  :  Shall be provided as per Cl.7.13 of spec.6-51-0028
   a. No. of computerised test  :  2 no. per Section, however exact locations
stations  to be decided by CP sub contractor based on Cl.7.13 of spec.6-51-0028 & in consultation with OWNER/EIL

b. No. of computerised test station readers/ portable data collection & storage instruments. : One per Section

c. Interval for data acquisition/ storing : Once every day (Refer Note below)

I. Polarisation coupons : Shall be provided as per Cl.7.12 of spec.6-51-0028 (Also Refer Cl. 9.1.G above)

J. Polarisation cell : Electrolytic type

K. Acquisition of land for anode ground bed, anode junction boxes and anode ground bed cable laying : By Contractor

L. Chain link fencing around the ground: bed : Shall be provided

M. Close interval potential logging survey: : Shall be carried out

N. Additional tests to be conducted for identifying pipe coating defects/ holidays : DCVG/CAT survey

O. Proposed location of Anode Ground bed (For impressedCurrent CP System) at existing/proposed CP stations/ : To be decided by CP contractor.

P. Proposed location of E/R probes/ Computerised test stations/ Polarisation Coupons : To be decided by CP contractor during detail engineering based on EIL specifications and in consultation with the Client.

Q. CP stations/ anode ground bed for Impressed current system :-
   a) CP stations shall be located coinciding with SV / IP stations, as far as possible.
   b) At all CP Station power supply to PCP system shall be through existing CPTR/CPPSM. However, for CP station at IP-1 & IP-3, cathodic protection power supply module (CPPSM) is to be provided by CP CONTRACTOR.
   c) Any other proposed location shall be included during detailed engineering, if required.

R. Additional requirements:
   a) Anode ground bed shall preferably be horizontal type of plot size 100mx10m (minimum) for the anode bed consisting of solid Hi-Si-Cr-cast iron anode and
60mx5m (minimum) for the anode bed consisting of MMO tubular anode. Irrespective of the life of anode bed or anode bed resistance worked out by the design calculations, each anode bed should contain minimum 20 No. solid Hi-Si-Cr-cast iron anode (51mm dia.X1524mm long, 20 kg weight) or 10 No. MMO tubular anode (25mm dia.X1000mm long). In case design calculations based on soil resistivity of the anode bed or the life of anode bed or anode bed resistance worked out to be of higher plot size or higher No. of anodes than the minimum requirement specified above, the same need to be considered.

b) Anode lead cable in between each cast iron anode or MMO tubular anode and AJB for shallow depth horizontal anode bed shall be PVDF insulated and HMWPE sheathed cable, 7 strands, 10mm² stranded copper conductor, single core, unarmoured cable, with a double insulation system. The primary insulation shall be 0.04 inch thick poly vinyl dyne fluoride (PVDF) 1100 Volt grade. The secondary insulation shall be 0.065 inch thick high molecular weight poly ethylene (HMWPE) sheathing jacket over the primary insulation, in place of 1x10 sq.mm PVC insulated and sheathed cable mentioned in spec.6-51-0029.

c) Specific approval need to be taken from OWNER/EIL by the CP vendor for installation of deep/semi-deep anode bed with the supporting bore-log data for the soil strata / permanent water table depth and the soil resistivity values taken both by soil box method and using Wenner's 4-pin method up to 50m depth. In case deep/semi-deep well anode bed with MMO tubular single string anode with single dead weight is accepted by EIL/OWNER, minimum 10 No. MMO tubular anode (25mm dia.X1000mm long) need to be considered in the anode string, anode lead cable shall be 1x50 sq.mm EPR/CSPE insulated cable or PVDF insulated and HMWPE sheathed cable. In case deep/semi-deep well anode bed with MMO tubular multiple string anode with dead weight for each string is accepted by EIL/OWNER, minimum 10 No. MMO tubular anode (25mm dia.X1000mm long) need to be considered, one in each anode string, anode lead cable shall be 1x10 sq.mm EPR/CSPE insulated cable or PVDF insulated and HMWPE sheathed cable between each anode and AJB. Minimum depth of deep/semi-deep well anode bed shall be 50m & minimum diameter of anode bed shall be 250mm. For installation of the anodes in the permanent water table, higher than 50m (minimum) depth specified above need to be considered in case the permanent water table is at lower depth. In case design calculations based on soil resistivity of the anode bed or the life of anode bed or anode bed resistance worked out to be of higher depth or higher No. of anodes than the minimum requirement specified above, the same need to be considered.

d) Anode ground bed resistance should be ideally 1 ohm (max) as mentioned in spec.6-51-0028. However, in case of very high soil resistivity at anode ground bed location, the upper acceptance limit of anode bed resistance may be increased at the sole discretion of EIL/OWNER.
e) Current measurement test station needs to be installed at all the intermediate CP Station for measurement of the upstream and downstream pipeline current as well as coating resistance. The current measurement test station needs to be installed also at the beginning and end CP Station for measurement of the upstream or downstream (one leg only) pipeline current as well as coating resistance.

f) In case anode ground bed for foreign pipeline is existing within 100m of the proposed pipeline ROW and cause interference to proposed pipeline, CP CONTRACTOR need to relocate the anode bed with the consent of the OWNER of the foreign pipeline.

g) Each CPPSM/CPTR units shall have GPS synchronised current interrupter with 0-999 second programmable timer and antenna for synchronised current interruption.

h) For observing various parameters/indications without opening the door, the transparent glass cover shall be provided at each CPPSM/CPTR units.

i) Necessary measures shall be adopted to mitigate the stray current interference due to crossings of high tension line, electrified railway track, existing pipeline in the close vicinity etc. by providing sacrificial anodes, grounding cells, diodes etc.

j) Surge diverter across insulation joints shall be solid state type.

k) Minimum distance between the horizontal shallow depth or vertical deep/semi-deep anode ground bed and the pipeline to be protected shall be considered 100m. In case design calculations based on soil resistivity of the anode bed and anode bed current indicates that remoteness of the anode bed shall be more than 100m, the same need to be considered.

l) Two permanent reference cells need to be installed on 48" line at each of the 13 No. existing CP Stations, three permanent reference cells on 36" line & two permanent reference cells on 48" line need to be installed at new intermediate CP Station cum pigging station (IP1), for monitoring and control of CP System through CPPSM/CPTR as well as SCADA/RTU.

m) Supply and installation of the power supply cable from switch fuse unit/ MCC /PDB of OWNER’S Electrical substation to CPPSM located at Intermediate SV cum CP station IP-1 shall be CP CONTRACTOR’s scope of work.

S. Operation philosophy for combined CP System of existing 36" line and new 48" line:
Common power source shall be considered for CP System of both the existing 36” line and new 48” line. One each new anode ground bed shall be installed at all existing CP Stations of 36” line and at new CP Station at (IP-1). Since existing anode ground bed shall be dismantled at Vijaipur dispatch terminal CP station, only 12 No. CP Stations shall be operating with two anode ground bed each when CP Station at (IP-1) & Vijaipur dispatch terminal shall be operating with one anode ground bed each (though 2 No. Anode bed shall be installed at Vijaipur CP Station, only one anode bed out of the two shall be used for the 48” & 36” pipeline). Positive header cable from the AJB of new anode ground bed shall be terminated to the Positive terminal of common CPPSM/CPTR where existing anode ground bed is already connected at 12 number existing CP Stations, so that both anode beds at each 12 number existing CP Station can work in parallel. Similarly Negative header cable from the CJB of the 48” line & 36” line shall be connected to the common Negative terminal of CPPSM/CPTR at all the 14 number CP Stations (13 existing and one new), so that separate drainage connections are made to each pipeline from the common CPPSM/CPTR at each CP Station. In addition to the separate drainage connections at each CP Station stated above, direct/resistance bonding connections shall also be made between the two pipelines at the test stations along the pipeline route at an average interval 1Km and at additional locations where ever required to minimise interference between the two lines. Out of the existing three permanent reference cell connections at CPPSM/CPTR from the existing 36” line at each CP Station, one permanent reference cell connection shall be removed and shall be replaced by one permanent reference cell connection from the new 48” line, so that each common CPPSM/CPTR at each CP Station can get feedback from both the 36” line & 48” line for control of CP System current. Operating current of each CP Stations shall be shared by each anode ground bed (where 2 anode beds shall operate in parallel) according to their resistance and each 36” / 48” pipe line according to their coating conductance. Due to such current sharing the PSP level of any one of the pipelines may become higher than the other. To minimize this PSP level difference between 36” / 48” pipe line, the max current limit settings and the target PSP settings at each CPPSM/CPTR at each CP Station need to be adjusted in such a manner so that entire length of both the pipeline is adequately protected without overprotecting any one of the pipelines.

Note :- For computerized test station : Interval of data acquisition/storing may be kept for once in every hour. This feature will be helpful for detecting/trouble shooting in case of encountering any interference. However in normal case, one reading per day is enough.

10. Special requirements for SCADA input:-
(a) Digital and analogue monitoring and control signals to SCADA which are available from the existing CPTR and CPPSM as well as which are required from the new 48” pipeline are as follows:
(I) **Name of station** : Vijaipur dispatch terminal CP station, Intermediate SV cum CP stations (SV-2, SV-4, SV-5, SV-8, SV-9, SV-11, SV-13 and SV-15), intermediate pigging station (IP4), existing CP Station at BURDHA (Chainage 170.00 KM), receipt terminal at Dadri (Chainage 497.79 KM)

### Signal list

<table>
<thead>
<tr>
<th>S. No.</th>
<th>DESCRIPTION</th>
<th>MONITORING (M) / CONTROL (C)</th>
<th>DIGITAL (D) / ANALOGUE (A)</th>
<th>NO. OF SIGNALS</th>
<th>TAG NO.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>CPPSM/CPTR OUT PUT VOLTAGE</td>
<td>M</td>
<td>AI</td>
<td>1(EXISTING)</td>
<td>CPPSM-V</td>
</tr>
<tr>
<td>2</td>
<td>CPPSM OUT PUT CURRENT</td>
<td>M</td>
<td>AI</td>
<td>1(EXISTING)</td>
<td>CPPSM-A</td>
</tr>
<tr>
<td>3</td>
<td>PIPE TO SOIL POTENTIAL</td>
<td>M</td>
<td>AI</td>
<td>1(EXISTING)</td>
<td>PSP</td>
</tr>
<tr>
<td>4</td>
<td>PIPELINE OVER PROTECTED</td>
<td>M</td>
<td>DI</td>
<td>1(EXISTING)</td>
<td>PL-OV</td>
</tr>
<tr>
<td>5</td>
<td>PIPELINE UNDER PROTECTED</td>
<td>M</td>
<td>DI</td>
<td>1(EXISTING)</td>
<td>PL-UV</td>
</tr>
<tr>
<td>6</td>
<td>ALL REFERENCE CELLS FAILED</td>
<td>M</td>
<td>DI</td>
<td>1(EXISTING)</td>
<td>REFC-F</td>
</tr>
<tr>
<td>7a</td>
<td>36” LINE REFERENCE CELL-1 VOLTAGE</td>
<td>M</td>
<td>AI</td>
<td>1(EXISTING)</td>
<td>REFC1-V</td>
</tr>
<tr>
<td>7b</td>
<td>36” LINE REFERENCE CELL-2 VOLTAGE</td>
<td>M</td>
<td>AI</td>
<td>1(EXISTING)</td>
<td>REFC2-V</td>
</tr>
<tr>
<td>7c</td>
<td>36” LINE REFERENCE CELL-3 VOLTAGE</td>
<td>M</td>
<td>AI</td>
<td>1(EXISTING)</td>
<td>REFC3-V</td>
</tr>
<tr>
<td>7d</td>
<td>48” LINE REFERENCE CELL-4 VOLTAGE</td>
<td>M</td>
<td>AI</td>
<td>1(CONTRACTOR TO PROVIDE)</td>
<td>REFC4-V</td>
</tr>
<tr>
<td>7e</td>
<td>48” LINE REFERENCE CELL-5 VOLTAGE</td>
<td>M</td>
<td>AI</td>
<td>1(CONTRACTOR TO PROVIDE)</td>
<td>REFC5-V</td>
</tr>
<tr>
<td>8</td>
<td>CPPSM IN AUTO MODE</td>
<td>M</td>
<td>DI</td>
<td>1(EXISTING)</td>
<td>CPPSM-AU</td>
</tr>
<tr>
<td>9</td>
<td>CURRENT INTERRUPTER START</td>
<td>C</td>
<td>DO</td>
<td>1(EXISTING)</td>
<td>CI-ST</td>
</tr>
<tr>
<td>10</td>
<td>CURRENT INTERRUPTER STOP</td>
<td>C</td>
<td>DO</td>
<td>1(EXISTING)</td>
<td>CI-STP</td>
</tr>
<tr>
<td>11</td>
<td>CURRENT INTERRUPTER RESET</td>
<td>C</td>
<td>DO</td>
<td>1(EXISTING)</td>
<td>CI-RST</td>
</tr>
</tbody>
</table>

(II) **NAME OF STATION**: CP STATION at (IP-1& IP-3)

### Signal List

<table>
<thead>
<tr>
<th>S. No.</th>
<th>DESCRIPTION</th>
<th>MONITORING (M) / CONTROL (C)</th>
<th>DIGITAL (D) / ANALOGUE (A)</th>
<th>NO. OF SIGNALS</th>
<th>TAG NO.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>CPPSM OUT PUT VOLTAGE</td>
<td>M</td>
<td>AI</td>
<td>1(CONTRACTOR TO PROVIDE)</td>
<td>CPTR-V</td>
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<tr>
<td>S. No.</td>
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<td>DIGITAL (D) / ANALOGUE (A)</td>
<td>NO. OF SIGNALS (PROVIDE)</td>
<td>TAG NO.</td>
</tr>
<tr>
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<td>-------------</td>
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<td>-----------------------------</td>
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</tr>
<tr>
<td>2</td>
<td>CPPSM OUT PUT CURRENT</td>
<td>M</td>
<td>AI</td>
<td>1 (CONTRACTOR TO PROVIDE)</td>
<td>CPTR-A</td>
</tr>
<tr>
<td>3</td>
<td>PIPE TO SOIL POTENTIAL</td>
<td>M</td>
<td>AI</td>
<td>1 (CONTRACTOR TO PROVIDE)</td>
<td>PSP</td>
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<tr>
<td>4</td>
<td>PIPELINE OVER PROTECTED</td>
<td>M</td>
<td>DI</td>
<td>1 (CONTRACTOR TO PROVIDE)</td>
<td>PL-OV</td>
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<td>5</td>
<td>PIPELINE UNDER PROTECTED</td>
<td>M</td>
<td>DI</td>
<td>1 (CONTRACTOR TO PROVIDE)</td>
<td>PL-UV</td>
</tr>
<tr>
<td>6</td>
<td>ALL REFERENCE CELLS FAILED</td>
<td>M</td>
<td>DI</td>
<td>1 (CONTRACTOR TO PROVIDE)</td>
<td>REFC-F</td>
</tr>
<tr>
<td>7a</td>
<td>36&quot; LINE REFERENCE CELL-1 VOLTAGE</td>
<td>M</td>
<td>AI</td>
<td>1 (CONTRACTOR TO PROVIDE)</td>
<td>REFC1-V</td>
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<tr>
<td>7b</td>
<td>36&quot; LINE REFERENCE CELL-2 VOLTAGE</td>
<td>M</td>
<td>AI</td>
<td>1 (CONTRACTOR TO PROVIDE)</td>
<td>REFC2-V</td>
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<td>7c</td>
<td>36&quot; LINE REFERENCE CELL-3 VOLTAGE</td>
<td>M</td>
<td>AI</td>
<td>1 (CONTRACTOR TO PROVIDE)</td>
<td>REFC3-V</td>
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<tr>
<td>7d</td>
<td>48&quot; LINE REFERENCE CELL-4 VOLTAGE</td>
<td>M</td>
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<td>1 (CONTRACTOR TO PROVIDE)</td>
<td>REFC4-V</td>
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<tr>
<td>7e</td>
<td>48&quot; LINE REFERENCE CELL-5 VOLTAGE</td>
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<td>CPTR-AU</td>
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<td>9</td>
<td>CURRENT INTERRUPTER START</td>
<td>C</td>
<td>DO</td>
<td>1 (CONTRACTOR TO PROVIDE)</td>
<td>CI-ST</td>
</tr>
<tr>
<td>10</td>
<td>CURRENT INTERRUPTER STOP</td>
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<td>DO</td>
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<td>CI-STP</td>
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<td>11</td>
<td>CURRENT INTERRUPTER RESET</td>
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<td>DESCRIPTION</td>
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<td>DIGITAL (D) / ANALOGUE (A)</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>PROVIDE</td>
</tr>
</tbody>
</table>

**Legend:**

1. **AI**: Analogue monitoring signal from Equipment to PLC/Telemetry interface cabinet (TIC)
2. **AO**: Analogue control signal from PLC/(TIC) to Equipment
3. **DI**: Digital Monitoring signal from Equipment to PLC/(TIC)
4. **DO**: Digital control signal from PLC/(TIC) to Equipment

**Notes:**

1. For any control signal the signal shall be available from SCADA for less than 2 seconds only.
2. The rating of the potential free contact for digital input and output signals from Equipment/ PLC/RTU shall be 24 V DC, 1.5 A DC. Analogue signals shall be 4-20 mA, galvanically isolated.
GAIL (INDIA) LIMITED

VIJAYPUR – DADRI – BAWANA PIPELINE PROJECT
(VIJAIPUR-DADRI SECTION)

VENDOR LIST
FOR
CP SYSTEM
(SMMS)

<table>
<thead>
<tr>
<th>Rev. No</th>
<th>Date</th>
<th>Purpose</th>
<th>Prepared by</th>
<th>Checked by</th>
<th>Approved by</th>
</tr>
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<td>31.07.2008</td>
<td>ISSUED WITH TENDER</td>
<td></td>
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</tbody>
</table>
A) RECOMMENDED LIST OF SUB-CONTRACTORS FOR CATHODIC PROTECTION SYSTEM WORKS

1. As per BQC

B) RECOMMENDED LIST OF MATERIAL/EQUIPMENT VENDORS FOR CATHODIC PROTECTION SYSTEM WORKS

1.0 MIXED METAL OXIDE ANODES

- M/S TITANOR COMPONENTS LTD., GOA, INDIA
- M/S ORANZIO DE NORA, ITALY
- M/S MAGNETOCHEMIE, HOLLAND
- M/S ACTEL LTD., U.K.
- M/S ELTECH SYSTEMS CORPORATION, USA
- M/S CERANODE TECHNOLOGIES, USA
- M/S MATCOR (USA) or equivalent

2.0 Hi-Si-Cr-Cast iron Anode

- M/S Metal Founder, Mumbai
- M/S Durichlor 51 solid rod cast iron anode

3.0 TRANSFORMER- RECTIFIER UNITS & CPPSM

- A) M/S Raychem RPG Ltd. (CANARA ELECTRIC), Mumbai
- B) Kristron Systems, Lower Parel, Mumbai.
- C) HOCKWAY, UK
- D) Good-All Electric, USA.

4.0 JUNCTION BOXES (CLASSIFIED TYPE)

- A) FLAME PROOF EQUIPMENT PVT. LTD. (FEPL), BOMBAY
- B) BALIGA LIGHTING, CHENNAI
- C) CEAG FLAME PROOF CONTROL GEARS, BOMBAY
- D) FLEXPRO ELECTRICALS, NAVSARI, GUJARAT

5.0 CABLES

- A) VICTOR CABLES
- B) FORT GLOSTER CABLES
- C) UNIVERSAL CABLES
- D) NETCO CABLE
- E) FINOLEX CABLES
- F) ASIAN CABLES
- G) RADIANT CABLES
6.0 PERMANENT REFERENCE ELECTRODES
A) PERMACELL/HARCO (USA)
B) BORIN MANUFACTURER, USA
C) M.C.MILLER, USA
D) CORRTECH (ZULU)

7.0 MCCB/MCB FOR POWER DISTRIBUTION BOARD
A) SIEMENS
B) L&T
C) MERLIN GERIN
D) MDS
E) INDO ASIAN
F) AEG
G) HAGER
H) HAVELL’S,
I) ABB
J) SCHNEIDER ELECTRIC INDIA PVT.LTD

8.0 HEAT SHRINK CAP FOR ANODE TO CABLE JOINT
A) M/S RAYCHEM, USA
B) M/S MATCOR (USA)

9.0 SURGE DIVERTOR - EXD
A. M/S DEHN
B. M/S. CORRPRO SYSTEMS
C. M/S SOHNE
D. M/S OBO

10. SOLID STATE POLARISTATION CELL
A) M/S DAIRYLAND
B) M/S. CORRPRO SYSTEMS

11. ANODE BACKFILL MATERIAL
M/S LoreSCO, USA
M/S Goa Carbon (Goa),
M/S India Carbon (Calcutta),
M/S Petrocarbon & Chemical Company (Haldia)

12. THERMIT WELDS
M/S ERICO, USA
M/S THERMOWELD, USA

13. PINBRAZING
M/S SAFE TRACK

M/S BAC, UK

14  MAGNESIUM & ZINC ANODES

M/S Impalloy International
M/S Corrpro International
M/S HOCKWAY, UK
M/S NAKABOHTEC, Japan
M/S Nippon Corrosion, Japan
M/S AFIC, KSA
M/S Wilson Walton International
M/S XIANG METAL, CHINA
M/S SHUNRUI, CHINA
M/S Platt Bros. and Company, USA
M/S YUXI, CHINA

15  ER- PROBE

M/S ROSE CORROSION SERVICES, UK
M/ S METAL SAMPLES, USA
M/ S ROHARBAK COSASCO, USA
M/ S CAPROCO, UK

C)  RECOMMENDED LIST OF SPECIALIST AGENCIES FOR DOING INTERFERENCE SURVEY AND IMPLEMENTING MITIGATION MEASURES AGAINST INTERFERENCE FOR CP SYSTEM OR HIGH INDUCED VOLTAGE IN PIPELINE DUE TO PROXIMITY OF HT LINES NEAR PIPELINE.

M/S PLE, GERMANY
M/ S VENDER VELDE, HOLLAND
M/S SSS, GERMANY
M/S SSS, INDIA
M/S NIPPON CORROSION, JAPAN
M/S IACS, UK
DATA SHEET - SACRIFICIAL ANODE CATHODIC PROTECTION SYSTEM FOR PIPELINES
DATA SHEET-
SACRIFICIAL ANODE CATHODIC PROTECTION SYSTEM FOR PIPELINES
PART I
(PURCHASER SPECIFIED DATA)

1.0 Type of coating for the pipelines : Coal tar enamel with 3 coat, 2 wrap / Fibre bonded epoxy / 3 Layer Polyethylene

2.0 Type of CP system : Permanent / Temporary using sacrificial anodes

3.0 Design life of protection :
- Temporary CP system : 1 Year or till commissioning of PCP, whichever is later

4.0 Design protection current density : As per specification no. 6-51-0027,Rev-2

5.0 Corrosion survey data : Enclosed / Corrosion survey shall be conducted by contractor

6.0 Type of sacrificial anode : Zinc / Magnesium low potential type (1.55V) / magnesium high potential type (1.75V) (To be selected by CP contractor based on the requirements of specification)

7.0 Electrical Resistance Probes : Shall be provided for marshy areas and water logged areas / Not required.

7.1 Quantity of E/R Probes :

<table>
<thead>
<tr>
<th>S.NO.</th>
<th>SPREAD NUMBER</th>
<th>QUANTITY OF E/R PROBES</th>
<th>REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>Section-A</td>
<td>2 nos.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Quantity indicated here in is tentative only. Contractor shall quote unit rates for E/R probes for addition/deletion purpose in future.</td>
</tr>
<tr>
<td>B.</td>
<td>Section-B</td>
<td>2 no.</td>
<td></td>
</tr>
<tr>
<td>C.</td>
<td>Section-C</td>
<td>2 no.</td>
<td></td>
</tr>
</tbody>
</table>

7.2 No. of E/R probe reading instrument: 3 No. (1 no. per Section)

8.0 Polarisation coupons : Required (by TCP contractor)
8.1 Size of exposed area of coupon : 100mm x 100mm / 

8.2 No. of coupons : To be decided by the TCP contractor as per specification requirement & in consultation with OWNER/CONSULTANT 

8.3 No. of magnets for operation of magnetic reed switch : To be decided by the TCP contractor as per specification requirement & in consultation with OWNER/CONSULTANT 

9.0 Close interval ‘ON’/’OFF’ potential: Shall not be carried out during TCP / need not be carried out. But at DC interference prone areas and high induced voltage areas such as EHV/HV transmission lines (11KV & above) crossing/running in parallel / foreign pipeline either crossing. Readings shall be taken using data logger at 24 hours or at hourly interval for suitable amount of time. 

10.0 Additional tests to be conducted : Pearson survey / DCVG survey / Not required for identifying pipe coating defects/during TCP holidays 

11.0 Indicative Design data for sacrificial anodes ground bed (see note ‘v’ below) 

11.1 To be decided by CP contractor 

<table>
<thead>
<tr>
<th>S.No</th>
<th>Chainage From KM</th>
<th>Chainage To KM</th>
<th>Pipeline Dia M</th>
<th>Pipeline Wall thickness mm</th>
<th>Type of coating</th>
<th>Anode material Zinc / Magnesium</th>
<th>Anode type Solid/Ribbon</th>
<th>Anode ground bed spacing</th>
<th>No. of anodes per ground bed Nos.</th>
</tr>
</thead>
</table>
11.2. Details of anodes (By CP Contractor)
- Type : Zinc                        Magnesium
- Net weight : _ _ _ Kg             _ _ _ Kg
- Size :
  - Bare : _ _ x _ _ x _ _ mm. min.   _ _ x _ _ x _ _ mm. Min.
  - Prepacked : _ _ x _ _ x _ _ mm. min.  _ _ x _ _ x _ _ mm. Min.

11.3. Type of anode installation : Horizontal / Vertical

11.4. Distance between individual anodes : _ _ _ M

11.5. Distance between centre line : 5000 mm min. for magnesium anodes / of pipeline and first anode 2000 mm min. for zinc anodes

11.6. Distance between edge of Pipeline and magnesium ribbon anode. : 500 mm min

Notes:

i. Where sacrificial anode system is specified as temporary cathodic protection system, unless otherwise specified, monitoring of the sacrificial anode cathodic protection system till the commissioning of permanent C.P. system shall be carried out by TCP contractor.
ii. In cases where sacrificial anode CP system is specified as temporary and where both temporary, permanent cathodic protection works are being executed by the same agency, activities of permanent CP system which are common to temporary C.P. system shall be completed as part of temporary C.P. system. In cases where temporary and permanent cathodic protection works are being executed by different agencies, the contractual scope of work shall be referred for further details.

iii. All civil works associated with the complete cathodic protection system are included in the scope of Contractor. This shall include providing cable trenches and foundations for all equipment, all test stations, etc.

iv. Contractor shall supply (as optional item see item 7 of SOW) all instruments, tools and tackles necessary for proper operation and maintenance of complete cathodic protection system and associated equipment.

v) The design data for anode ground beds and anodes shall be decided by TCP contractor depending on the protection current requirement of the pipeline as laid. Contractor shall quote for TCP system on lump sum basis.

vi) Contractor shall fill up all the data asked for in the ‘Data sheet sacrificial anode cathodic protection system for pipelines, part-II (to be filled in by the contractor)’ and submit the same for EIL’s review.

vii) List of acceptable vendors: (Refer elsewhere)

The make of equipment, materials shall be as per vendor list vide attachment No. 6921-060-06-45-VN-01
DATA SHEET
SACRIFICIAL ANODE CATHODIC PROTECTION SYSTEM FOR PIPELINES
PART-II
(TO BE FILLED IN BY THE VENDOR)

1.0 E/R probes
1.1 Make and model no. of E/R probes :
1.2 Material of E/R probes :
1.3 size of the exposed area of the probe :
1.4 Make and model no. of E/R probe reading instrument :

2.0 Permanent reference electrodes
2.1 Type :
2.2 Make & model no. :
2.3 Design life of electrode under burial : ____ Years
Condition

3.0 Polarisation cells
3.1 Type :
3.2 Make & model no. :
3.3 Maximum DC leakage current at 40°C at:
   - 1V DC across the Polarisation cell : ___ mA
   - 1.5V DC across the Polarisation cell: ___ mA
   - 2.0V DC across the Polarisation cell: ___ mA
3.4 50 Hz AC current rating at 40°C
3.5 No. of operations over life time under maximum ratings: \(\_\_\_\_\_\_\_\_\text{Nos.}\)

4.0 Polarisation Coupons

4.1 Exposed size of metal:

4.2 Metal type:

4.3 Make and model no. of reed switch:

4.4 Make and model no. of reed switch operator magnet:

4.5 Rating of reed switch

4.5.1 Continuous current rating: \(\_\_\_\_\_\_\text{A DC, at} \_\_\_\_\_\_\text{V DC}\)

4.5.2 Breaking current: \(\_\_\_\_\_\_\text{A DC, at} \_\_\_\_\_\_\text{V DC}\)

5.0 Surge Diverters

5.1 Type:

5.2 Ratings:

5.2.1 Current, 8/20 micro second wave:

5.2.2 AC spark over voltage 50 Hz AC:

   - Impulse(1.2/50 micro second):

6.0 Cables

6.1 Type:

6.2 Voltage grade:

6.3 Make:

7.0 Cable to pipe connection
7.1 Make and model number of Cad weld Material:

- Pin brazing equipment:

8.0 Details of anodes

8.1 Prepacked type

- Anode material: Zinc Magnesium
- Net weight: ___ Kg min. ___ Kg min.
- Size:
  - Bare: ___ x ___ x ___ mm. min. ___ x ___ x ___ mm. Min.
  - Prepacked: ___ x ___ x ___ mm. min. ___ x ___ x ___ mm. Min.
- Make: ___

8.2 Ribbon type

- Anode material: Zinc Magnesium
- Net weight: ___ Kg min per metre ___ Kg min per metre
- Size: ___ x ___ x ___ mm. min ___ x ___ x ___ mm. min
- Make: ___

9.0 Makes

9.1 Test stations:

9.2 Special Backfill for sacrificial anodes:
**FORM-IA**

DETAILS OF SPECIFIC EXPERIENCE OF BIDDER / HIS NOMINATED SUB-CONTRACTOR FOR SACRIFICIAL ANODE CP SYSTEM (SEPARATE SHEETS SHALL BE FILLED UP FOR EACH JOB/PROJECT HANDLED)

Name of CP sub contractor:

<table>
<thead>
<tr>
<th>SL. NO.</th>
<th>DESCRIPTION (For Sacrificial anode CP System)</th>
<th>LENGTH OF PIPELINE</th>
<th>DIAMETER OF PIPELINE</th>
<th>TYPE OF PIPE COATING</th>
<th>TYPE OF ANODES</th>
<th>NO. OF ANODE GROUND BEDS FOR THE PIPELINE</th>
<th>NAME OF PROJECT AND OWNER</th>
<th>WORK ORDER NO. (**)</th>
<th>DATE OF COMMENCEMENT OF WORK</th>
<th>DATE OF COMPLETION OF WORK (**)</th>
<th>NAME OF BACK-UP AGENCY CONSIDERED</th>
<th>EXPERIENCE OF BACK-UP AGENCY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Design and engineering experience</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>2</td>
<td>Supply of CP equipment/material</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Installation of CP system</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>4</td>
<td>Testing and commissioning</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

* Strike out which ever is not applicable

** Copy of the work order and completion certificate shall be attached
## FORM-II

DETAILS OF SPECIFIC EXPERIENCE OF BIDDER / HIS NOMINATED SUB-CONTRACTOR FOR CP SYSTEM/ BACK UP AGENCY* FOR INTERFERENCE DETECTION AND MITIGATION (SEPARATE SHEET SHALL BE FILLED FOR EACH JOB/PROJECT HANDELED)

NAME OF THE SUB-CONTRACTOR FOR CP SYSTEM:
NAME OF THE BACKUP AGENCY FOR INTERFERENCE DETECTION & MITIGATION:

<table>
<thead>
<tr>
<th>SL. NO.</th>
<th>CAUSE OF INTERFERENCE</th>
<th>LENGTH OF PIPELINE</th>
<th>DIAMETER OF PIPELINE</th>
<th>TYPE OF PIPELINE COATING</th>
<th>NO. OF CP STATIONS FOR THE PIPELINE</th>
<th>NAME OF PROJECT AND OWNER</th>
<th>WORK ORDER NO. (**)</th>
<th>DATE OF COMMENCEMENT OF WORK (**)</th>
<th>DATE OF COMPLETION OF WORK (**)</th>
<th>DETAILS OF BACK-UP AGENCY, IF HIRED FOR CP INTERFERENCE/ MITIGATION</th>
<th>NAME OF AGENCY OF BACK UP AGENCY (***), EXPERIENCE OF WORK</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Cathodically protected foreign pipelines crossing/ parallel running</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Cathodically unprotected foreign pipelines/ structures crossing/ parallel running</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>High voltage line AC/DC (66KV and above) crossing &amp; parallel running</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>AC/DC electrified traction</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>5</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* STRIKE OUT WHICH EVER IS NOT APPLICABLE  
** COPY OF WORK ORDER AND COMPLETION CERTIFICATE SHALL BE ATTACHED  
*** LIST OF INTERFERENCE DETECTION, MITIGATION JOBS DONE ALONG WITH WORK ORDER AND COMPLETION CERTIFICATE SHALL BE ATTACHED
DATA SHEET -
IMPOSED CURRENT CATHODIC PROTECTION SYSTEM FOR PIPELINES

ENGINEERS INDIA LIMITED
NEW DELHI

PROJECT : VIJAYPUR-DADRI PIPELINE
CLIENT : M/s GAIL

DATA SHEET
6921-060-06-45-DS-02

Page 1 of 8
DATA SHEET

IMPRESSED CURRENT CATHODIC PROTECTION SYSTEM FOR PIPELINES

PART-I

(PURCHASER SPECIFIED DATA)

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0 Pipeline coating</td>
<td>3 layer Polyethylene coating</td>
</tr>
<tr>
<td>2.0 Type of CP system</td>
<td>Permanent / Temporary</td>
</tr>
<tr>
<td>3.0 Design life of protection</td>
<td>35 Yrs</td>
</tr>
<tr>
<td>4.0 Design protection current density</td>
<td>As per specification no. 6-51-0028, Rev-2.</td>
</tr>
<tr>
<td>5.0 Current drainage &amp; coating resistance measurement survey</td>
<td>Shall be carried out, in addition current measurement survey need to be conducted by CP contractor for assessment of current distribution on each leg of CP Station.</td>
</tr>
<tr>
<td>6.0 Corrosion survey data</td>
<td>Enclosed / Corrosion survey shall be conducted by CP contractor</td>
</tr>
<tr>
<td>7.0 Integration of permanent CP with Temporary CP</td>
<td>In the scope of the CP contractor / Not in the scope of the contractor</td>
</tr>
<tr>
<td>8.0 Type of Anodes for anode ground bed</td>
<td>Solid Hi-Si-Cr-cast iron / Tubular mixed metal oxide titanium</td>
</tr>
<tr>
<td>9.0 Electrical resistance probes (E/R Probes)</td>
<td>Shall be provided for marshy areas and water logged area as part of TCP activity</td>
</tr>
<tr>
<td>10.0 Computerised test stations</td>
<td>Required</td>
</tr>
<tr>
<td>10.1 No. of computerised test stations</td>
<td>6 No. (One per each Spread)</td>
</tr>
<tr>
<td>10.2 Data collection interval</td>
<td>Hourly or once every 24 hours interval</td>
</tr>
<tr>
<td>10.3 No. of computerised test station readers/Data retrieval computer of portable type for data collection</td>
<td>Three No. (One per Section)</td>
</tr>
<tr>
<td>11.0 Polarisation coupons</td>
<td>Required / Not required Shall be provided as part of TCP activity</td>
</tr>
<tr>
<td>12. Surge diverter across insulation joints</td>
<td>To be provided in line with requirement of Cl.7.9.2 of spec.6-51-0028, Rev-2.</td>
</tr>
</tbody>
</table>
13. Grounding through Polarisation cells
   in conjunction with galvanic anodes:
   To be provided for each block valve & at HT line
   (66KV & above) crossings and at locations
   where the AC induced voltage 15V or more is observed,
   in line with Cl.no.7.9.1 of spec.6-51-0028,Rev-2. The
   galvanic anode shall be of
   weight/size for design life of PCP system. The polarization
   cell shall be of electrolytic type of rating as per cl. No. 4.9 of
   spec. no. 6-51-0029,Rev-1.

14. Acquisition of land for:
   anode ground bed, anode junction
   boxes and anode ground bed cable
   laying
   By Contractor

15. Chain link fencing around the ground:
   Shall be provided / Shall not be provided
   bed.

16. Close interval potential logging survey:
   Shall be carried out

17. Additional tests to be conducted:
   Shall be carried out (Also refer Note (xiv)
   for identifying pipe coating defects/
   holidays

18. Interference detection & mitigation:
   Shall be done by Contractor for both 36” & 48” pipeline & as
   per Cl.no.10.0 of spec.no.6-51-0028,Rev-2.

19. Proposed location of CP stations/anode ground beds:

<table>
<thead>
<tr>
<th>S. No</th>
<th>C.P. station No.</th>
<th>Proposed location of CP station</th>
<th>Rating of anode ground bed</th>
<th>Type of CP Power supply unit - CPTR unit/CPPSM</th>
<th>Rating of CPPSM/CPTR unit V/A DC</th>
<th>Type of installation-Indoor/out door</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Vijaipur terminal</td>
<td>By Contractor</td>
<td>CPTR</td>
<td>By Contractor</td>
<td>Existing</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>SV-2</td>
<td>-DO-</td>
<td>CPPSM</td>
<td>-DO-</td>
<td>Existing</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>SV-4</td>
<td>-DO-</td>
<td>CPPSM</td>
<td>-DO-</td>
<td>Existing</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>SV-5</td>
<td>-DO-</td>
<td>CPPSM</td>
<td>-DO-</td>
<td>Existing</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>BURDHA (CH 170)</td>
<td>-DO-</td>
<td>CPPSM</td>
<td>-DO-</td>
<td>Existing</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>SV-8</td>
<td>-DO-</td>
<td>CPPSM</td>
<td>-DO-</td>
<td>Existing</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>SV-9</td>
<td>-DO-</td>
<td>CPPSM</td>
<td>-DO-</td>
<td>Existing</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>SV-11</td>
<td>-DO-</td>
<td>CPPSM</td>
<td>-DO-</td>
<td>Existing</td>
<td></td>
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<tr>
<td>9</td>
<td>SV-13</td>
<td>-DO-</td>
<td>CPPSM</td>
<td>-DO-</td>
<td>Existing</td>
<td></td>
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<tr>
<td>10</td>
<td>SV-15</td>
<td>-DO-</td>
<td>CPPSM</td>
<td>-DO-</td>
<td>Existing</td>
<td></td>
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<tr>
<td>11</td>
<td>IP 1</td>
<td>-DO-</td>
<td>CPPSM</td>
<td>-DO-</td>
<td>Indoor to be provided</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>IP 3</td>
<td>-DO-</td>
<td>CPPSM</td>
<td>-DO-</td>
<td>Existing to be replaced</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>IP 4</td>
<td>-DO-</td>
<td>CPPSM</td>
<td>-DO-</td>
<td>Existing</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Dadri terminal</td>
<td>-DO-</td>
<td>CPTR</td>
<td>-DO-</td>
<td>Existing</td>
<td></td>
</tr>
</tbody>
</table>
20. Proposed location of E/R probes / Computerised test stations / Polarisation coupons:

Location/quantity of E/R probes, Computerised test stations, Polarization coupons shall be decided by CP sub contractor as per specification requirement and in consultation with Owner/EIL during detail engineering.

<table>
<thead>
<tr>
<th>S.No</th>
<th>Locations of ER probes</th>
<th>Locations of Computerised test stations</th>
<th>Locations of polarisation coupons</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes:

i) Unless otherwise specified in project specifications/data sheet, integration of the permanent impressed current CP system with the sacrificial anode temporary CP system (whether provided by a different contractor or included along with the impressed current CP system) shall be the responsibility of the impressed current CP contractor whose scope shall include disconnection of sacrificial anodes wherever required.

ii) The permanent CP system includes certain activities, which are common with the temporary and permanent cathodic protection facilities. In cases where temporary and permanent cathodic protection works are being executed by the same agency, the common activities shall be completed as part of temporary cathodic protection system. In cases where temporary and permanent cathodic protection works are being executed by different agencies, the contractual scope of work shall be referred for further details.

iii) Obtaining approval certificate from electrical inspectorate for electrical installation and carrying out any modifications as per the requirement of electrical inspectorate shall be included in contractor scope.

iv) All civil works associated with the complete cathodic protection system are included in scope of Contractor. This shall include providing cable trenches and foundations for all equipment, kiosks, anode lead junction boxes, all test stations, deep well ground beds, etc.

v) Contractor shall supply (as optional item see item 7 of SOW) all instruments, tools and tackles necessary for proper operation and maintenance of complete cathodic protection system and associated equipment.
vi) Contractor shall clearly bring out during bidding stage, the requirement of additional CP stations/higher rated ground bed, if any, over and above those specified in clause 19 above.

vii) Vendor shall fill up all the data asked for in the ‘Data sheet Impressed current cathodic protection system for pipelines, part II (to be filled in by the vendor)’ and submit the same for EIL’s review.

viii) Necessary coordination with pipeline laying contractor shall also be in the scope of CP contractor.

x) Reference signal cables coming from permanent reference cells and pipeline shall be 1-pair X 2.5 MM\(^2\) and shall be laid in a separate cable trench. These cables shall not be laid in cable trench for power/anode/cathode cables.

xi) The maker of equipment, materials shall be as per vendor list vide attachment No. 6921-060-06-45-VN-01

xii) For specific requirements, refer clause no. 11.0 of Design Basis document no. 6921-060-06-45-DB-01.

xiii) Anode Ground Bed shall preferably be horizontal type, however type of anode ground bed finally selected shall be as per soil resistivity data by CP sub-contractor.

xiv) CAT survey with ‘A’ frame shall be carried out at a regular interval of 250 meters along the route of pipeline where abnormality found during CPL survey, to identify coating defects/holidays. Where signal loss observed is higher, reading shall be taken at close intervals as per the direction of Engineer-in-Charge. DCVG survey shall be carried out to pin point the coating defect/holiday wherever signal loss is greater than 2db/unit distance and complete report shall be submitted to Owner/EIL for further action.

21.0 LIST OF ATTACHMENTS (Refer elsewhere)

For List of attachment, refer document no. 6921-060-06-45-LL-01 attached elsewhere in this tender document
DATA SHEET
IMPRESSED CURRENT CATHODIC PROTECTION SYSTEM FOR PIPELINES
PART-II
(TO BE FILLED IN BY THE VENDOR)

1.0 E/R probes
1.1 Make and model no. of E/R probe :
1.2 Material of E/R probe :
1.3 Size of the exposed area of the probe :
1.4 Make and model no. of E/R probe reading instrument :

2.0 Permanent reference electrodes
2.1 Make & model no. :
2.2 Design life of electrode under burial : _ _ _ Years condition.

3.0 Polarisation cells
3.1 Type :
3.2 Make & model no. :
3.3 Maximum DC leakage current at 40\(^\circ\) C at
   - 1V DC across the Polarisation cell : _ _ _ mA
   - 1.5V DC across the Polarisation cell: _ _ _ mA
   - 2.0V DC across the Polarisation cell: _ _ _ mA
3.4 50 Hz AC current rating at 40\(^\circ\) C
   - Continuous : _ _ _ A
   - Short time : _ _ _ KA for _ _ _ sec
3.5 Rated no. of operations over life time
   under maximum ratings : _ _ _ Nos.

4.0 Polarisation Coupons
4.1 Exposed area of metal :
4.2 Metal type :
4.3 Make and model no. of reed switch : 

VENDOR : 
SIGNATURE: 
DATE : 
PROJECT : VIJAIPUR-DADRI PIPELINE
CLIENT : M/s GAIL

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4.4 Make and model no. of reed switch: operator magnet

4.5 Rating of reed switch:
- Continuous current rating: _ _ _ A DC, at _ _ _ V DC
- Breaking current: _ _ _ A DC, at _ _ _ V DC

5.0 Surge Diverters
5.1 Type:

5.2 Ratings:
5.2.1 Current, 8/20 micro second wave:

5.2.2 AC spark over voltage
- 50 Hz AC:
- Impulse(1.2/50 micro second):

5.3 Make:

6.0 Cables
6.1 Type and voltage grade
- For anode tail cables: _ _ _ / _ _ _ V
- For other CP cables: _ _ _ / _ _ _ V

6.2 Make
- For anode tail cables:
- For other CP cables:

7.0 Cable to pipe connection
- For charged pipeline:
- For non charged pipeline:

7.1 Make and model number of:
- Cad weld Material:
- Pin brazing equipment:

8.0 Anode type and make
8.1 Impressed current anodes
- Type:
- Make:
8.2. Sacrificial anodes make
- Zinc anodes
- Zinc ribbon anodes

9.0 Make of
9.1 CPTR unit

9.2 CPPSM

9.3 Test stations

9.4 Anode junction box

9.5 Cathode junction box

9.6 Calcined petroleum coke breeze

9.7 Permanent reference electrodes
- CuCuSO₄ type
- AgAgCl type

9.8 Special Backfill for sacrificial anodes:
GAIL (INDIA) LIMITED

VIJAYPUR – DADRI – BAWANA PIPELINE PROJECT
(VIJAIPUR-DADRI SECTION)

DATA SHEET FOR
CATHODIC PROTECTION TRANSFORMER RECTIFIER UNIT
(SMMS)

0 04.07.2008 ISSUED WITH TENDER

<table>
<thead>
<tr>
<th>Rev. No</th>
<th>Date</th>
<th>Purpose</th>
<th>Prepared by</th>
<th>Checked by</th>
<th>Approved by</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>04.07.2008</td>
<td></td>
<td></td>
<td></td>
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</tbody>
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## DATA SHEET

### CATHODIC PROTECTION TRANSFORMER RECTIFIER UNIT

**PART - I (TO BE FURNISHED BY PURCHASER)**

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Input power supply</td>
<td>240 V ± 10 %, 50 Hz ± 3 %, 1 Phase</td>
</tr>
<tr>
<td>2</td>
<td>Input power supply fault level</td>
<td>Refer elsewhere</td>
</tr>
<tr>
<td>3</td>
<td>Number of output circuits</td>
<td>One/two as required</td>
</tr>
<tr>
<td>4</td>
<td>Output voltage (+ve earthed)</td>
<td>0.5 V (min.) DC, 50V (max.) DC (see note 2)</td>
</tr>
<tr>
<td>5</td>
<td>Rated output current</td>
<td>50 A (see note 2)</td>
</tr>
<tr>
<td>6</td>
<td>Pipe to soil potential setting range (Vps)</td>
<td>-0.85V - to -2.5V</td>
</tr>
<tr>
<td>7</td>
<td>Minimum set potential range (Vrs)</td>
<td>-0.4V to -0.9V</td>
</tr>
<tr>
<td>8</td>
<td>Maximum pipeline potential range (Vpm)</td>
<td>-1.1V to -2.5V</td>
</tr>
<tr>
<td>9</td>
<td>Minimum pipeline potential range (Vpm)</td>
<td>-0.7V to -1.0V</td>
</tr>
<tr>
<td>10</td>
<td>Number of reference cells for control</td>
<td>Two /</td>
</tr>
<tr>
<td>11</td>
<td>Equipment design temperature (IS 9676)</td>
<td>45°C</td>
</tr>
<tr>
<td>12</td>
<td>Shade of final paint</td>
<td>Vendor Standard /</td>
</tr>
<tr>
<td>13</td>
<td>Commissioning at site</td>
<td>By Contractor</td>
</tr>
<tr>
<td>14</td>
<td>Remote monitoring and control</td>
<td>Required (Refer SCADA I/O elsewhere)</td>
</tr>
<tr>
<td>15</td>
<td>Type of Control</td>
<td>Close loop control with PSP of reference cells in feedback loop (as per clause no. 6.4 of spec. no. 6-51-0025).</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
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<tr>
<td>---</td>
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</tr>
<tr>
<td></td>
<td>- Manual</td>
<td>Constant voltage and constant current mode (CVCC) having regulated output voltage at set value of constant voltage and constant current with current limit features (as per clause 6.4 of spec. 651-0025).</td>
</tr>
<tr>
<td>16</td>
<td>Current Interrupter</td>
<td>Required</td>
</tr>
<tr>
<td>16.1</td>
<td>Type of current interrupter</td>
<td>Mounted in CPTR unit (GPS based timer interrupters for measuring OFF potentials shall be provided)</td>
</tr>
<tr>
<td>16.2</td>
<td>Interrupter controls (for start, stop, reset)</td>
<td>Auto (operation through SCADA) and Manual</td>
</tr>
<tr>
<td>17</td>
<td>Specific requirement (if any)</td>
<td></td>
</tr>
</tbody>
</table>

**NOTE:**

1. All Pipe to soil potentials (PSP) measured/set values specified are w.r.t. copper-copper sulphate half cell.
2. The output voltage, current ratings of CPTR units and their location along the ROW of the pipe line shall be as per contractor/vendor data in S.No.1 of Part II of the data sheet.
3. CPTR unit shall be provided with a door having transparent glass cover for viewing various parameters/indications without opening the door. The type of indicating lamps shall be minimum 10mm dia. LED type.
4. *Separate data shall be furnished for each rating of CPTR unit.*
### PART - II (TO BE FILLED BY CONTRACTOR/VENDOR)

1. Rating of each CPTR unit along R.O.W.

<table>
<thead>
<tr>
<th>S. No</th>
<th>Location along ROW</th>
<th>CPTR unit output rating</th>
<th>Installation in substation building/ in an outdoor kiosk</th>
<th>Size of inomer cable</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Voltage</td>
<td>Current</td>
<td></td>
</tr>
<tr>
<td></td>
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</tr>
</tbody>
</table>

2. Guaranteed technical particulars of CPTR unit.

<table>
<thead>
<tr>
<th></th>
<th>2.1 Efficiency</th>
<th>at 10 % load</th>
<th>*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>at 25 % load</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>at 50 % load</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>at 75 % load</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>at 100 % load</td>
<td>*</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>2.2 Voltage regulation (Manual mode)</th>
<th>* _______ %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>from zero to 100 % load variation and throughout the output voltage range (Refer clause 6.4.3 of spec. no. 6-51-0025)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>2.3 Current regulation (Manual mode)</th>
<th>* _______ %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>from 0.5 V to 100 % output voltage variation and throughout the output current range (Refer clause 6.4.3 of spec. no. 6-51-0025)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>2.4 Closed loop PSP regulation in auto mode (refer clause 6.4.3 of spec. no. 6-51-0025)</th>
<th>± _______ mV</th>
</tr>
</thead>
</table>
### 2.5 Output ripple at full load current:

<table>
<thead>
<tr>
<th>Voltage Level</th>
<th>Auto mode</th>
<th>Manual mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>At 10% output voltage</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>At 50% output voltage</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>At 100% output voltage</td>
<td>*</td>
<td>*</td>
</tr>
</tbody>
</table>

*(Refer clause 6.2.3 of spec. no. 6-51-0025)*

### 3. Technical particulars of Current interrupter

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>3.1 Type of interrupter</strong></td>
<td>Mounted with CPTR unit</td>
</tr>
<tr>
<td><strong>3.2 Power supply voltage</strong></td>
<td>*</td>
</tr>
<tr>
<td><strong>3.3 Detail of output Contractor</strong></td>
<td>*</td>
</tr>
<tr>
<td>Make</td>
<td>*</td>
</tr>
<tr>
<td>Current rating</td>
<td>* A, DC, suitable for the interruption duty.</td>
</tr>
<tr>
<td>Voltage rating of coil</td>
<td>* V, AC/DC suitable for the interruption duty.</td>
</tr>
<tr>
<td><strong>3.4 Timer Details</strong></td>
<td></td>
</tr>
<tr>
<td>Make</td>
<td>*</td>
</tr>
<tr>
<td>Timing range</td>
<td>On: 0.1 - 99.9 Sec</td>
</tr>
<tr>
<td></td>
<td>Off: 0.1 - 99.9 Sec</td>
</tr>
<tr>
<td>Timing Accuracy</td>
<td>*</td>
</tr>
</tbody>
</table>

* Separate data shall be furnished for each rating of CPTR unit.
GAIL (INDIA) LIMITED

VIJAYPUR – DADRI – BAWANA PIPELINE PROJECT
(VIJAIPUR-DADRI SECTION)

DATA SHEET FOR
CATHODIC PROTECTION POWER SUPPLY MODULE
(SMMS)

04.07.2008 ISSUED WITH TENDER

<table>
<thead>
<tr>
<th>Rev. No</th>
<th>Date</th>
<th>Purpose</th>
<th>Prepared by</th>
<th>Checked by</th>
<th>Approved by</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>04.07.2008</td>
<td>ISSUED WITH TENDER</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# DATA SHEET
CATHODIC PROTECTION POWER SUPPLY MODULE

## PART - I (TO BE FURNISHED BY PURCHASER)

<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Input power supply</td>
<td>(-)24VDC ±15%</td>
</tr>
<tr>
<td>2</td>
<td>Input power supply fault level</td>
<td>Refer elsewhere</td>
</tr>
<tr>
<td>3</td>
<td>Number of output circuits</td>
<td>One/two as required</td>
</tr>
<tr>
<td>4</td>
<td>Output voltage (+ve earthed)</td>
<td>0.5 V (min.) DC, 25V (max.) DC (see note 2)</td>
</tr>
<tr>
<td>5</td>
<td>Rated output current</td>
<td>25 A (see note 2)</td>
</tr>
<tr>
<td>6</td>
<td>Pipe to soil potential setting range (Vps)</td>
<td>-0.85V - to -2.5V</td>
</tr>
<tr>
<td>7</td>
<td>Minimum set potential range (Vrs)</td>
<td>-0.4V to -0.9V</td>
</tr>
<tr>
<td>8</td>
<td>Maximum pipeline potential range (Vpm)</td>
<td>-1.1V to-2.5V</td>
</tr>
<tr>
<td>9</td>
<td>Minimum pipeline potential range (Vpm)</td>
<td>-0.7V to -1.0V</td>
</tr>
<tr>
<td>10</td>
<td>Number of reference cells for control</td>
<td>Two /</td>
</tr>
<tr>
<td>11</td>
<td>Equipment design temperature (IS 9676)</td>
<td>45°C</td>
</tr>
<tr>
<td>12</td>
<td>Shade of final paint</td>
<td>Vendor Standard /</td>
</tr>
<tr>
<td>13</td>
<td>Commissioning at site</td>
<td>By Contractor</td>
</tr>
<tr>
<td>14</td>
<td>Remote monitoring and control</td>
<td>Required (Refer SCADA I/O elsewhere)</td>
</tr>
<tr>
<td>15</td>
<td>Type of Control</td>
<td>Close loop control with PSP of reference cells in feedback loop (as per clause no. 6.4 of spec. no. 6-51-0025).</td>
</tr>
</tbody>
</table>
### Manual

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>Current Interrupter</td>
<td>Required</td>
</tr>
<tr>
<td>16.1</td>
<td>Type of current interrupter</td>
<td>Mounted in CPPSM unit (GPS based timer interrupters for measuring OFF potentials shall be provided)</td>
</tr>
<tr>
<td>16.2</td>
<td>Interrupter controls (for start, stop, reset)</td>
<td>Auto (operation through SCADA) and Manual</td>
</tr>
<tr>
<td>17</td>
<td>Specific requirement (if any)</td>
<td></td>
</tr>
</tbody>
</table>

**NOTE:**

1. All Pipe to soil potentials (PSP) measured/set values specified are w.r.t. copper-copper sulphate half cell.
2. The output voltage, current ratings of CPPSM units and their location along the ROW of the pipe line shall be as per contractor/vendor data in S.No.1 of Part II of the data sheet.
3. CPPSM unit shall be provided with a door having transparent glass cover for viewing various parameters/indications without opening the door. The type of indicating lamps shall be minimum 10mm dia. LED type.
4. *Separate data shall be furnished for each rating of CPPSM unit.*
PART - II (TO BE FILLED BY CONTRACTOR/VENDOR)

1. Rating of each CPPSM unit along R.O.W.

<table>
<thead>
<tr>
<th>S. No</th>
<th>Location along ROW</th>
<th>CPPSM unit output rating</th>
<th>Installation in substation building/ in an outdoor kiosk</th>
<th>Size of inomer cable</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Voltage</td>
<td>Current</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2. Guaranteed technical particulars of CPPSM unit.

2.1 Efficiency

- at 10 % load *
- at 25 % load *
- at 50 % load *
- at 75 % load *
- at 100 % load *

2.2 Voltage regulation

(from zero to 100 % load variation and throughout the output voltage range (Refer clause 6.4.3 of spec. no. 6-51-0025)

(Manual mode) * __________ %

2.3 Current regulation

(from 0.5 V to 100 % output voltage variation and throughout the output current range (Refer clause 6.4.3 of spec. no. 6-51-0025)

(Manual mode) * __________ %

2.4 Closed loop PSP regulation in auto mode (refer clause 6.4.3 of spec. no. 6-51-0025)

± __________ mv
2.5 Output ripple at full load current:

<table>
<thead>
<tr>
<th></th>
<th>Auto mode</th>
<th>Manual mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>At 10% output voltage</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>At 50% output voltage</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>At 100% output voltage</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>(Refer clause 6.2.3 of spec. no. 6-51-0025)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3. Technical particulars of Current interrupter

3.1 Type of interrupter | Mounted with CPPSM unit

3.2 Power supply voltage | *

3.3 Detail of output Contractor

Make | *

Current rating | * A, DC, suitable for the interruption duty.
Voltage rating of coil | * V, AC/DC suitable for the interruption duty.

3.4 Timer Details

Make | *

Timing range

On | 0.1 - 99.9 Sec
Off | 0.1 - 99.9 Sec

Timing Accuracy | *

* Separate data shall be furnished for each rating of CPPSM unit.
कैथोडिक सुरक्षा पावर सप्लाई मॉड्यूल (सी.पी.पी.एस.एम) के लिए विनिर्देश

SPECIFICATION FOR CATHODIC PROTECTION POWER SUPPLY MODULE (CPPSM)
Abbreviations:

CPPSM : Cathodic protection power supply module
MTBF  : Mean time between failure
MTTR  : Mean time to repair
PCB   : Printed circuit board
MOV   : Metal oxide varistor
PSP   : Pipe to soil potential
CVCC  : Constant Voltage and Constant Current Mode

Electrical Standards Committee
Convener : Mr. VP Sharma
Members : Mr. KV Subramanyam
          Mr. S.K Sood
          Mr. SC Mittal/Mr. Vineet Aggarwal
          Mr. A Ananthanarayan
          Mr. RP Goyal
          Mr. CR Mandal
          Mr. R Chaudhury
          Mr. UA Patro
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1.0 SCOPE

2.0 CODES AND STANDARDS

3.0 SITE CONDITIONS

4.0 GENERAL REQUIREMENTS

5.0 TECHNICAL REQUIREMENTS

6.0 EQUIPMENT DESCRIPTION

7.0 INSPECTION, TESTING AND ACCEPTANCE

8.0 PACKING AND DESPATCH
1.0 SCOPE

This specification covers the requirements for the design, manufacture and testing of Cathodic Protection Power Supply Module (CPPSM) working on controlled switch mode principle intended to supply power to cathodic protection system for underground pipelines/structures.

2.0 CODES AND STANDARDS

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

IS: 1248 (Parts-1, 2, 8 & 9) : Direct acting indicating analogue electrical measuring instruments and accessories.

IS: 3700 (Parts-1 to 11) : Essential rating and characteristics of semiconductor devices

IS: 3715 (Parts-1 to 4) : Letter symbols for semiconductor devices


IS: 5469 (Parts-1 to 4) : Code of practice for the use of semiconductor junction devices.

IS: 6619 : Safety code for semiconductor rectifier equipment.

IS: 7204 (Parts-1 to 4) : Stabilised power supplies DC output.

IS: 12021 (Parts-1 to 4) : Control transformers for switchgear and control gear for voltages not exceeding 1000 V AC.

IS: 13703 (Parts-1 to 4) : Low voltage fuses for voltages not exceeding 1000 V AC or 1500 V DC.

IS: 13947 (Parts-4, section-1) : Low voltage switchgear and control gear.

2.2 In case of imported equipment, standards of the country of origin shall be applicable if these standards are equivalent or stringent than the applicable Indian standards.

2.3 The equipment shall also conform to the provisions of Indian Electricity rules and other statutory regulations currently in force in the country.

2.4 In case of any contradiction between various referred standards/specifications/data sheet and statutory regulations the following order of priority shall govern:

- Statutory regulations.
- Data sheets.
- Job specification.
- This specification.
- Codes and standards.
3.0 SITE CONDITIONS

The CPPSM 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. Service conditions shall be as specified in the data sheet. If not specifically mentioned therein, a design ambient temperature of 40°C and an altitude not exceeding 1000 m above mean sea level shall be considered.

4.0 GENERAL REQUIREMENTS

4.1 The offered equipment shall be brand new with state of art technology and proven field track record. No prototype equipment shall be offered.

4.2 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment for at least 15 years from the date of supply.

4.3 Vendor shall give a notice of at least one year to the end user of equipment and EIL before phasing out the product/spares to enable the end user for placement of order for spares and services.

5.0 TECHNICAL REQUIREMENTS

5.1 Fabrication and General Details

5.1.1 CPPSMS shall be housed in sheet steel enclosure. The front, rear walls and doors shall be made by using minimum 2 mm thick sheet steel and side walls shall be made of minimum 1.6 mm thick sheet steel. Wherever required, suitable stiffeners shall be provided. 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. Degree of protection for the panel shall be minimum IP-41. The CPPSM panel shall, preferably, not need rear access for operation, maintenance and shall be suitable for mounting flushed to the wall.

5.1.2 Suitable hooks shall be provided for lifting the panel. These hooks when removed shall not leave any hole in the panel or imperfection in the paint finish.

5.1.3 All instruments shall be panel mounted type and back connected. All fuses shall be provided inside the panel and shall be of link type. 660 V grade PVC insulated BIS approved wires with stranded copper conductor of size minimum 2.5 mm² shall be used for power and auxiliary wiring. Control wiring for electronic circuits shall be through flat ribbon cable or through copper wire of minimum 0.5 mm diameter. All wirings shall be ferruled with PVC ferrules at both ends for ease of identification. Clamp type terminals suitable for termination up to 10 mm² 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.

5.1.4 All live parts shall be properly shrouded. This shall ensure complete safety to personnel intending routine maintenance by opening the panel doors.

5.1.5 CPPSM shall be suitable for bottom cable entry unless otherwise specified in the data sheet and shall be supplied complete with crimping type tinned copper 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 as specified in the data sheet.

5.1.6 The CPPSM shall be field proven. The design, internal component layout and rating of component shall ensure high MTBF and low MTTR. Prototype equipment shall not be acceptable. Layout of panel components shall enable easy access to the components for maintenance.
5.1.7 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.

5.1.8 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.

5.1.9 If required the panel shall be provided with 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 and HRC fuse. The space heater shall have porcelain-insulated connectors. Where space heater is not provided, the electronic PCBs/components and other control devices shall be made immune to moisture condensation.

5.1.10 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.

5.1.11 An earth bus bar of minimum (25 x 3) mm² 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 (40x5) mm² 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.

5.1.12 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) laminoid 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.

5.1.13 Where specified in the data sheet the CPPSM shall be housed in an outdoor kiosk. The kiosk shall be made of sheet steel of minimum 3 mm thick and epoxy painted on both internal and external surfaces. Hinged lockable doors shall be provided at the front and back. Acrylic transparent glass window shall be provided on the front door of the kiosk so that the meters, indications and positions of the control switches on the CPPSM can be seen without opening the door of the kiosk. The kiosk shall be suitable for outdoor mounting and shall give proper protection to the CPPSM against rain, other harsh weather conditions. Necessary ventilation arrangement with louvers and wire mesh shall be provided for proper operation of the CPPSM. The cable entry to the kiosk shall be from bottom through cable glands. Suitable canopy shall be provided on the top of the kiosk.

5.1.14 Painting

All metal surfaces 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 surface shall be prepared by applying a coat of phosphate paint and a coat of yellow zinc chromate primer. The undersurface shall be made free from all imperfections before undertaking the finishing coat.
After preparation of the under surface, the panel shall be spray painted with two coats of final paint or shall be powder coated. Colour shade of final paint shall be approved by the purchaser before final painting is started. The finished panels shall be dried in stowing ovens 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 or suitably treated to prevent corrosion. If these parts are moving elements, then they shall be greased.

6.0 EQUIPMENT DESCRIPTION

The CPPSM shall be complete with following main sections:
- Input controls.
- Power converter and filters.
- Output protections
- System controls
- Current interrupter
- Control, indication and metering

6.1 Input Controls

6.1.1 A moulded case circuit breaker with thermal over load and short circuit release (rated for the input power supply short circuit current) shall be provided at the input for power supply control.

6.2 Power Converter and Filters

6.2.1 The CPPSM shall convert and control the input DC power supply voltage/current into variable DC output voltage/current through switching power semiconductor devices (Thyristor/power transistor/power MOSFET, etc.). The variation in the output voltage/current shall be achieved through control of duty cycle of conduction of the switching power semiconductor devices. The current and voltage ratings of the power semiconductor devices shall be at least two times the maximum device current and min. two times the maximum voltage coming across it respectively. The voltage rating of the power semi-conductor devices shall be co-coordinated with the breakdown voltage of lightning arrestor provided at the output so that the power semiconductor devices are protected from any voltage surge coming from the pipeline. Shunt zeners / MOV shall be provided across the power semiconductor devices for protection. The power semiconductor devices shall have humidity/moisture resistant finish and mounted in sufficiently sized heat sink designed to provide adequate cooling under worst conditions of operation. The power semiconductor devices shall have adequate protection against high dv/dt and di/dt.

6.2.2 Where specified in the data sheet, the converter shall electrically isolate the input power to CPPSM from its output so that the grounding of the positive output of the CPPSM through anode ground bed shall not affect the grounding system of the input power supply. Alternatively, a separate DC to DC converter having electrical isolation between input and output power supply shall be provided at the input of the CPPSM.

6.2.3 The power semiconductor devices shall be protected by semiconductor fuses or the system shall have instantaneous short circuit-current limit feature to protect the devices against output short circuits. An adjustable output over current limit feature shall be provided.

6.2.4 Filter shall be provided in the input power supply circuit to minimise the AC injected into the DC input power supply system.

6.2.5 Adequate filtering shall be provided on the DC output of the converter to limit the ripple content in the output to less than 5% at rated output.
6.2.6 The converter system shall be of natural air cooled type.

6.2.7 For CPPSMs with multiple output circuits, each output circuit shall have independent output converter and output filters.

6.3 Output Protections

Two pole moulded case circuit breaker or miniature circuit breaker rated for the DC output current, short circuit current and having thermal overload, short circuit release shall be provided in the output. A lightning arrester rated for minimum 10KA impulse current discharge capacity and rated voltage & max. spark over voltage rating suitable to protect the CPPSM components against lightning and switching surges shall be provided at the output. For CPPSMs with multiple output circuits, each output circuit shall have independent protections.

6.4 System Controls

6.4.1 The CPPSM shall have two distinct modes of operation (independent for each output circuit) as below:

a) Constant Voltage - Constant Current Mode (CVCC)

In this mode the output voltage (Vos) of CPPSM shall be continuously adjustable from 0.5V DC to the rated output voltage specified on the data sheet. Current limit feature shall be provided in this mode of operation. The current limit (Ios) shall be continuously adjustable from zero to rated output current.

For constant voltage mode of operation the output current limit shall be set at maximum and output voltage setting shall be varied. Irrespective of output current demand the chosen value of the output voltage shall be maintained by the control system till the current limit is reached. After that the output current limit shall be maintained and output voltage shall decrease to keep the current constant.

For constant current mode of operation the output voltage shall be set at maximum and output current shall be varied through varying the setting of output current limit. Irrespective of output voltage requirement the control system shall maintain the output current to the set current limit value till the voltage limit is reached. After that the output voltage limit shall be maintained and output current shall decrease to keep the voltage constant.

b) Auto PSP Mode

In this mode of operation the output of the CPPSM shall operate in an external closed loop with pipe-to-soil potential (PSP) in feed back loop. The CPPSM control shall adjust the output voltage such that the PSP as measured by reference cell always remains equal to the set potential on the unit. The set potential (Vps) shall have high long time stability and minimum temperature drift. The set potential shall be continuously adjustable over the range specified in data sheet. An adjustable over current limit shall be provided to limit the maximum output current.

The unit shall be designed to operate with the number of reference cells connected to it (to be provided by others) as specified in data sheet. In case of more than one reference cell being specified, CPPSM shall have feature to automatically select the reference cell having less negative potential than the others and use the same for auto control of the unit (e.g. (-) 0.8 V is less negative than (-) 0.9 V). Adequate hysteresis shall be provided in selecting the less negative potential reference cell, to avoid hunting between the reference cells at change over conditions.
In case of open circuit or short circuit of the reference cell or potential being less negative than a minimum set potential (Vrs), for the controlling reference cell, the unit shall sense these conditions as reference cell failure and shall automatically switch over to the other healthy reference cell for control. Should fault occur in all the reference cells, the output voltage or current of the CPPSM shall adjust automatically to a preset value (Vas/las), which shall be adjustable.

In both CVCC and auto PSP modes of operation the electronic over current limit shall be fast enough to protect the active devices of the unit and fast enough to act before tripping of MCCB/MCB or blowing of fuse.

6.4.2 The unit shall continuously monitor the PSP and necessary annunciation shall be provided in case of PSP either exceeding the specified maximum limit (Vpm) or remaining lower than the specified minimum limit (Vpn).

6.4.3 The output voltage regulation for no load to full load variation with input voltage variation from maximum to minimum shall not be more than 2.5 % of rated voltage throughout the range of output voltage and over the specified ambient temperature variation as specified in data sheet, in CVCC- constant voltage mode of operation. In auto PSP mode the closed loop PSP regulation for no load to full load variation with input voltage variation from maximum to minimum shall be within 20mV throughout the PSP setting range specified.

In CVCC- constant current mode of operation, the current regulation for minimum to maximum output voltage and minimum to maximum variation in input voltage, shall not be more than 2.5% throughout the range of output current.

6.4.4 The output of the unit shall be ungrounded and shall allow grounding of positive terminal of the output through the anode ground bed.

6.4.5 For CPPSMs with multiple output circuits, each output circuit shall have independent control system.

6.5 Current Interrupter

6.5.1 If specified on the data sheet a current interrupter for CPPSM output current interruption shall be provided.

6.5.2 The current interrupter shall have an output contactor with current rating minimum 125% of the output current rating of the CPPSM and a digital timer to operate it.

6.5.3 The timer shall have ‘ON’ and ‘OFF’ timings. When the timer is turned on the ‘ON’ timing shall start and shall close the output contactor till the end of the ‘ON’ timing. At the end of the ‘ON’ timing the ‘OFF’ timing shall start and keep the contactor open till the end of the ‘OFF’ timing. At the end of the ‘OFF’ timing the ‘ON’ timing shall start again. This process of ‘ON’ and ‘OFF’ timing shall continue.

6.5.4 The ‘ON’ and ‘OFF’ timings of the timer shall be settable by separate 2 digit thumbwheel switches, each settable from 1 to 99 seconds. The timing error of the timer shall be less than 5 parts per million. In case of microprocessor based system keypad with display may be provided in place of thumbwheel switches.

6.5.5 Whenever the timer is switched on it shall always start with ON ‘timing’. A timer-reset push button shall be provided. On pressing this pushbutton during operation of the timer, the timer shall get reset and upon release of the button, the timer shall restart with ‘ON’ timing.

6.5.6 The power required for operation of the timer and contactor shall be derived from the main power supply to the CPPSM.
6.5.7 The following controls and indications shall be provided for current interrupter. The controls shall be housed in a lockable cover, so that normally they are not accessible. The indications shall be mounted on the door.

a) Controls
- Timer power ‘ON’ / ‘OFF’
- Timer reset
- Thumb wheel switch for ‘ON’ timing
- Thumb wheel switch for ‘OFF’ timing

In case of microprocessor based system, keypad with display may be provided in place of thumbwheel switches.

b) Indications (LED)
- Timer power ‘ON’
- ‘ON’ timing
- ‘OFF’ timing

6.5.8 The output contact of the current interrupter contactor shall be wired in the positive DC output of the CPPSM. A link shall be provided for shorting these terminals whenever the current interrupter is not in use.

6.5.9 If specified in the data sheet the current interrupter shall be an independent unit of portable type. The interrupter unit shall have terminals for input power supply and terminals of the contactor in the timer output. The input power supply and the rating of the timer output contactor shall be as specified on the data sheet.

6.5.10 Where the current interrupter is not specified with CPPSM or is specified as portable type external to the CPPSM, then the CPPSM shall have provision for connection of input power supply terminals and output contacts of external current interrupter for current interruption test. A link shall be provided for shorting the output terminals provided in CPPSM for current interruption, whenever the current interrupter is not connected.

6.5.11 For CPPSMs with multiple output circuits, each output circuit shall have independent current interrupter.

6.6 Controls, Indication and Metering

6.6.1 Following controls shall be provided on CPPSM front door.

a) ON/OFF control for input through MCCB.
b) ON /OFF control for output through MCCB/MCB.
c) Auto/CVCC mode selector switch.
d) Potentiometers for Vos, Vps and Ios settings.
e) Selector switch for selecting indication of PSP set and PSP actual for all the reference cells.

6.6.2 Following controls shall be provided inside the module at user accessible common location:

a) Potentiometer for Vrs, Vpm, Vpn and Vas/ias settings.
b) Controls for current interrupter:
   - Timer power ‘ON’ / ‘OFF’
   - Timer reset
   - Thumb wheel switch for ‘ON’ timing
   - Thumb wheel switch for ‘OFF’ timing
6.6.3 CPPSM shall have following indicating lights (lamps or minimum 5 mm dia LEDs):

a) CPPSM ON/OFF
b) Unit in auto/CVCC (2 lamps)
c) Reference cell controlling the closed loop control of the CPPSM (number of lamps same as number of reference cells).
d) Reference cell faulty (number of lamps same as number of reference cells).
e) Pipeline over protected.
f) Pipeline under protected
g) Indications for current interrupter:
   - Timer power ‘ON’
   - ‘ON’ timing
   - ‘OFF’ timing

It shall be possible to switch-off all the indication lamps by a single switch. In case of LED indication lights this facility may not be provided.

6.6.4 Following meters having min cl. 1.5 accuracy shall be provided on the CPPSM:

a) Digital meter for output voltage
b) Digital meter for output current
c) Digital voltmeter to measure PSP set (Vps) and PSP actual for all the reference cells. The meter shall have range from (-) 4 V to 0 V and shall have cl. 0.5 accuracy.
e) Digital meters for measuring Vrs, Vpm, Vpn and Vas/las settings.
f) Meters for input voltage and current

It shall be possible to switch-off all the digital meters preferably by a single switch.

6.6.5 If specified in data sheet, CPPSM shall incorporate provision for remote monitoring of the unit through SCADA system as below:

a) Potential free contacts for the following:
   - All the reference cells failed. (Contact open on alarm condition)
   - Pipeline overprotected. (Contact open on alarm condition)
   - Pipeline under protected. (Contact open on alarm condition)
   - System in auto-mode. (Contact close in auto condition)
   - System in CVCC mode. (Contact close in CVCC mode)

b) 4 to 20 mA electrically isolated signal for the following:
   - PSP (-4V to 0V)
   - CPPSM output voltage
   - CPPSM output current

The transducers shall have electrical isolation between input and output. The isolation insulation shall withstand 2 kV, 50 Hz for minimum 1 minute. The accuracy class of the transducer shall be 0.5. The transducers shall be protected against input and output voltage surges. The transducer shall be suitable for driving upto 600 ohms load impedance located upto 500 m away and wired with 0.5 mm² copper conductor cable. The transducers shall be suitable for minimum 125% continuous over load in the input voltage/current parameter.

6.6.6 For units having multiple outputs, each output circuit shall have independent controls, indication and metering.
7.0 TESTS AND ACCEPTANCE

7.1 During fabrication, the equipment shall be subjected to inspection by owner or his authorised representative to assess the progress of the work as well as to ascertain that only quality raw materials are used for the same. He shall be given all assistance to carryout the inspection.

7.2 Final acceptance test shall be carried out at manufacturer's works under his care and expense. Instruments and equipments required for testing shall be arranged by manufacturer. Owner's representative shall be given minimum 2 weeks prior notice for witnessing the tests. Test certificates indicating test results shall be furnished by the manufacturer. Acceptance tests shall include but not be limited to the tests listed below.

7.2.1 Visual Inspection

This shall include-
- Completeness of the equipment in line with specification.
- Checking of all settings.
- All labels provided and satisfactory.
- Dimensional checking.
- Proper mounting of components and neatness of wiring etc.
- Model number.

7.2.2 Insulation tests

The voltage specified in the table below shall be applied for one minute to the circuits indicated:

<table>
<thead>
<tr>
<th>Withstand voltage</th>
<th>Control electronics</th>
<th>Power electronics</th>
<th>Auxiliary circuits</th>
</tr>
</thead>
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<tr>
<td>&lt;60V</td>
<td></td>
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<tr>
<td>To earth</td>
<td>700V D.C.</td>
<td>2xUn1 + 1000V</td>
<td>2xUn2 + 1000V</td>
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<tr>
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<tr>
<td>To power electronics</td>
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<td>-</td>
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</tr>
<tr>
<td>To auxiliary circuits</td>
<td>2xUn2 + 1000V</td>
<td>2xUn1 + 1000V</td>
<td>-</td>
</tr>
</tbody>
</table>

(Un1 and Un2 are nominal voltage rating of power electronics and auxiliary circuits respectively).

D.C. test voltages may be applied instead of A.C. The magnitude of D.C. test voltages to be applied shall be 2 times the above-mentioned A.C. (r.m.s) Values.

Insulation resistance test shall be conducted before and after heat run test.

7.2.3 Heat run test

All CPPSMs shall be subjected to a heat run test performed at rated voltage for period not less than 16 hours prior to execution of functional tests.

At least one CPPSM of each rating shall be loaded to its rated output through out 16 hour test period. All other CPPSMs shall be energized under partial load or zero load current condition through out the test period.

7.2.4 Functional tests

Functional tests as below shall be performed on each CPPSM. If during execution of functional tests, any electronic component of the unit is required to be replaced e.g. due to malfunction or failure of the unit to fulfill the performance requirements of the specification, then the load test shall be repeated at rated current following which functional tests shall be carried out.
7.2.4.1 CVCC mode operation testing
   a) Constant voltage operation

   During the test, current limit shall be set to rated output current. Performance testing shall be carried out for various output voltage settings and load varying from zero to maximum. The verification of operation of the control functions, measurement of output voltage, current, input voltage, current, ripple in the output, input, evaluation of output voltage regulation and efficiency of the unit shall be carried out during the testing.

   b) Constant current operation

   During the test, voltage limit shall be set to rated output voltage. Performance testing shall be carried out for various output current limit settings and load resistance varied to achieve output voltage from minimum to maximum. The verification of operation of the control functions, measurement of output voltage, current, input voltage, current, ripple in the output, input, evaluation of output current regulation of the unit shall be carried out during the testing.

7.2.4.2 Auto PSP mode operation

Suitable set-up shall be arranged for output loading and reference cell feed back. The closed loop performance and regulation shall be checked with the PSP set voltage varied from 0.85V to 1.2V.

Disconnecting the reference cell feed back connection in the above set up shall simulate the reference cell failed condition. The output voltage/current of the unit shall go to the value set on the potentiometer Vas/Ias provided inside the CPPSM. The settings on Vas/Ias shall be varied and the output voltage/current shall be observed.

7.2.4.3 Operation of sensors for pipeline over protection, under protection, reference cell failure and reference cell selection logic in auto PSP mode shall be verified by connecting variable external voltage sources to reference cell inputs of the CPPSM. The number of external voltage sources shall be same as number of reference cell inputs specified for the CPPSM.

7.2.4.4 The unit shall be checked for operation of the current limit by over loading the unit in both CVCC and auto PSP modes of operation. For Units where semiconductor fuses are not provided for protection of the power semiconductor device, the protection of same shall be tested as below:

   A switch rated for making and carrying CPPSM output short circuit current shall be connected to the output terminals of the unit. The output voltage and the output current limit settings of the unit shall be set to the maximum rated values. The switch connected in the output shall be shorted quickly.

   The unit shall go to current limit mode and shall not damage any active component of the unit.

7.2.4.5 The current interrupter shall be tested for time interval settings and specified operation.

8.0 PACKING AND DESPATCH

The equipment shall be properly packed for selected mode of transportation i.e. by ship/rail or trailer. The panels shall be wrapped in polythene sheets before being placed in crates to prevent damage to finish. Crates shall have skid bottom for handling. Special notations such as ‘Fragile’, ‘This side up’, ‘Center of gravity’, ‘Weight’ etc., shall be clearly marked on the package together with Tag nos., P.O. Nos. etc.

The equipment may be stored outdoors for long periods before erection. The packing shall be completely suitable for outdoor storage in areas with heavy rains/high ambient temperature.
SPECIFICATION
FOR
CATHODIC PROTECTION
TRANSFORMER RECTIFIER UNIT

कैथोडिक सुरक्षा ट्रान्सफार्मर परिशोध इकाई के लिए विनिर्देश

REVISED AND ISSUED AS STANDARD SPECIFICATION

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<th>Date</th>
<th>Purpose</th>
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Abbreviations:

CPTR units : Cathodic protection transformer rectifier units
MTBF : Mean time between failure
MTTR : Mean time to repair
PCB : Printed circuit board
MOV : Metal oxide varistor
PSP : Pipe to soil potential
CVCC : Constant Voltage and Constant Current Mode

Electrical Standards Committee
Convener : Mr. VP Sharma
Members : Mr. KV Subramanyam  
           Mr. S.K Sood  
           Mr. SC Mittal/Mr. Vineet Aggarwal  
           Mr. A Ananthanarayan  
           Mr. RP Goyal  
           Mr. CR Mandal  
           Mr. R Chaudhury  
           Mr. UA Patro
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8.0 PACKING AND DESPATCH
1.0 SCOPE

This specification covers the requirements for the design, manufacture and testing of Cathodic Protection Transformer Rectifier units (CPTR units) working on controlled rectification principle intended to supply power to cathodic protection system for underground pipelines/structures.

2.0 CODES AND STANDARDS

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

- **IS: 1248** (Parts-1, 2, 8 & 9) : Direct acting indicating analogue electrical measuring instruments and accessories.

- **IS: 3700** (Parts-1 to 11) : Essential rating and characteristics of semiconductor devices

- **IS: 3715** (Parts-1 to 4) : Letter symbols for semiconductor devices

- **IS: 4411** : Code of designation of semiconductor devices.

- **IS: 5469** (Parts-1 to 4) : Code of practice for the use of semiconductor junction devices.

- **IS: 6619** : Safety code for semiconductor rectifier equipment.

- **IS: 7204** (Parts-1 to 4) : Stabilised power supplies DC output.

- **IS: 12021** (Parts-1 to 4) : Control transformers for switchgear and control gear for voltages not exceeding 1000 V AC.

- **IS: 13703** (Parts-1 to 4) : Low voltage fuses for voltages not exceeding 1000 V AC or 1500 V DC.

- **IS: 13947** (Parts-4, section-1) : Low voltage switchgear and control gear.

2.2 In case of imported equipment, standards of the country of origin shall be applicable if these standards are equivalent or stringent than the applicable Indian standards.

2.3 The equipment shall also conform to the provisions of Indian Electricity rules and other statutory regulations currently in force in the country.

2.4 In case of any contradiction between various referred standards/specifications/data sheet and statutory regulations the following order of priority shall govern:

- Statutory regulations.
- Data sheets.
- Job specification.
- This specification.
- Codes and standards
3.0 SITE CONDITIONS

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. Service conditions shall be as specified in the data sheet. If not specifically mentioned therein, a design ambient temperature of 40°C and an altitude not exceeding 1000 m above mean sea level shall be considered.

4.0 GENERAL REQUIREMENTS

4.1 The offered equipment shall be brand new with state of art technology and proven field track record. No prototype equipment shall be offered.

4.2 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment for at least 15 years from the date of supply.

4.3 Vendor shall give a notice of at least one year to the end user of equipment and EIL before phasing out the product/spares to enable the end user for placement of order for spares and services.

5.0 TECHNICAL REQUIREMENTS

5.1 Fabrication and General Details

5.1.1 CPTR unit shall be housed in sheet steel enclosure. The front, rear walls and doors shall be made by using minimum 2 mm thick sheet steel and side walls shall be made of minimum 1.6 mm thick sheet steel. Wherever required, suitable stiffeners shall be provided. 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. Degree of protection for the panel shall be minimum IP-41. The CPTR unit panel shall, preferably, not need rear access for operation, maintenance and shall be suitable for mounting flushed to the wall.

5.1.2 Suitable hooks shall be provided for lifting the panel. These hooks when removed shall not leave any hole in the panel or imperfection in the paint finish.

5.1.3 All instruments shall be mounted on a panel. All fuses shall be provided inside the panel and shall be of link type. 660 V grade PVC insulated BIS approved wires with stranded copper conductor of size minimum 2.5 mm² shall be used for power and auxiliary wiring. Control wiring for electronic circuits shall be through flat ribbon cable or through copper wire of minimum 0.5 mm diameter. All wirings shall be ferruled with PVC ferrules at both ends for ease of identification. Clamp type terminals suitable for termination up to 10 mm² 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.

5.1.4 All live parts shall be properly shrouded. This shall ensure complete safety to personnel intending routine maintenance by opening the panel doors.

5.1.5 CPTR 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 as specified in the data sheet.
5.1.6 The input power factor of the unit at rated load shall be 0.8 lag or better.

5.1.7 The CPTR unit shall be field proven. The design, internal component layout and rating of component shall ensure high MTBF and low MTTR. Prototype equipment shall not be acceptable.

5.1.8 All the control equipment like switches, pushbuttons, potentiometers etc. shall be located at a convenient height of minimum 300 mm and maximum 1800 mm from the bottom of the panel.

5.1.9 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.

5.1.10 If required the panel shall be provided with 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. The space heater shall have porcelain connectors. Where space heater is not provided the electronic PCBs/components and other control devices shall be made immune to moisture condensation.

5.1.11 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.

5.1.12 An earth bus bar of minimum (25 x 3) mm² 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 (40x5) mm² 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.

5.1.13 All panel mounted equipments (e.g. lamps, pushbuttons, switches, meters, PCBs, etc.) shall be provided with suitable nameplates. Nameplates shall be engraved out of 3-ply (black-white-black) laminoid 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.

5.1.14 Where specified in the data sheet the CPTR unit shall be housed in an outdoor kiosk. The kiosk shall be made of sheet steel of minimum 3 mm thick and epoxy painted on both internal and external surfaces. Hinged lockable doors shall be provided at the front and back. The kiosk shall be suitable for outdoor mounting and shall give proper protection to the CPTR unit against rain, other harsh weather conditions. Necessary ventilation arrangement with louvers and wire mesh shall be provided for proper operation of the CPTR unit. The cable entry to the kiosk shall be from bottom through cable glands. Suitable canopy shall be provided on the top of the Kiosk.

5.1.15 Painting

All metal surfaces 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 surface shall be prepared by applying a coat of phosphate paint and a coat of yellow zinc chromate primer. The undersurface shall be made free from all imperfections before undertaking the finishing coat.

After preparation of the under surface, the panel shall be spray painted with two coats of final paint or shall be powder coated. Colour shade of final paint shall be approved by the purchaser before final painting is started. The finished panels shall be dried in stowing ovens 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 suitably treated to prevent corrosion. If these parts are moving elements, then they shall be greased.

6.0 **EQUIPMENT DESCRIPTION**

The CPTR unit shall be complete with following main sections:
- Transformer and input controls.
- Rectifier and filter
- Output protections
- System controls
- Control, indication and metering

6.1 **Transformer and Input Controls**

6.1.1 The transformer shall be natural cooled dry type with separate primary and secondary windings. An intermediate earth screen shall be provided between primary and secondary windings. CPTR Units having multiple output circuits shall have separate secondary windings for each output circuit. Transformer shall be vacuum impregnated with epoxy varnish and baked. The safety factor for transformer rating shall be minimum 125%.

6.1.2 Single-phase transformers may be provided up to 50V, 50A DC output rating of the CPTR units. Beyond this rating, 3 phase transformers shall be provided.

A moulded case circuit breaker with thermal over load and short circuit release shall be provided at the input of the transformer. Miniature circuit breaker with thermal overload and short circuit release in place of moulded case circuit breaker may be provided, where the miniature circuit breaker rated for the incoming AC supply short circuit current indicated in the data sheet is available.

6.2 **Rectifier and Filters**

6.2.1 The rectifier shall be made of thyristors and diodes as basic components. The CPTR unit shall be suitable for 415 V AC, 3-ph power supply. Rectifier shall be 3 phase full wave type and controlled type. For CPTR units rated 50V, 50A DC or less, the unit may be suitable for 240V AC, 1 ph power supply and the rectifier shall be full wave type and controlled type. Alternatively, for single phase AC CPTR units, diode rectifier of full wave type in the secondary of the transformer and triac or back to back connected thyristors 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 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.
The rectifier elements shall have humidity/moisture resistant finish and mounted in sufficiently sized heat sink designed to provide adequate cooling under worst conditions of operation. The rectifier elements shall have adequate protection against high $dv/dt$ and $di/dt$.

6.2.2 The thyristors/triacs shall be protected by semiconductor fuses. For units rated 50V, 50A DC or less, if the thyristors or triacs are adequately over rated and system has enough inductance so that in case of sudden output short circuit the over current limit feature comes into action before short circuit current rises beyond the rating of the thyristors/triacs, then the semiconductor fuses may not be provided. This feature shall be demonstrated during testing of the unit at works.

6.2.3 Adequate filtering shall be provided on the DC output of the rectifier to limit the ripple content in the output to less than 5% at rated output.

6.2.4 The rectifier system shall be of natural air cooled type.

6.2.5 For CPTR units with multiple output circuits, each output circuit shall have independent rectifier and filter.

6.3 Output Protections

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 arrester rated for minimum 10KA impulse current discharge capacity and rated voltage & maximum spark over voltage rating suitable to protect the CPTR unit components against lightning and switching surges shall be provided at the output. For CPTR units with multiple output circuits, each output circuit shall be provided with circuit breaker and lightning arrester.

6.4 System Controls

6.4.1 The CPTR unit shall have two distinct modes of operation (independent for each output circuit) as below:

a) Constant Voltage and Constant Current Mode (CVCC)

In this mode the output voltage of CPTR unit shall be continuously adjustable from 0.5V DC to the rated output voltage specified on the data sheet. The set output voltage ($V_{os}$) shall remain constant irrespective of output current. Current limit feature shall be provided. The current limit ($I_{os}$) shall be continuously adjustable from zero to rated output current.

For constant voltage mode of operation the output current limit shall be set at maximum and output voltage setting shall be varied. Irrespective of output current demand the chosen value of the output voltage shall be maintained by the control system till the current limit is reached. After that the output current limit shall be maintained and output voltage shall decrease to keep the current constant.

For constant current mode of operation the output voltage shall be set at maximum and output current shall be varied through varying the setting of output current limit. Irrespective of output voltage requirement the control system shall maintain the output current to the set current limit value till the voltage limit is reached. After that the output voltage limit shall be maintained and output current shall decrease to keep the voltage constant.
b) Auto PSP mode

In this mode of operation the output of the CPTR unit shall operate in an external closed loop with pipe to soil potential (PSP), measured by reference cell, in feed back loop. The CPTR unit control shall adjust the output voltage such that the PSP as measured by reference cell always remains equal to the set potential on the unit. The set potential (Vps) shall have high long time stability and minimum temperature drift. The set potential shall be continuously adjustable over the range specified in data sheet.

The unit shall be designed to operate with number of reference cells connected to it (to be provided by others) as specified in data sheet. In case of more than one reference cell being specified, CPTR unit shall have feature to automatically select the reference cell having less negative potential than the others and use the same for auto control of the unit (e.g. (-) 0.8 V is less negative than (-) 0.9 V). Adequate hysterisis shall be provided in selecting the less negative potential reference cell, to avoid hunting between the reference cells at change over conditions.

In case of open circuit or short circuit of reference cell or potential being less negative than a minimum set potential (Vrs), the unit shall sense these conditions as reference cell failure and shall automatically switch over to the other healthy reference cell for control. Should fault occur in all the reference cells, the output voltage or current of the CPTR unit shall adjust automatically to a preset value (Vas/las), which shall be adjustable.

In both CVCC and auto PSP modes of operation a fast acting electronic over current limit protection shall be provided. This protection shall be fast enough to protect the active devices of the unit and fast enough to act before tripping of MCCB/MCB or blowing of fuse.

6.4.2 The unit shall continuously monitor the PSP and necessary annunciation shall be provided in case of PSP either exceeding the specified maximum limit (Vpm) or remaining lower than the specified minimum limit (Vpn).

6.4.3 The output voltage regulation for no load to full load variation with input voltage variation from maximum to minimum shall not be more than 2.5% of rated voltage through out the range of output voltage and over the specified ambient temperature variation as specified in data sheet, in CVCC- constant voltage mode of operation. In auto PSP mode the closed loop PSP regulation for no load to full load variation with input voltage variation from maximum to minimum and PSP feedback varying over the specified range shall be within 20 mV.

In CVCC- constant current mode of operation, the current regulation for minimum to maximum output voltage and minimum to maximum variation in input voltage shall not be more than 2.5% through out the range of output current.

6.4.4 The DC output of the CPTR unit shall be floating (ungrounded) in the Unit. However the CPTR Unit shall allow grounding of positive output terminal through the anode ground bed.

6.4.5 For CPTR units with multiple output circuits, each output circuit shall have independent control system.

6.5 Current Interrupter

6.5.1 If specified on the data sheet a current interrupter for CPTR Unit output current interruption shall be provided.

6.5.2 The current interrupter shall have an output contactor with current rating minimum 125% of the output current rating of the CPTR unit and a digital timer to operate it.
6.5.3 The timer shall have ‘ON’ and ‘OFF’ timings. When the timer is turned on the ‘ON’ timing shall start and shall close the output contactor till the end of the ‘ON’ timing. At the end of the ‘ON’ timing the ‘OFF’ timing shall start and keep the contactor open till the end of the ‘OFF’ timing. At the end of the ‘OFF’ timing the ‘ON’ timing shall start again and close the output contactor. This process of ‘ON’ and ‘OFF’ timing shall continue.

6.5.4 The ‘ON’ and ‘OFF’ timings of the timer shall be settable by separate 2 digit thumbwheel switches, each settable from 1 to 99 seconds. The timing error of the timer shall be less than 5 parts per million. In case of microprocessor based system keypad with display may be provided in place of thumbwheel switches.

6.5.5 Whenever the timer is switched on it shall always start with ON ‘timing’. A timer-reset push button shall be provided. On pressing this pushbutton during operation of the timer, the timer shall get reset and upon release of the button the timer shall restart with ‘ON’ timing.

6.5.6 The power required for operation of the timer and contactor shall be derived from the main power supply to the CPTR unit.

6.5.7 The following controls and indications shall be provided for current interrupter. The controls shall be housed in a lockable cover, so that normally they are not accessible. The indications shall be mounted on the door.

a) Controls

- Timer power ‘ON’ / ‘OFF’
- Timer reset
- Thumb wheel switch for ‘ON’ timing
- Thumb wheel switch for ‘OFF’ timing

In case of microprocessor based system keypad with display may be provided in place of thumbwheel switches.

b) Indications(LED)

- Timer power ‘ON’
- ‘ON’ timing
- ‘OFF’ timing

6.5.8 The output contact of the current interrupter contactor shall be wired in the positive DC output of the CPTR unit. A link shall be provided for shorting these terminals whenever the current interrupter is not in use.

6.5.9 If specified in the data sheet the current interrupter shall be an independent unit of portable type. The interrupter unit shall have terminals for input power supply and terminals of the output contactor. The input power supply and the rating of the output contactor shall be as specified on the data sheet. Terminals shall be provided in the CPTR unit for taking power supply to the current interrupter.

6.5.10 Where the current interrupter is not specified with CPTR unit or is specified as portable type external to the CPTR unit, then the CPTR unit shall have provision/ terminals for connection of input power supply and output contacts of external current interrupter, for current interruption test. A link shall be provided for shorting the output terminals provided in CPTR unit whenever the current interrupter is not connected.

6.5.11 For CPTR units with multiple output circuits, each output circuit shall have independent current interrupter.
6.6 Controls, Indication and Metering

6.6.1 Following controls shall be provided on CPTR unit front door.

a) ON/OFF control for input through MCCB/MCB.
b) ON/OFF control for output through MCCB/MCB.
c) Auto/CVCC mode selector switch.
d) Potentiometers for Vos, Vps and Ios settings.
e) Selector switch for selecting indication of PSP set and PSP actual for all the reference cells.

6.6.2 Following controls shall be provided inside the module at user accessible common location:

a) Potentiometer for Vrs, Vpm, Vpn and Vas/IAS settings.
b) Controls for current interrupter:
   - Timer power ‘ON’ / ‘OFF’
   - Timer reset
   - Thumb wheel switch for ‘ON’ timing
   - Thumb wheel switch for ‘OFF’ timing

6.6.3 TR unit shall have following indicating lights (lamps or minimum 5 mm dia LEDs):

a) CPTR unit ON/OFF
b) Unit in auto/CVCC (2 lamps)
c) Reference cell controlling the closed loop control of the CPTR unit (number of lamps same as number of reference cells).
d) Reference cell faulty (number of lamps same as number of reference cells).
e) Pipeline over protected.
f) Pipeline under protected
g) Indications for current interrupter:
   - Timer power ‘ON’
   - ‘ON’ timing
   - ‘OFF’ timing

It shall be possible to switch-off all the indication lamps by a single switch. In case of LED indication lights this facility may not be provided.

6.6.4 Following meters having min cl.1.5 accuracy shall be provided on the CPTR unit:

a) Digital meter for output voltage
b) Digital meter for output current
c) Digital voltmeter to measure PSP set (Vps) and PSP actual for all the reference cells. The meter shall have range from -4 V to 0 V and shall have cl.0.5 accuracy.
e) Digital meters for measuring Vrs, Vpm, Vpn and Vas/IAS settings.
f) Meters for input voltage and current

It shall be possible to switch-off all the digital meters preferably by a single switch.

6.6.5 If specified in data sheet, CPTR unit shall incorporate provision for remote monitoring of the unit through SCADA system as below:

a) Potential free contacts for the following:
   - All the reference cells failed. (Contact open on alarm condition)
   - Pipeline overprotected. (Contact open on alarm condition)
   - Pipeline under protected. (Contact open on alarm condition)
   - System in auto-mode. (Contact close in auto condition)
   - System in CVCC mode. (Contact close in CVCC mode)
b) 4 to 20 mA electrically isolated signal for the following:
   - PSP (-4V to 0V)
   - CPTR unit output voltage
   - CPTR unit output current

The transducers shall have electrical isolation between input and output. The isolation insulation shall withstand 2kV, 50Hz for minimum 1 minute. The accuracy class of the transducer shall be 0.5. The transducers shall be protected against input and output voltage surges. The transducer shall be suitable for driving up to 600 ohms load impedance located up to 500 m away and wired with 0.5 mm² copper conductor cable.

6.6.6 For units having multiple outputs, each output circuit shall have independent controls, indication and metering.

7.0 TESTS AND ACCEPTANCE

7.1 During manufacture, the equipment shall be subjected to inspection by owner or his authorised representative to assess the progress of the work as well as to ascertain that only quality raw materials are used for the same. He shall be given all assistance to carryout the inspection.

7.2 Final acceptance test shall be carried out at manufacturer's works under his care and expense. Instruments and equipments required for testing shall be arranged by manufacturer. Owner's representative shall be given minimum 2 weeks prior notice for witnessing the tests. Test certificates indicating test results shall be furnished by the manufacturer. Acceptance tests shall include but not be limited to the tests listed below.

7.2.1 Visual Inspection

This shall include-
- Completeness of the equipment in line with specification.
- Checking of all settings.
- All labels provided.
- Dimensional checking.
- Proper mounting of components and neatness of wiring etc.
- Model number.

7.2.2 Insulation tests

The voltage specified in the table below shall be applied for one minute to the circuits indicated:

<table>
<thead>
<tr>
<th>Withstand voltage</th>
<th>Control electronics</th>
<th>Power electronics</th>
<th>Auxiliary circuits</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;60V</td>
<td>Un₁ + 1000V</td>
<td>Un₂ + 1000V</td>
<td>Un₁ + 1000V</td>
</tr>
<tr>
<td>To earth</td>
<td>700V D.C.</td>
<td>2xUn₁ + 1000V</td>
<td>2xUn₂ + 1000V</td>
</tr>
<tr>
<td>To control electronics</td>
<td>-</td>
<td>2xUn₁ + 1000V</td>
<td>2xUn₂ + 1000V</td>
</tr>
<tr>
<td>To power electronics</td>
<td>2xUn₁ + 1000V</td>
<td>-</td>
<td>2xUn₁ + 1000V</td>
</tr>
<tr>
<td>To auxiliary circuits</td>
<td>2xUn₂ + 1000V</td>
<td>2xUn₁ + 1000V</td>
<td>-</td>
</tr>
</tbody>
</table>

(Un₁ and Un₂ are nominal voltage rating of power electronics and auxiliary circuits respectively).

D.C. test voltages may be applied instead of A.C. The magnitude of D.C. test voltages to be applied shall be 2 times the above-mentioned A.C. (r.m.s) Values.

Insulation resistance test shall be conducted before and after heat run test.
7.2.3 **Heat run test**

All CPTR units shall be subjected to a heat run test performed at rated voltage for period not less than 16 hours prior to execution of functional tests.

At least one CPTR unit of each rating shall be loaded to its rated output through out 16 hour test period. All other CPTR units shall be energized under partial load or zero load current condition through out the test period.

7.2.4 **Functional tests**

Functional tests as below shall be performed on each CPTR unit. If during execution of functional tests, any electronic component of the unit is required to be replaced e.g. due to malfunction or failure of the unit to fulfil the performance requirements of the specification, then the load test shall be repeated at rated current following which functional tests shall be carried out.

7.2.4.1 **CVCC mode operation testing**

a. **Constant voltage operation**

During the test, current limit shall be set to rated output current. Performance testing shall be carried out for various output voltage settings and load varying from zero to maximum. The verification of operation of the control functions, measurement of output voltage, current, input AC voltage, current, power factor, ripple in the output, evaluation of output voltage regulation and efficiency of the unit shall be carried out during the testing.

b. **Constant current operation**

During the test, voltage limit shall be set to rated output voltage. Performance testing shall be carried out for various output current limit settings and load resistance varied to achieve output voltage from minimum to maximum. The verification of operation of the control functions, measurement of output voltage, current, input AC voltage, current, power factor, ripple in the output, evaluation of output current regulation of the unit shall be carried out during the testing.

7.2.4.2 **Auto PSP mode operation**

Suitable set up shall be arranged for output loading and reference cell feed back. The closed loop performance and regulation shall be checked with the PSP set voltage varied from 0.85V to 1.2V.

Disconnecting the reference cell feed back connection in the above set up shall simulate the reference cell failed condition. The output voltage/current of the unit shall go to the value set on the potentiometer Vas/ias provided inside the CPTR UNIT. The settings on Vas/ias shall be varied and the output voltage/current shall be observed.

7.2.4.3 **Operation of sensors for pipeline over protection, under protection, reference cell failure and reference cell selection logic in auto PSP mode** shall be verified by connecting variable external voltage sources to reference cell inputs of the CPTR unit. The number of external voltage sources shall be same as number of reference cell inputs specified for the CPTR unit.

7.2.4.4 The unit shall be checked for operation of the current limit by over loading the unit in both CVCC and auto PSP modes of operation. For Units where semiconductor fuses are not provided for protection of the thyristors/traics, the protection of same shall be tested as below:
A switch rated for making and carrying CPTR unit output short circuit current shall be connected to the output terminals of the unit. The output voltage and the output current limit settings of the unit shall be set to the maximum rated values. The switch connected in the output shall be shorted quickly.

The unit shall go to current limit mode and shall not damage any active component of the unit.

7.2.4.5 The current interrupter shall be tested for time interval settings and specified operation.

8.0 PACKING AND DESPATCH

The equipment shall be properly packed for selected mode of transportation i.e. by ship/rail or trailer. The panels shall be wrapped in polythene sheets before being placed in crates to prevent damage to finish. Crates shall have skid bottom for handling. Special notations such as ‘Fragile’, ‘This side up’, ‘Center of gravity’, ‘Weight’ etc., shall be clearly marked on the package together with Tag nos., P.O. Nos. etc.

The equipment may be stored outdoors for long periods before erection. The packing shall be completely suitable for outdoor storage in areas with heavy rains/high ambient temperature.
क्षरण सर्वेक्षण के लिये विनिर्देश

SPECIFICATION FOR CORROSION SURVEY

<table>
<thead>
<tr>
<th>Rev. No</th>
<th>Date</th>
<th>Purpose</th>
<th>Prepared by</th>
<th>Checked by</th>
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<th>Standards Bureau Chairman</th>
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<td>VPS</td>
<td>SG</td>
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</table>
Abbreviations:

AC : Alternating Current
BIS : Bureau of Indian Standards
BS : British Standards
CP : Cathodic Protection
DC : Direct Current
EHV : Extra High Voltage
HV : High Voltage
HVDC : High Voltage Direct current
NACE : National Association for Corrosion Engineers
ROU : Right of Use

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          Mr. S.K. Dhawan (Inspection)
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1.0 SCOPE
2.0 CODES AND STANDARDS
3.0 GENERAL
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5.0 TESTS ON SOIL SAMPLES
6.0 ADDITIONAL DATA COLLECTION
7.0 REPORT
1.0 SCOPE

The specification covers the requirements for corrosion survey including measurement of soil resistivity, chemical analysis of soil/water and collection of other cathodic protection related data along ROU of the pipelines.

2.0 CODES AND STANDARDS

Equipment and measurement techniques shall unless otherwise specified, conform to the requirement of latest revisions of following applicable standards:

BIS specifications

BS specifications and codes of practice

NACE publications

The work shall be carried out in compliance with all applicable local laws and regulations.

In case of any contradiction between various referred standards/specifications/data sheet and statutory regulations the following order of priority shall govern:

- Statutory regulations.
- Data sheets.
- Job specification.
- This specification.
- Codes and standards.

3.0 GENERAL

This specification defines the basic guidelines for carrying out the corrosion survey. Contractor shall be responsible for providing necessary data interpretation based on corrosion survey measurements, which is intended to form a basis for design of cathodic protection system for the pipeline.

4.0 SOIL RESISTIVITY SURVEY

4.1 Unless otherwise specified the soil resistivity measurements shall be carried out at intervals of approximately 1000 m along the ROU. Where soil resistivity is less than 100 ohm. m and two successive readings differ by more than 2:1 then additional soil resistivity readings in between the two locations shall be taken.

4.2 To carryout the soil resistivity measurement Wenner's 4 pin method or approved equal shall be used. The depth of resistivity measurement at each location shall be at around 1 m and at the burial depth of the pipeline accounting for the cuttings/fillings or 2 m approximately which ever is higher. At locations where multi layer soil with large variation in resistivity/corrosiveness is expected and/or locations specifically advised by OWNER or his representative resistivity measurements at additional depth of up to 3 m (approx) or more shall be taken. In general the resistivity of soil, which shall be surrounding the pipe, shall be measured. Hence the depth of measurement / electrode spacing may vary depending on topography and strata at the area.

4.3 At places where ROU has not yet been cleared, measurements shall be made right over the centre line of pipeline route surveyed accounting for the cuttings/fillings also.
4.4 Observations shall be made enclosing the soils adjoining the trench wherever pipeline trenching has already been done.

4.5 The observations shall be made enclosing the soil immediately surrounding the pipeline route where ROU has been cleared but trenching has not been done.

4.6 All measurements shall be taken at right angles to the ROU unless otherwise asked by OWNER or his representative at site.

4.7 At places in ROU where other pipelines are already existing care shall be taken to precisely locate such pipes line and take such precautions that observations are not adversely affected by presence of such pipelines.

4.8 Care shall also be taken that the observations are not influenced by presence of other earth currents in the area especially in the vicinity of EHV/HV lines and plants using earth return in their source of power etc.

4.9 Wherever possible / advised by OWNER or his representative, depth of water table shall be determined by resistivity observations.

4.10 All measurements shall be made and recorded in metric units. While recording the data reference to the nearest intersecting point shall be made. To provide visual representation of variations in the resistivity along ROU, values shall be plotted on semi log graph sheets. The resistivity graph shall also indicate the resistivity at additional depths measured at various locations and depth of water table.

5.0 TESTS ON SOIL SAMPLES

Soil/water samples shall be collected along the ROU for analysis. Samples shall be collected on an average at one location for every 10 km along ROU with minimum at approximate two equidistant locations. Exact locations shall be decided at site depending on the type of soil, soil resistivity and in consultation with OWNER or his representative. At each location the soil samples shall be collected at 1 m, 2 m depth and at scheduled / designed depth of pipeline if it is more than 2 m at the location.

The collected soil / water samples shall be analysed to determine presence and percentage of corrosive compounds including carbonates, bicarbonates, nitrates, chlorides, oxygen activity, moisture content and pH value.

6.0 ADDITIONAL DATA COLLECTION

The following data shall be collected with a view to generate design data for evaluation of cathodic protection interaction possibilities due to presence of other services in ROU and its vicinity:

6.1 Following information regarding foreign service/pipeline in or around the ROU (for existing and those, which are likely to come up during contract execution).

6.1.1 Types of service / pipeline and year of laying.

6.1.2 Diameter and pipeline coating in case of pipeline.

6.1.3 Parallel running / crossing.

6.1.4 Year of laying / commissioning.
6.1.5 Depth of laying.

6.1.6 Type of existing cathodic protection systems (impressed current / sacrificial).

6.1.7 Location and type (Deep well / surface) of anode ground bed.

6.1.8 Rating of impressed current type of anode ground bed.

6.1.9 Location of existing CP power supply units and their output voltage, current, pipe to soil potential readings.

6.1.10 Location of existing test stations.

6.1.11 Remedial measures existing on foreign service/pipeline to prevent interactions.

6.1.12 Graphical representation of existing structure / pipe to soil potential records.

6.1.13 Possibility of integration/isolation of CP system of the foreign service/pipeline with that of the proposed pipeline, which may involve negotiations with owner's of foreign services.

6.1.14 Where pipeline is likely to pass close to any existing ground bed (with in 100 m approx), anode-bed potential gradient survey shall be carried out to verify possible interference with the CP system of the pipeline covered under this project.

6.2 Voltage rating, phases and sheathing details of cables running parallel or crossing the ROU.

6.3 Existing and proposed DC/AC power sources and systems using earth return path such as HVDC substations/ earthing stations, fabrication yards with electric welding etc. in the vicinity of the entire pipeline route.

6.4 Crossing and parallel running of electrified and non-electrified traction (along with information regarding, operating voltage, AC/DC type etc.) as well as abandoned tracks near ROU having electrical continuity with the tracks in use.

6.5 Crossing or parallel running of any existing or proposed EHV/HV AC/DC overhead power lines along with details of voltage, AC/DC type etc.

6.6 Voltage rating, phases, sheathing details of underground power cables along ROU or in its vicinity.

6.7 Any other relevant information that may be needed in designing and implementing of proper cathodic protection scheme for the proposed pipeline.

7.0 REPORT

On completion of all the field and laboratory work an interim report incorporating results generated from surveys, additional data collected, results of test carried out, etc. shall be submitted for comments / approval. The report shall also highlight any adverse impact on performance of sacrificial anodes due to the percentage of corrosive compounds including carbonates, bicarbonates, nitrates, chlorides present in the soil and pH value of the soil noticed during the survey. The final report incorporating comments / missing data shall be furnished for records. The report along with various drawings, graphs etc. prepared in connection with the work shall be submitted along with six prints by the contractor.
पाइपलाइनों की सैक्रिफिशियल एनोड कैथोडिक संरक्षण प्रणाली के लिए विनिर्देश

SPECIFICATION FOR SACRIFICIAL ANODE CATHODIC PROTECTION SYSTEM FOR PIPELINES
Abbreviations:

AC  Alternating current
BS  British Standards
BIS  Bureau of Indian Standards
CP  Cathodic Protection
CMRI  Central Mining Research Institute
CPPSM  Cathodic Protection Power Supply Module
CPTR  Cathodic Protection Transformer Rectifier
CTE  Coal tar enamel
DC  Direct Current
EHV  Extra High Voltage
FBE  Fusion bonding epoxy
HDD  Horizontal Directional Drilling
HV  High Voltage
HVDC  High Voltage Direct Current
IS  Indian Standards
MOV  Motor operated valve
Micro A/mm²  Micro-ampere per square millimeter
NACE  National Association of Corrosion Engineers
PE  Polyethylene
PVC  Polyvinyl Chloride
ROW  Right of way
SV  Sectionalizing Valve

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Mr. U.A. Patro
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4.0 CORROSION SURVEY
5.0 CATHODIC PROTECTION DESIGN PARAMETERS
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7.0 SYSTEM DETAILS
8.0 INSTALLATION
9.0 FIELD TESTING AND COMMISSIONING
10.0 INTERFERENCE MITIGATION
11.0 SYSTEM MONITORING
12.0 CLOSE INTERVAL POTENTIAL LOGGING SURVEY
1.0 SCOPE

1.1 This specification defines the requirements of design, engineering, installation, testing and commissioning of sacrificial anodes cathodic protection system for external surface of cross country onshore underground pipelines/structures including supplementing of corrosion survey, investigation for interference/interaction problems and mitigation of the same.

1.2 This specification defines the basic guidelines to develop a suitable sacrificial anode cathodic protection system for the pipelines/structures required to be protected. All data required in this regard shall be taken into consideration to develop an acceptable design and for proper engineering of the system.

1.3 Compliance with these specifications and/or approval of any of the contractor’s documents shall in no case relieve the contractor of his contractual obligations.

2.0 APPLICABLE CODES AND STANDARDS

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

- NACE Standard RP-0169 : Standard Recommended Practice Control of External Corrosion on Underground or Submerged Metallic Piping Systems.

- NACE Publication 10A190 : Measurement technique related to criteria for CP of Underground or Submerged Steel Piping System (as defined in NACE Standard RPO169-83).


- NACE Standard RP-0286 : Standard Recommended Practice The Electrical isolation of Cathodically Protected Pipelines.

- NACE Publication No.54276: Cathodic Protection Monitoring for Buried Pipelines.

- BS 7361 Part I : Code of Practice for Cathodic Protection for land and Marine applications.

- VDE 0150 : Protection against Corrosion due to Stray Current from DC Installations.

- IS:1554 Part I : PVC insulated (heavy duty) cables.

2.2 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.
2.3 The equipment shall also confirm to the provisions of Indian Electricity rules and other statutory regulations currently in force in the country.

2.4 In case of any contradiction between various referred standards/specifications/data sheet and statutory regulations the following order of priority shall govern:

- Statutory regulations.
- Data sheets.
- Job specification.
- This specification.
- Codes and standards.

3.0 SYSTEM IMPLEMENTATION

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

a) Corrosion survey data interpretation report and design basis for C.P. system.
b) C.P. system design package.
c) Detailed engineering package.
d) Field testing and commissioning procedure.
e) Procedures for interference testing and mitigation.
f) Close interval potential logging survey and system monitoring procedures.
g) As built documentation.

4.0 CORROSION SURVEY

4.1 The details of corrosion survey including soil resistivity data along ROW and other data required for C.P. design if available with the Owner shall be included as part of project specification/data sheet. However, verification of its veracity and adequacy shall be the entire responsibility of the contractor. In addition, contractor shall have to generate/collect additional data as per clause 4.2 below required for completeness of the job. Contractor shall also carry out soil resistivity survey at sacrificial anode ground bed locations for proper design of ground beds as specified in data sheet. Wenner’s 4-pin method or approved equal shall be used for such measurements. Survey instruments shall have maximum AC and DC ground current rejection feature.

Care shall be taken to ensure that the resistivity observations are not influenced by the presence of foreign pipelines/structures, and earth currents in the vicinity of EHV/HV lines and installations using earth return in their power system etc.

Where specified in the project specification/data sheet, the contractor shall carry out corrosion survey along the ROW of the pipeline conforming to the specifications included in the tender document.

4.2 Additional Data to be Collected

The following data shall be collected to generate design data for evaluation of interaction/interference possibilities due to presence of other services in ROW/in vicinity. OWNER shall provide assistance for liaison work to the extent possible.
i) Route and types of foreign service/pipeline in and around or crossing the right of way (including those existing and those which are likely to come up during contract execution).

ii) Diameter, wall thickness, pressure, soil cover, and coating scheme used, type of cathodic protection system provided, if any, and year of laying/commissioning in case of foreign pipelines.

iii) Details of the existing cathodic protection systems protecting the services i.e. type of protection, location, type, rating of anode beds, test station locations and their connection schemes. Present output current and voltage readings of the CP power supply units.

iv) Remedial measures existing on foreign pipelines/services to prevent interaction.

v) Graphical representation of existing structure/ pipe-to-soil potential records.

vi) Possibility of integration/isolation of CP systems, which may involve negotiations with owners of other services.

vii) Information on existing and proposed DC/AC power sources and systems using earth return path such as HVDC substations/ earthing stations, fabrication yards with electric welding etc. in the vicinity of the entire pipeline route.

viii) Crossing and parallel running of electrified and non-electrified traction (along with information regarding, operating voltage, AC/DC type etc.) as well as abandoned tracks near ROW having electrical continuity with the tracks in use.

ix) Crossing or parallel running of any existing or proposed 11 KV and above AC/DC overhead power lines along with details of voltage, AC/DC type etc.

x) Voltage rating, phases, sheathing details of underground power cables running along ROW or in its vicinity.

xi) Any other relevant information that may be needed in designing and implementing proper protection scheme for the proposed pipeline.

Contractor shall conduct necessary potential gradient surveys for any existing anode ground beds that may interfere with the CP system of the pipelines covered under this project.

4.2 Report

On completion of all fieldwork, a report incorporating all the results generated from surveys and details of additional data collected shall be prepared. The report shall also contain detailed interpretation of survey results and resistivity data enclosed, probable interference prone areas 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.

5.0 CATHODIC PROTECTION DESIGN PARAMETERS

Unless otherwise specified in the data sheet, following parameters shall be used for design of cathodic protection system.
Where the cathodic protection system is specified for temporary protection, those parts of sacrificial anode cathodic protection system, which will be integrated, with the permanent CP system shall be designed based on permanent CP parameters.

5.1 Protection Current Density

i) Pipe lines having coal tar enamel (CTE) coating with two / three layers of reinforcement.

<table>
<thead>
<tr>
<th>Pipeline surrounding</th>
<th>Minimum Protection Current Density*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Temporary CP (µ A/m²)</td>
</tr>
<tr>
<td>Soil resistivity more than 100 ohm. m</td>
<td>40</td>
</tr>
<tr>
<td>Soil resistivity 10 ohm m to 100 ohm.m</td>
<td>75</td>
</tr>
<tr>
<td>Soil resistivity less than 10 ohm. m</td>
<td>500</td>
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<tr>
<td>Sea water</td>
<td>1000</td>
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</table>

ii) Pipe lines having fusion bonded epoxy coating

<table>
<thead>
<tr>
<th>Pipeline surrounding</th>
<th>Minimum Protection Current Density*</th>
</tr>
</thead>
<tbody>
<tr>
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<td>Temporary CP (µ A/m²)</td>
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<tr>
<td>Soil resistivity more than 100 ohm. m</td>
<td>25</td>
</tr>
<tr>
<td>Soil resistivity 10 ohm m to 100 ohm.m</td>
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<tr>
<td>Soil resistivity less than 10 ohm. m</td>
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iii) Pipe lines having polyethylene(PE) coating

<table>
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<th>Pipeline surrounding</th>
<th>Minimum Protection Current Density*</th>
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The above current density values for temporary CP system are applicable for CP system design life up to two years.
5.2 The pipe protection Current Density indicated in the clause 5.1 above shall be applicable where the temperature of the fluid transported by the pipeline/ the surface temperature of the buried portion of the pipeline does not exceed 30° C. Where this temperature exceeds 30° C, the protection Current Density shall be increased suitably in consultation with the Owner/EIL.

5.3 At HDD (horizontal directional drilling) crossing, the pipe protection current density applicable for marshy area shall be considered.

5.4 Safety factor for current density : 1.3

5.5 Anode utilisation factor :
  : 0.85 for solid anodes
  : 0.6 for ribbon anodes

5.6 Pipeline natural potential : (-) 0.45V.

5.7 Unless otherwise specified in data sheet the design life of temporary CP shall be one year and that of permanent CP shall be 30 years.

5.8 Along the ROW where soil resistivity is higher than 100 ohm. m temporary CP for the pipeline may not be provided after obtaining specific approval from the Owner.

6.0 CATHODIC PROTECTION DESIGN CRITERIA

Cathodic protection system shall be designed to meet the following criteria:

6.1 The pipe to soil potential measurements shall be between (-) 0.95 V (ON) and (-) 1.5 V (ON) for polyethylene coated pipe lines, between (-) 0.95 V (ON) and (-) 1.7 V (ON) for fusion bonded epoxy/coal tar coated pipe lines with respect to a copper/copper sulphate reference electrode.

6.2 A positive potential swing of 100 milli volts or more shall be considered sufficient to indicate the presence of an interaction/interference situation requiring investigation and incorporation of mitigation measures by the CONTRACTOR.

7.0 SYSTEM DETAILS

The system shall include the following major equipment/sub-systems unless otherwise specified in project specifications.

- Sacrificial anodes and anode ground beds
- CP system at cased crossings
- Test stations
- Surge diverter and polarisation cell
- Permanent reference cells
- Electrical resistance probes
- Interconnecting cables
- Cables to pipe connections

All equipment shall be new and procured from approved manufacturers. Equipment offered shall be field proven. Equipment requiring specialised 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. All equipment including test stations, anode lead 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 flame proof type and shall meet the requirement of IS: 2148 or equivalent international standard and shall be suitable for gas group IIB, temperature class T3 (200°C). Indigenous equipment shall be certified by CMRI or any other recognised testing body and shall be approved by the concerned statutory authority. All flameproof equipment shall carry the BIS license marking as per the requirement of statutory authorities.

All Imported equipment for hazardous area may be tested and certified by an independent certifying agency of country of equipment origin and shall be approved by the concerned statutory authority in India.

7.1 Anode Ground Beds

Along ROW where soil resistivity predominantly remains low, ranges from 0-10 ohm. m and pH value is within 9, zinc anodes may be provided.

Anodes of type I as per ASTM-B 418 standard shall be used for seawater, brackish water or saline electrolyte application and anode of type II as per ASTM-B 418 standard shall be used for fresh water, back fill and soil applications.

7.1.1 Along ROW where soil resistivity is predominantly in the range of 10 ohm. m to 30 ohm. m, low potential (1.55V) magnesium anodes may be provided.

7.1.2 Along ROW where soil resistivity is predominantly in the range of 30 ohm.m to 50 ohm.m high potential (1.75V) magnesium anodes may be provided.

7.1.3 At high resistivity area where resistivity is of the order of 50 ohm. m and above magnesium ribbon anodes may be provided.

7.1.4 Where magnesium anode is used for protection of polyethylene coated pipelines, the anodes shall preferably of low potential (1.55V) type.

7.1.5 Anodes shall be installed along the pipeline at suitable intervals as per pipeline protection voltage attenuation calculations and ground bed resistance/current output of anode installations. At high resistivity area the magnesium ribbon anodes shall be installed all along the pipeline by the side of the pipeline in the pipeline trench.

7.1.6 Suitability of the selected sacrificial anodes for the soil conditions with particular attention to carbonates, bicarbonates, phosphates and nitrates, shall be checked for proper operation by the contractor. The anodes shall be laid in proper type of back fill, such that the effect of soil is minimum on the anode effectiveness and life. Suitable safe guards against anode passivation in prevailing soil shall be taken by the contractor.
7.1.7 Each electrically continuous section of pipeline shall be protected totally by single type of anode to avoid inter-anode circulation currents.

7.1.8 The anodes shall be installed at sufficient depth to reach moist soil and shall be separated from the pipeline by at least 5 m and 2 m for magnesium and zinc anodes respectively. The magnesium ribbon anode shall be separated from the pipeline by at least half a meter. The anode connections to pipe line shall be routed through test stations.

7.1.9 At the temporary CP anode ground bed, the leads of all the anodes shall be joined together in a junction box filled with epoxy and buried. A single cable shall be routed from the junction box to test station.

7.1.10 For sacrificial anode ground bed which is intended for permanent CP system and/or which is to be integrated with permanent CP system, the leads of all the anodes shall be brought up to the test station and shall be terminated individually.

7.1.11 The number of anodes at each ground bed shall be sufficient for providing the specified pipe protection current density taking into consideration the ground bed resistance, cable resistance, etc. For permanent cathodic protection system, contractor shall prepare a table for number of anodes required at different soil resistivities to produce the specified protection current for the specified designed life. For temporary cathodic protection system, an indicative design data for sacrificial anodes ground bed in tabular form is given in data sheet. The number of anodes for ground bed, spacing of ground beds based on the applicable soil resistivity, size of pipeline, type of coating for the pipeline shall be chosen from the table after necessary verification by the CP contractor. Any deficiency in the protection system if noticed during commissioning or during monitoring shall be corrected by the CP contractor by suitably augmenting the system with additional anodes without any cost/schedule implications.

7.1.12 For the portion of the pipeline for which the CP system has been specified based on the permanent CP system parameters, the contractor shall ascertain the requirement of the cathodic protection current density indicated in clause 5.1 above. Where specified in the project specification/data sheet the requisite current density test/survey shall be conducted by the contractor to establish the adequacy of CP current requirement and number of anode ground beds.

7.2 Test Stations

7.2.1 Test stations shall be provided along the pipeline ROW for monitoring the performance of the cathodic protection system at the following locations. Test stations shall be provided at additional locations, if required, so that distance between any two adjacent test stations does not exceed 1000 meters in inhabited areas and 2000 meters in uninhabited areas like forest/deserts:

   a) At the locations of anode ground beds.
   b) At both sides of metalled road crossings.
   c) At all insulating joints.
   d) At vulnerable locations with drastic changes in soil resistivity.
e) At locations of surge diverters, pipeline grounding through polarisation cells, zinc and magnesium anodes.

f) At EHV/HV AC/DC overhead line crossings and selected locations where EHV/HV overhead line is in the vicinity of the pipeline.

g) At railway line crossings and at selected locations along lines running parallel to the pipeline.

h) At both sides of major river crossings.

i) At EHV/HV cable crossings or along routes where EHV/HV cables are running in parallel.

j) In the vicinity of DC networks or grounding systems and HVDC grounding systems where interference problems are suspected.

k) At crossings of other pipelines/structures.

l) At the locations of reference cell and Electrical Resistance probe installation.

m) At both sides of cased crossings.

n) Locations where interference is expected.

o) At locations of Sectionalising Valve (SV) stations.

p) At any other locations considered necessary by OWNER/OWNER’s representative.

7.2.2 Test stations used for sacrificial anodes shall have shunt for measurement of anode current, provision for resistance insertion to limit the anode current output and anode-disconnecting link.

7.2.3 Test stations for bonding shall be provided with shunt and resistor as a means to monitor and control current flow between the pipeline and foreign pipelines or structures that may exist in common ROW.

7.2.4 Test station with current measuring facility shall be provided at interference prone areas, on both sides of major river crossings, near marshy areas and minimum one for every 10 km max. along the pipeline.

7.2.5 The test stations shall be installed with the face of the test station facing the pipeline. The nameplate of test stations shall carry the following minimum information:

- Chainage in km.
- Test station connection scheme
- Distance from pipeline in metres.
- Direction of product flow.

7.2.6 Terminals and different schemes of wiring shall be provided as per the test station connection scheme. Minimum twenty percent spare terminals shall be provided in each test station.
7.2.7 Minimum two cables shall be provided from the pipeline at any test station.

7.2.8 The location of all the test stations shall be marked with their connection schemes and other relevant informations on alignment sheets. A detailed test-station schedule shall be prepared.

7.3 Permanent Reference Cells

7.3.1 High purity copper-copper sulphate reference cells with proven high reliability shall be provided for stable coupon to soil potential measurement at the locations of polarisation coupons.

7.3.2 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. For marshy area in saline soils, high purity zinc may be considered as an alternative to silver/silver chloride.

7.3.3 The life of reference cells shall be minimum 10 years under burial conditions.

7.3.4 The test station connection scheme inside the test station shall clearly indicate the type of reference cell (Cu CuSO₄/Ag AgCl).

7.4 Electrical Resistance Probe

7.4.1 Where specified in data sheet electrical resistance probes (E/R probes) utilising the electrical resistance technique shall be provided along the pipeline at marshy areas and at vulnerable locations to monitor the external corrosion activity on the pipeline. The lead-wires of the probe shall be connected to pipeline through test station and terminated inside test station enabling periodic resistance measurement of the probe using a portable measuring instrument.

7.4.2 The E/R probes shall be provided preferably at the bottom portion of pipeline. The number of E/R probes, the locations of their installation and the number of portable E/R probe reading instruments shall be as specified in the project specification/data sheet.

7.5 Surge Diverter and polarisation Cell

7.5.1 Surge Diverter

Explosion proof type spark gap surge diverter shall be connected across each insulating joint to protect it from high voltage surges.

7.5.2 Polarisation Cell

(i) Wherever the pipeline is either crossing or running in parallel with overhead EHV/HV transmission lines of voltage grade 66kV and above, it is mandatory that the pipeline shall be grounded to discharge any accumulated potential/surge that may appear in case of transmission line faults, as per below:-

- The pipeline shall be grounded through polarization cell with zinc galvanic anodes of minimum 20kg net weight each at location where pipeline crosses EHV/HV transmission lines.
- The pipeline shall be grounded at regular intervals of maximum 1km where EHV/HV transmission lines run parallel within 25 m of the pipeline.

(ii) Locations along pipeline where continuous induced over-voltage due to other overhead transmission lines/underground cables of voltage grade below 66kV is expected or observed during commissioning, the pipeline shall be grounded through polarisation cell to the earth system of the EHV/HV tower causing the voltage induction or to a separate earthing system of zinc anodes through polarisation cell.

(iii) The polarization cell shall be installed inside test station of suitable size.

(iv) Type of polarization cell shall be as specified in data sheet.

7.5.3 The total system including cable, cable termination, surge diverters/polarisation cells/anodes shall be suitable for the anticipated fault current at the location of its installation.

7.5.4 The surge diverter, polarisation cell and anode system shall be suitable for the design life of permanent CP system. The grounding system shall have minimum resistance to earth to restrict the pipeline voltage as per NACE/VDE criteria but shall not exceed 5 ohms. The anodes shall be pre packed with special backfill adequately so that the performance of the anode is not affected by the carbonates, bicarbonates, nitrates, etc., present in the soil. In any case, the thickness of back fill shall not be less than 50mm on all the sides of the anode.

7.6 Motor operated valves where located on the cathodically protected portion of the pipeline shall be grounded by a zinc or magnesium anode of 20 kg net where the type of anode provided for the CP system of the pipeline is zinc or magnesium respectively. The MOV power supply cable armour shall be insulated (by cutting and taping with insulation tape) at MOV end to avoid armour carrying CP current.

7.7 The above ground cathodically unprotected pipeline at intermediate SV stations, pigging stations, etc. and terminals shall be earthed with GI earth electrodes. The resistance to earth of grounding shall be limited to 5 ohms max.

7.8 CP at cased crossing

7.8.1 At cased crossings where casing is coated, the casing shall be protected by sacrificial anode installations, provided at both ends of casing. The anode installation shall be sized based on the permanent C.P. design parameters and design life of permanent CP system. At cased crossings where casing is painted or uncoated, additional protection for casing pipes may not be provided.

7.8.2 The carrier pipe inside the painted or coated casing shall be protected by zinc ribbon anodes weld connected to the outer surface of bottom of carrier pipe extending up to hour hand positions of 4 and 8 O'clock. The anodes shall be placed at close intervals as per design calculations with minimum one number of anodes installed between every two supports provided between carrier and casing. The anodes shall be sized based on the permanent CP design parameters for marshy area and design life of permanent CP system.
7.8.3 Where casing is bare (i.e. uncoated or unpainted) additional protection for carrier pipe may not be provided.

7.9 Reference Cell Access Points

Reference cell access points shall be provided near insulating joint locations and at SV stations, where the ground is paved, 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.

7.10 Cables

7.10.1 Cables shall be with annealed high conductivity, stranded copper conductor, PVC insulated, 650/1100V grade, armoured, PVC sheathed conforming to IS.1554 Part-I except for the cables for reference cells and pipeline for potential measurement. The size of the copper conductor shall be 6 sq.mm. for anode tail cable from anode to buried junction box or test station (in case of permanent CP anode ground bed), 10 sq.mm. from buried junction box to test station and 10 sq.mm. from test station to pipeline. The size of cable for bonding, polarisation cell, grounding anodes and surge diverter connections shall be suitable for the maximum fault current subject to minimum 25 sq mm. The length of anode tail cable shall be sufficient for routing from anode to buried junction box or test station for anodes for temporary CP or permanent CP respectively.

7.10.2 The cables for reference cells and pipeline potential measurements shall be of 4 sq.mm copper conductor, PVC insulated, Aluminium backed by mylar/polyester tape shielded, PVC sheathed, armoured, PVC over all sheathed type.

8.0 INSTALLATION

8.1 Cable Laying

8.1.1 Cables shall be laid in accordance with the layout drawings to be prepared by the contractor. No straight through joint shall be permitted. Cable route shall be carefully measured and cables cut to required length. Minimum half metre cable slack shall be provided near anodes, pipeline and test stations to account for any settling.

8.1.2 All cables inside station/plant area shall be laid at a depth of 0.75 M. 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.

8.1.3 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.

8.1.4 All underground unarmoured cables including anode tail cables shall run through PE sleeves. The cables routed along the pipeline shall be carried at the top of the carrier pipe by securely strappping it at intervals with adhesive tape or equivalent as required.

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

8.1.7 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 CPTR units, etc.

8.1.8 The armour of all the cables from pipeline to test station (potential measurement, reference cell cables, cathode cables, etc.) and test station to ground bed (anode cable) shall be earthed only at test station end of the cable to avoid armour carrying CP current. The cable armour shall be insulated by cutting and taping with insulation tape.

8.2 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 hydrocarbons shall be avoided.

8.3 Cable to pipe connections

All cable connections to the new pipeline shall be made by an approved exothermic process or by pin brazing. However, cable connection to charged pipelines shall be made by pin brazing. Exothermic welding shall be adopted for water pipelines. The resistance of the cable to pipe at the connection point shall not exceed 0.1 ohm. Coating shall be repaired after connection of cable conductor to pipeline. The coating repair material shall be compatible with the original coating and shall prevent ingress of water along the cable surface and at the interface of coating repair with the original pipe coating.

8.4 Ground bed Fencing

Where specified in project specifications/data sheet a chain link fencing shall be provided around the location of each ground bed, designed based on the permanent CP design parameters.

9.0 FIELD TESTING AND COMMISSIONING

9.1 System testing at site

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

9.1.2 Before the C.P. system 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 required for the intended operation. Owner/Owner’s representative may witness all tests. Intimation shall be given at least one week before commencing the tests.

9.1.3 All tools, equipment and instruments required for testing shall be provided by Contractor.

9.1.4 Generally, the following minimum tests must be carried out and recorded.
i) Cables
- Cable No.
- Voltage grade.
- Conductor cross section.
- Continuity check.
- Voltage test.
- Insulation resistance values between each core & earth, between cores.
- All cables shall be tested by 500 V megger.

ii) Insulating joint
- Location.
- Pipe to soil potential of both protected and non-protected sides of the insulating joint before and after energisation of CP system.

iii) Surge diverter
- Location/identification number.
- Rating
- Type
- Explosion proof enclosure.
- Check for healthiness.
- Check for proper connection.

iv) Polarisation Cell
- Location/Identification number.
- Type.
- Ratings.
- Check for wiring.
- Check standby current drain after CP system energisation. (Current drain with respect to voltage across the cell shall be recorded).
- Details of grounding provided for the polarisation cell.

v) Anode Ground Bed
- Location/Station
- Vertical/horizontal
- Check for actual layout and compliance with drawings.
- Current output of ground bed.
- Current out put of each anode (in case of permanent CP anode ground beds)

vi) E/R Probe
- Location/Identification number
- Checking of wiring as per schematics
- Resistance reading of probe
- Installed on top/bottom/side of the pipeline

vii) Reference Cell
- Location
- Type of cell
- Potential reading
- Installed on top/bottom level of pipeline
9.2 Commissioning

9.2.1 Natural potential of pipe to soil for the complete pipeline and casing pipeline at the locations of cased crossings shall be measured at all the test station locations, recorded prior to connecting anodes to pipe line and casing pipeline respectively.

9.2.2 The anode shall be connected to pipeline in the test station and the pipe to soil potential observation shall be made after allowing sufficient time for polarisation. The current output of each anode at permanent CP anode ground bed or the total current output of anode bed at temporary CP anode ground bed shall also be measured to ensure that it does not exceed the output current capacity of the anodes. In case the anode output current exceeds the rated capacity, it shall be controlled by insertion of resistance element in the anode circuit inside test station and the pipe to soil potential shall be rechecked for adequacy of protection. At locations of polarisation coupons the coupon ‘OFF’ potential shall be measured by switching off the reed switch. Additional anodes shall be provided where required to achieve desired level of protection and to keep the anode out put current with in the rated value. In case pipe to soil potential exceeds the specified value, suitable resistance shall be inserted in the anode circuit to limit the potential.

Anode installation shall become individually operational as above.

9.2.3 At the locations of cased crossings where anode installations are provided for the protection of the casing pipe, these anode installations shall be commissioned as per the procedure detailed in clause 9.2.2. above.

9.2.4 After connecting all the anode ground beds to pipe line, measurement of pipe to soil potentials shall be taken at each test station to ensure conformity to protection criteria.

9.2.5 In case of insufficient protection as per the CP design criteria, on any portion of the pipeline/casing pipeline (at cased crossings where casing is cathodically protected) Contractor shall carry out necessary additions/modifications to the provided protection in consultation with the Owner/Owner’s representative.

9.2.6 Resistance readings of the probe shall be taken at all the locations of electrical resistance probes.

10.0 INTERFERENCE MITIGATION

10.1 Investigations shall be made for stray current electrolysis of the pipeline, mutual interference between the pipeline and foreign pipelines/structures, interference on foreign pipelines/structures due to the CP of the pipeline and ground bed, AC induction on pipeline due to 11 KV and above overhead HV/EHV line, interference due to high voltage DC line, HVDC groundings, electric traction etc.

10.2 Where transmission lines cross the pipeline or run in parallel within or more than 25m from the pipeline, AC voltage measurements shall also be made on the pipeline to find out continuous induction of voltage. In case of induced voltage being beyond safe limits, the pipeline shall be grounded in line with clause no.7.5 above.

10.3 Measurements including pipe/structure to soil potential and pipeline/structure current etc. on the pipeline/structure being CP protected and on foreign pipelines/structures shall be
made to investigate the current discharge and pickup locations. In case of fluctuating stray current, investigations shall be made continuously over a period of time and if required simultaneously at different locations to find out the stray current source(s). For measurements over longer durations, recorders shall preferably be used.

10.4 Where foreign pipelines (unprotected or protected by independent CP system) run in parallel to the pipeline in same trench or very near to the pipeline, and are not bonded to the pipeline then investigation shall be made for current discharge points on both the pipelines.

10.5 Mitigation measures shall be provided depending on type of stray current electrolysis/interference. These shall include installation of bond with variable resistor, diodes, installation of galvanic anodes for auxiliary drainage of current, adjustment/relocation (if possible) of offending interference source, provision of electrical shield etc. depending on the type of interference.

10.6 Bonding with foreign pipeline/structure, as a mitigation measure shall be provided where the owner of the foreign pipeline/structure has no objection, otherwise alternative mitigation measure shall be provided. Where bonding is provided for mitigation, the bonding resistor shall be adjusted for optimum value for minimum/no interference. Galvanic anodes installed as a mitigation measure shall be sized for the design life specified for permanent CP.

11.0 SYSTEM MONITORING

Where the CP system provided is temporary, the C.P. system shall be monitored at all test stations once in a month for healthiness/adequacy of protection till commissioning of permanent CP or for design life of temporary CP specified, which ever is less. During this period if any deficiency/interference in protection system is noticed, the same shall be rectified/augmented by providing additional anodes as required. The monitoring report shall be submitted regularly to owner for his review/information.

12.0 CLOSE INTERVAL POTENTIAL LOGGING SURVEY

Where specified in project specification/data sheet, contractor shall carry out a close interval potential survey over the entire length of pipeline by computerised potential logging method and identify the under protected/over protected area, any major coating damage on the pipeline, after the back-filling has been consolidated sufficiently and CP system has stabilized. Contractor shall provide required mitigation measures and rectify the under/over-protected zones, identify if any, the major pipeline coating defects required to be repaired. During the survey the reference cell shall be calibrated minimum once in 24 hours.

Where specified in the project specification/data sheet, additional tests for detailed identification of coating defects shall be conducted by the contractor.
पाइपलाइनों की इम्प्रेस्ड करेंट कैथोडिक संरक्षण प्रणाली के लिए विनिर्देश

SPECIFICATION FOR IMPRESSED CURRENT CATHODIC PROTECTION SYSTEM FOR PIPELINES

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Format No. 8-00-0001-F1 Rev. 0

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### Abbreviations:

<table>
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<th>Abbreviation</th>
<th>Description</th>
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<tr>
<td>AC</td>
<td>Alternating current</td>
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<tr>
<td>BS</td>
<td>British Standards</td>
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<tr>
<td>BIS</td>
<td>Bureau of Indian Standards</td>
</tr>
<tr>
<td>CP</td>
<td>Cathodic Protection</td>
</tr>
<tr>
<td>CMRI</td>
<td>Central Mining Research Institute</td>
</tr>
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<td>CPPSM</td>
<td>Cathodic Protection Power Supply Module</td>
</tr>
<tr>
<td>CPTTR</td>
<td>Cathodic Protection Transformer Rectifier</td>
</tr>
<tr>
<td>CTE</td>
<td>Coal tar enamel</td>
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<tr>
<td>DC</td>
<td>Direct Current</td>
</tr>
<tr>
<td>EHV</td>
<td>Extra High Voltage</td>
</tr>
<tr>
<td>FBE</td>
<td>Fusion bonding epoxy</td>
</tr>
<tr>
<td>HDD</td>
<td>Horizontal Directional Drilling</td>
</tr>
<tr>
<td>HV</td>
<td>High Voltage</td>
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<td>HVDC</td>
<td>High Voltage Direct Current</td>
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<td>IS</td>
<td>Indian Standards</td>
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<tr>
<td>MOV</td>
<td>Motor operated valve</td>
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<tr>
<td>Micro A/mm²</td>
<td>Micro-ampere per square millimeter</td>
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<tr>
<td>NACE</td>
<td>National Association of Corrosion Engineers</td>
</tr>
<tr>
<td>PE</td>
<td>Polyethylene</td>
</tr>
<tr>
<td>PVC</td>
<td>Polyvinyl Chloride</td>
</tr>
<tr>
<td>ROW</td>
<td>Right of way</td>
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<td>SV</td>
<td>Sectionalizing Valve</td>
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### Electrical Standards Committee

**Convenor:**  Mr. A. Ananthanarayan  
**Members:**  Mr. V.P. Sharma  
Mr. K.V. Subramanyam  
Mr. C.R. Mandal/Mr. Ashok Chaudhary  
Mr. S.K. Kaul  
Mr. U.A. Patro
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11.0 CLOSE INTERVAL POTENTIAL SURVEY
1.0 SCOPE

1.1 This specification defines the requirements of system design, engineering, installation, testing and commissioning of an Impressed Current Cathodic Protection System for cross-country onshore underground pipelines/structures including supplementing of corrosion survey, close interval potential logging survey, investigations for interaction/interference problems and mitigation of the same.

1.2 This specification provides the basic parameters to develop a suitable impressed current cathodic protection system for the pipelines/structures requiring protection. All data required in this context shall be taken into consideration to develop an acceptable design and for proper engineering of the system.

1.3 Compliance with these specifications, and/or approval of any documents submitted by contractor shall in no case relieve the contractor of his contractual obligations.

2.0 APPLICABLE CODES AND STANDARDS

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

i) NACE Standard RP-0169 : Standard Recommended Practice Control of External Corrosion on Underground or Submerged Metallic Piping Systems

ii) NACE Publication 10A190 : Measurement technique related to criteria for CP of Underground or Submerged Steel Piping System (as defined in NACE Standard RPO169-83)

iii) NACE Standard RP-0177 : Standard Recommended Practice Mitigation of Alternating Current and Lightning Effects on Metallic Structures and Corrosion Control Systems

iv) NACE Standard RP-0286 : Standard Recommended Practice The Electrical isolation of Cathodically Protected Pipelines.

v) NACE Publication No. 54276: Cathodic Protection Monitoring for Buried Pipelines.


vii) IS 8062 : Recommended Practice ICCP for Underground Piping

viii) BS 7361 Part I : Code of Practice for Cathodic Protection for land and marine application.
ix) VDE 0150 : Protection against Corrosion due to Stray Current from DC Installations.

x) IS:1554 Part I : PVC insulated (heavy duty) cables

2.2 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.

2.3 The equipment shall also confirm to the provisions of Indian Electricity rules and other statutory regulations currently in force in the country.

2.4 In case of any contradiction between various referred standards/ specifications/ data sheet and statutory regulations the following order of priority shall govern:

- Statutory regulations.
- Data sheets.
- Job specification.
- This specification.
- Codes and standards.

3.0 SYSTEM IMPLEMENTATION

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

i) Corrosion survey data interpretation report and plot plans for land acquisition.
ii) Conceptual system design.
iii) Basic engineering package.
iv) Detailed engineering package.
v) Field testing and commissioning procedures.
vi) Procedures for interference testing and mitigation.
vii) Close interval potential logging survey procedure.
viii) As built documentation.

4.0 CORROSION SURVEY

4.1 General

4.1.1 The details of corrosion survey including soil resistivity data along ROW and other data required for C.P design if available with the Owner shall be included as part of project specification/data sheet. However, verification of its veracity and adequacy shall be the entire responsibility of the contractor. In addition, contractor shall have to generate/collect additional data as per clause 4.4 below required for completeness of the job.

Contractor shall carry out soil resistivity survey at anode ground bed locations for design of ground bed. Where specified in the data sheet, Contractor shall carry out corrosion survey along the ROW of the pipeline conforming to the specifications included in the tender document.
4.1.2 To carry out soil resistivity measurement Wenner’s 4-pin method or an equivalent method approved by Owner shall be used. Survey instruments shall have maximum AC and DC ground current rejection feature.

Care shall be taken to ensure that the resistivity observations are not influenced by the presence of foreign pipelines/structures, and earth currents in the vicinity of EHV/HV lines and installations using earth return in their power system etc.

4.2 Soil Resistivity Survey At Impressed Current Anode Ground Bed Plot

4.2.1 Each selected anode bed plot shall be sub-divided into sub-plots. Sizes of sub-plots shall depend upon the expected depth for soil resistivity investigations. Each of these sub-plots shall be investigated for resistivity data individually. Sufficient observations shall be taken at each of these sub-plots as required and desired by Owner/Owner’s representative to obtain sufficient information about sub-soil stratification and, wherever possible, to establish the depth of water table. The number of subplots at each ground bed plot shall be decided at site in consultation with Owner/Owner’s representative.

4.2.2 Number, location, demarcation and size of sub-plots and number of sets of resistivity observations required for each sub-plot shall be individually decided for each ground bed plot location.

4.2.3 One or more ground bed plots may be required to be selected and surveyed at each CP station to form a suitable ground bed.

4.3 Topographic Surveys

Cathodic protection stations consisting of 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 the CONTRACTOR, which shall be suitable for use in land acquisition etc.

4.4 Additional Data to be Collected

The following data shall be collected to generate design data for evaluation of interaction/interference possibilities due to presence of other services in ROW or in its vicinity. OWNER shall provide assistance for liaison work to the extent possible.

i) Route and types of foreign service/pipeline in and around or crossing the right of way (including those existing and those which are likely to come up during contract execution).

ii) Diameter, wall thickness, pressure, soil cover, and coating scheme used, type of cathodic protection system provided, if any, year of laying/commissioning in case of foreign pipelines.

iii) Details of the existing cathodic protection systems protecting the services i.e. type of protection, location, type, rating of anode beds, test station locations and their connection schemes. Present output current and voltage readings of the CP power supply units.

iv) Remedial measures existing on foreign pipelines/services to prevent interaction.
v) Graphical representation of existing structure/pipe-to-soil potential records.

vi) Possibility of integration/isolation of CP systems, which may involve negotiations with owners of other services.

vii) Existing and proposed DC/AC power sources and systems using earth return path such as HVDC substations/earthing stations, fabrication yards with electric welding etc. in the vicinity of the entire pipeline route.

viii) Crossing and parallel running of electrified and non-electrified traction (alongwith information regarding, operating voltage, AC/DC type etc.) as well as abandoned tracks near ROW having electrical continuity with the tracks in use.

ix) Crossing or parallel running of any existing or proposed EHV/HV AC/DC overhead power lines along with details of voltage, AC/DC type etc.

x) Voltage rating, phases, sheathing details of underground power cables along ROW or in its vicinity.

xi) Any other relevant information that may be needed in designing and implementing proper cathodic protection scheme for the proposed pipeline.

Contractor shall conduct necessary potential gradient surveys for any existing anode ground beds that may interfere with the CP system of the pipelines covered under this project.

4.5 Report

On completion of all field work, a report incorporating all the results generated from surveys and details of additional data collected shall be prepared. The report shall also contain detailed interpretation of survey results and resistivity data, probable interference prone areas, selected locations for anode ground beds, etc., to form a design basis for the scheme of cathodic protection. This report shall also include various drawings prepared in connection with the above work. Soil resistivity values shall be plotted on semilog graph sheets.

5.0 CATHODIC PROTECTION DESIGN PARAMETERS

A distinctly independent impressed current cathodic protection system shall be provided to protect the external surfaces of the complete pipeline/structure installation as specified.

Unless otherwise stated in the data sheets, the following parameters shall be used for design of permanent cathodic protection system:

5.1 Protection Current Density Range

i) Pipe lines having coal tar enamel (CTE) coating with two/three layers of reinforcement.
**ii) Pipe lines having fusion bonded epoxy (FBE) coating:**

<table>
<thead>
<tr>
<th>Pipeline surrounding</th>
<th>Minimum Protection Current Density* $(\mu A/m^2)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil resistivity more than 100 ohm. m</td>
<td>200</td>
</tr>
<tr>
<td>Soil resistivity 10 ohm m to 100 ohm.m</td>
<td>300</td>
</tr>
<tr>
<td>Soil resistivity less than 10 ohm. m</td>
<td>2000</td>
</tr>
<tr>
<td>Sea water</td>
<td>5000</td>
</tr>
</tbody>
</table>

**iii) Pipe lines having polyethylene (PE) coating**

<table>
<thead>
<tr>
<th>Pipeline surrounding</th>
<th>Minimum Protection Current Density* $(\mu A/m^2)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil resistivity more than 100 ohm. m</td>
<td>90</td>
</tr>
<tr>
<td>Soil resistivity 10 ohm m to 100 ohm.m</td>
<td>125</td>
</tr>
<tr>
<td>Soil resistivity less than 10 ohm. m</td>
<td>500</td>
</tr>
</tbody>
</table>

* Actual current density to be adopted shall be decided based upon soil and other environmental conditions, current drainage survey data, proximity of foreign pipe lines/structures and other interference areas affecting the installation. Where considered necessary for satisfactory protection of pipeline the current density shall be suitably increased by contractor. Also refer to clause 7.1 iv) below.

At HDD (horizontal directional drilling) crossing, the pipe protection current density applicable for marshy area shall be considered.

5.2 The pipe protection Current Density indicated in the clause 5.1 above shall be applicable where the temperature of the fluid transported by the pipeline/ the surface temperature of the buried portion of the pipeline does not exceed 30º C. Where this temperature exceeds 30º C, the protection Current Density shall be increased suitably in consultation with the Owner/EIL.
5.3 Safety factor for current density : 1.3
5.4 Anode utilisation factor:
   (For high silicon cast iron anode):
   - 0.85 for centre connected anode.
   - 0.6 for end connected anode.
5.5 Anode surface current density:
   (For high silicon cast iron anode,
   for continuous operation):
   - 15 Amp./sq.m (max.) for shallow anode ground bed
   - 10 Amp./sq.m (max.) for deep well anode ground bed
5.6 Anode consumption rate:
   (For high silicon cast iron anode):
   - 0.2 kg./Amp.yr.
5.7 Pipeline natural potential:
   - (-) 0.45 V
5.8 Design life of CP system:
   - 30 years, unless specified otherwise in the data sheet.
5.9 Anode ground bed loop resistance:
   including anode to ground resistance,
   anode and cathode cable resistances:
   - 1 ohm (max.)

(The output voltage rating of the CPTR unit / CPPSM 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).

5.10 For mixed metal oxide coated titanium anodes the anode utilisation factor, anode surface current density and anode consumption rate etc. shall be as per the guaranteed values published by the manufacturer and supported by test certificates/field proven ness.

6.0 CATHODIC PROTECTION DESIGN CRITERIA

Cathodic protection system shall be designed to meet the following criteria:

i) The pipe to soil potential measurements shall be between (-) 0.9V (OFF) and (-) 1.18V (OFF) with respect to a copper/copper sulphate reference electrode.

ii) In rare circumstances, a minimum polarisation shift of (-) 100 millivolts may be accepted as an adequate level of cathodic protection for the pipeline with the approval of Owner.

iii) A positive potential swing of 100 millivolts or more shall be considered sufficient to indicate the presence of an interaction/interference situation requiring investigation and incorporation of mitigation measures by the CONTRACTOR.

7.0 SYSTEM DETAILS

The system shall include the following major equipment/sub-systems unless otherwise specified in project specifications:

- CP stations
- CPTR units/cathodic protection power supply modules (CPPSM).
- Anode ground beds and anodes
- Anode junction box
- Cathode junction box
- Test stations
- Permanent reference cells
- Electrical resistance probes
- Polarisation cell and surge diverter
- Polarisation coupons
- Computerized Test Stations
- CP system at cased crossing
- Bond Stations
- Cables

All equipment shall be new and procured from approved reputed manufacturers. Equipment offered shall be field proven. Equipment requiring specialised maintenance or operation shall be avoided as far as possible. Prototype equipment shall not be accepted.

All equipment/materials shall conform to the relevant specifications included in the tender document.

All equipment including CPTR unit, CPPSM, test stations, anode lead 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: 2148 or equivalent international standard and shall be suitable for gas group IIB, temperature class T3 (200°C). Indigenous equipment shall be certified by CMRI or any other recognised testing body and shall be approved by the concerned statutory authority. All flameproof equipment shall carry the BIS license marking as per the requirement of statutory authorities.

All Imported equipment for hazardous area may be tested and certified by an independent certifying agency of country of equipment origin and shall be approved by the concerned statutory authority in India.

7.1 Cathodic Protection Stations

The number and exact locations of CP stations shall be worked out based on the corrosion survey data collected. In addition, the following guidelines shall be followed for selecting the locations:

i) Number of CP stations and their selected locations shall ensure that these remain valid and are adequate for the full design life of the system after considering all foreseeable factors.

ii) As far as possible, the availability of nearby low resistivity areas for location of associated ground beds must be ensured while selecting the locations of CP stations.

iii) As far as possible, locations of intermediate CP stations shall coincide with the locations of SV stations.

iv) The proposed locations of CP stations and anode ground bed current ratings are detailed in project specifications/data sheets. The same shall be verified for adequacy by the contractor. The requisite current drainage tests/survey shall be conducted by the contractor.
to establish the adequacy of CP current requirement indicated in clause 5.0 above and adequacy of number, ratings of CP stations for permanent CP system indicated in the data sheet. The minimum end of life pipe protection current requirement shall be considered as the current requirement indicated in the clause 5.0 above or 3 times the current density value measured by the current drainage survey for polyethylene coated pipeline and 4 times the current density value measured by the current drainage survey for fusion bonded epoxy, coal tar enamel with reinforcement coated pipeline, whichever is maximum.

7.2 **CP Transformer Rectifier Unit/CPPSM**

If specified in project specifications/data sheet, the supply, installation, testing and commissioning of cathodic protection power supply module (CPPSM) /indoor type Cathodic Protection Transformer Rectifier Unit (CPTR unit)/ outdoor type CPTR unit installed in kiosk along with kiosk shall be included in contractor's scope. The CP TR units shall be provided at CP stations where reliable AC power supply is available. CPPSM shall be provided at other CP stations where reliable DC power supply instead of reliable AC power supply is available. The CPTR unit/CPPSM shall be installed in non-hazardous (safe) area as specified in data sheets.

7.3 **Anode Ground Beds**

i) Each CP station shall have an independent anode ground bed, which may be of shallow or deep well construction depending upon the data collected by the contractor. Deep well ground beds may also be used in the congested locations where availability of suitable land for spread out ground beds is restricted.

ii) Ground bed shall be located electrically remote from the pipeline and foreign pipeline/ other buried metallic structures. Nearest part of the anode bed shall at least be 100 meters away from the pipeline and foreign pipeline/ other buried metallic structures. The anodes installed in the ground shall be located in perennially moist strata, wherever possible. Horizontal ground beds shall be at right angles to the pipeline, as far as possible.

The location of ground bed shall be checked and ensured for remoteness from the pipeline and other buried foreign pipelines/structures, building foundations, switchyards, electrical earthing systems, etc.

iii) Unless otherwise agreed, anodes shall be of high silicon cast iron type or mixed metal oxide coated titanium anodes.

iv) Sheet steel anode canisters of adequate size shall be provided for each anode. Anode canisters shall be filled with petroleum coke breeze. In case of deep well ground beds non-canistered anodes with petroleum coke breeze in the well surrounding the anodes shall be provided.

v) Each shallow anode-bed shall contain anodes with canisters positioned horizontally or vertically in the soil with suitable backfill. The depth of anodes (depth of top of anode in case of vertically laid anodes) shall not be less than 2 meter from grade level.

vi) Layout of anode installation in anode bed shall be detailed out in drawings showing anode installation details, anode grouping, anode wiring, anode cable routing, etc. The deep well anode ground bed details shall include the details of anodes, deep well casing, anode positioning, anode cable supporting, deep well gas venting, active, passive portions of the ground bed, etc.
vii) Anodes shall be supplied complete with tail cables, which shall be long enough for termination on their associated anode lead junction boxes without intermediate joints. Exact lengths and termination details shall be indicated in construction drawings.

viii) Potential gradient around the anode bed shall be within safety requirements with regard to interference on foreign structures and its effective boundary shall be defined.

ix) In case of two parallel pipelines running in the same ROW, the anode ground beds of the respective pipelines shall be located on the respective sides of the pipelines.

7.4 Anode Junction Box

Depending on the size and configuration of anode ground beds, one or more anode junction boxes shall be provided at each ground bed. 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 shall have provision for measurement and control of individual circuit/anode current.

7.5 Cathode Junction Box

Where output of the CP power supply unit is connected to multiple pipelines a cathode junction box shall be provided near the pipelines at the location of connection of the negative drainage cable to the pipelines.

The negative of the CP power source shall be connected to the incoming circuit of the cathode junction box. The junction box shall have separate outgoing circuit one for each pipeline to collect the negative drainage currents from each of the parallel pipelines.

The incoming circuit shall have a current measurement facility. Each outgoing circuits shall have provision for measurement and control of current.

7.6 Test Stations

7.6.1 Test stations shall be provided along the pipeline ROW for monitoring the performance of the cathodic protection system at the following locations. Test stations shall be provided at additional locations, if required, so that distance between any two adjacent test stations does not exceed 1000 meters in inhabited areas and 2000 meters in uninhabited areas like forest/deserts:

i) At all insulating joints.

ii) At both sides of metalled road crossings.

iii) At vulnerable locations with drastic changes in soil resistivity.

iv) At locations of surge diverters, pipeline grounding through polarisation cells, zinc and magnesium anodes.

v) At EHV/HV AC/DC overhead line crossings and selected locations where EHV/HV overhead line is in the vicinity of the pipeline.
vi) At railway line crossings and at selected locations along lines running parallel to the pipeline.

vii) At both sides of major river crossings.

viii) At EHV/HV cable crossings or along routes where EHV/HV cables are running in parallel.

ix) In the vicinity of DC networks or grounding systems and HVDC grounding systems where interference problems are suspected.

x) At crossings of other pipelines/structures.

xi) At the locations of reference cell, electrical resistance probe and polarization coupon installation.

xii) At the location of computerised test stations.

xiii) At both sides of cased crossings.

xiv) Locations where interference is expected.

xv) At locations of sectionalising valve (SV) stations.

xvi) At any other locations considered necessary by Owner/Owner’s representative

7.6.2 Test stations for bonding shall be provided with shunt and resistor as a means to monitor and control current flow between the pipeline and foreign pipelines or structures that may exist in common ROW.

7.6.3 Test stations with current measuring facility shall be provided at each CP station drainage point (to measure pipeline current on any one side of pipeline from drainage point at intermediate CP station and towards protected side of the pipeline at starting, end point CP stations), at interference prone areas, on both sides of major river crossings, near marshy areas and minimum one for every 10 km max. along the pipeline.

7.6.4 Test stations shall be installed with the face of the test station facing the pipeline. The nameplate of test stations shall carry the following minimum information:

- Chainage in km.
- Test station connection scheme
- Distance from pipeline in meter.
- Direction of product flow.

7.6.5 Number of terminals and different schemes of wiring shall be as per the test station connection scheme. Minimum twenty percent spare terminals shall be provided in each test station.

7.6.6 Minimum two cables from the pipeline shall be provided at any test station.

7.6.7 The location of all the test stations shall be marked with their connection schemes and other relevant information on alignment sheets. A detailed test-station schedule shall be prepared.
7.7 Permanent Reference Cells

7.7.1 High purity copper/copper sulphate reference cells with proven high reliability shall be provided for stable pipe to soil potential measurement at CP stations, polarization coupons and computerized test station locations along ROW.

7.7.2 Silver/Silver Chloride reference cells in place of copper/copper sulphate cells shall be provided at marshy area locations, where water table is high and chloride concentration is more than 300 ppm. For marshy area in saline soil, high purity zinc may be considered as an alternative to silver/silver chloride. The test station connection scheme shall clearly indicate the type of the reference electrode (Cu CuSO₄/Ag AgCl) at these locations.

7.7.3 The life of the reference cells shall be minimum 10 years under the installed conditions.

7.7.4 The cable from reference cells shall be provided up to CP power source at CP stations and up to test stations at the locations of polarization coupons, computerised test stations. The cable up to CP power source shall be routed through test stations near pipeline.

7.8 Electrical Resistance Probe

7.8.1 Where specified in project specification/data sheet electrical resistance probes (E/R probes) utilising the electrical resistance technique shall be provided along the pipeline at marshy areas and at vulnerable locations to monitor the external corrosion activity on the pipeline. The lead-wires of the probe shall be connected to pipeline through test station and terminated inside test station enabling periodic resistance measurement of the probe using a portable probe measuring instrument.

7.8.2 The material of the E/R probe element shall be of the same alloy as of the pipeline material. The probes shall be provided preferably at the bottom portion of pipeline.

7.8.3 The number of E/R probes, the locations of their installation and the number of portable E/R probe reading instruments shall be as specified in the project specification/data sheet.

7.9 Polarisation Cell and Surge Diverter

7.9.1 Polarisation Cell

i) Wherever the pipeline is either crossing or running in parallel with overhead EHV/HV transmission lines of voltage grade 66kV and above, it is mandatory that the pipeline shall be grounded to discharge any accumulated potential/surge that may appear in case of transmission line faults, as per below:-

- The pipeline shall be grounded through polarization cell with zinc galvanic anodes of minimum 20kg net weight each at location where pipeline crosses EHV/HV transmission lines.

- The pipeline shall be grounded at regular intervals of maximum 1km where EHV/HV transmission lines run parallel within 25m of the pipeline.

ii) Locations along pipeline where continuous induced over-voltage due to other overhead transmission lines/underground cables of voltage grade below 66kV is expected or observed during commissioning, the pipeline shall be grounded through polarisation cell to the earth
system of the EHV/HV tower causing the voltage induction or to a separate earthing system of zinc anodes through polarisation cell.

iii) Polarisation cell shall be installed inside test station of suitable size.

iv) Type of polarization cell shall be as specified in data sheet.

7.9.2 Surge Diverter

Explosion proof spark gap surge diverter shall be provided across each insulating joint to protect it from high voltage surges. surge diverters shall be suitable for installation in classified areas.

7.9.3 The total system including cables, cable termination, anodes/surge diverters, polarisation cell shall be suitable for the anticipated fault current at the location of installation.

7.9.4 The surge diverter and polarisation cell system shall be suitable for the design life of permanent CP system. The grounding system shall have minimum resistance to earth to restrict the pipeline voltage as per NACE/VDE criteria but shall not exceed 5 ohms.

7.9.5 The anodes shall be pre packed with special backfill adequately so that the performance of the anode is not affected by the carbonates, bicarbonates, nitrates, etc., present in the soil. In any case, the thickness of back fill shall not be less than 50mm on all the sides of the anode.

7.10 Motor operated valves where located on the cathodically protected portion of the pipeline shall be grounded by a zinc anode of 20 kg net. Magnesium anodes grounding, if any, provided during temporary CP system shall be disconnected. The MOV power supply cable armour shall be insulated (by cutting and taping with insulation tape) at MOV end to avoid armour carrying CP current.

7.11 The above ground cathodically unprotected pipeline at terminals, intermediate SV stations, pigging stations, etc. shall be earthed with GI earth electrodes. The resistance to earth of grounding shall be limited to 5 ohms max.

7.12 Polarisation Coupons

Where specified in the project specification/data sheet steel coupons of pipeline material shall be provided along the pipeline to monitor the adequacy of the CP system to polarize/protect coating holidays. Coupon shall be installed at CP station drainage points, predicted cathodic protection mid points along the pipeline, at locations where the pipeline is bonded to foreign pipeline/structures, interference prone areas, marshy areas and at other locations such that minimum one coupon is installed maximum every 10 km approximate or the maximum interval specified in the project specification/data sheet, along the pipe line.

Coupons shall be installed at bottom 1/3rd portion of the pipeline and 250 mm away from the pipe surface.

The coupons shall be constructed from the pipeline material and shall have uncoated surface of 100 mm x 100 mm 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 hall be connected through a magnetic reed switch inside the test station to enable measurement of coupon ‘OFF’ potential.
A permanent reference electrode shall be installed adjacent to the coupon in a manner so as to measure the representative potential of the coupon.

Magnets for operation of reed switch shall be provided as specified in the project specification/data sheet.

7.13 **Computerized Test Stations**

Where specified in the project specification/data sheet computerized test stations shall be provided along the ROW of the pipeline for automatically monitoring and recording the pipe to soil potential, pipe current, etc. of the pipeline, casing pipeline and foreign pipelines, etc., as required. The computer with in the test station shall measure and record these parameters regularly at programmed intervals. The computers shall have required number of input ports for measurement of potentials and current as applicable at the location of its installation. Computers shall have real time clock and record the time of data measurement. Each computer shall an identification number incorporated in its software, which shall be clearly indicated along with the data display/print out.

The computers shall be programmed to collect and store all the field parameters at intervals as specified in the project specification/data sheet.

Data-retrieval computer of portable type suitable for use in field shall be provided as specified in the project specification/data sheet for programming the field computers and retrieving the data stored by the field computers.

7.14 **CP at Cased Crossing**

7.14.1 At cased crossings where casing is coated, the casing shall be protected by sacrificial anode installations provided at both ends of casing. The anode installation shall be sized based on the permanent C.P. design parameters and design life of permanent CP system. At cased crossings where casing is uncoated or painted, additional protection for casing pipes may not be provided.

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

7.14.3 Where casing is uncoated or unpainted additional protection for carrier pipe may not be provided.

7.15 **Reference Cell Access Points**

*Reference cell access points shall be provided near insulating joint locations and at SV stations, where the ground is paved, 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.*
7.16 Cables

7.16.1 Cables shall be with annealed high conductivity stranded copper conductor, PVC insulated, 650/1100 V grade, armoured, PVC sheathed conforming to IS 1554 part-I, except for the cables for anode tail, reference cells and pipeline for potential measurements. The size of the copper conductor shall be minimum 35 sq.mm. for anode and cathode cables, 6 sq.mm. for current measurement, 10 sq.mm. for anode tail cables and polarization coupon protection cables. The size of cable for bonding, polarisation cell, grounding anodes and surge diverter connections shall be suitable for the maximum fault current subject to minimum 25 sq mm.

7.16.2 The anode tail cables shall be PE insulated, 650V grade, unarmoured, PVC sheathed and length shall be sufficient for termination on anode lead junction box without any joint in between.

7.16.3 The cables for reference cells, coupon and pipeline potential measurements shall be of 4 sq.mm copper conductor, PVC insulated, Aluminium backed by mylar/polyester tape shielded, PVC sheathed, armoured, PVC over all sheathed type.

7.16.4 The CPTR unit incomer cable shall be minimum 4 sq.mm. Copper conductor, 650/1100 V grade, PVC insulated, armoured, PVC sheathed. The cable shall be of 3 core type for single phase CPTR units and of 4 core type for 3 phase CPTR units.

7.16.5 The cables for connecting various transducers from CPTR unit/CPPSM to telemetry interface junction box shall be twisted pair with individual pair shielded and overall shielded with aluminium backed by mylar/polyester tape, PVC sheathed, armoured, PVC over all sheathed type.

8.0 INSTALLATION

8.1 Cable Laying

i) Cables shall be laid in accordance with layout drawings to be prepared by the contractor. No straight through joint shall be permitted. Cable route shall be carefully measured and cables cut to required length. Minimum half metre cable slack shall be provided near anodes, anode junction box, pipeline and test stations to account for any settling.

ii) All cables inside station/plant area shall be laid at a depth of 0.75 metre. Cables outside station/plant area shall be laid at a depth of minimum 1.5 metres. Cables shall be laid in sand under brick cover and back filled with normal soil. For cables laid outside the station/plant area, polyethylene warning mats shall be placed at a depth of 0.9 metre from the finished grade, to mark the route.

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

iv) All underground unarmoured cables including anode tail cables shall run through PE sleeves. Distant measurement cables and permanent reference cell cables routed along the pipeline shall be carried at the top of the carrier pipe by securely strapping it at intervals with adhesive tape or equivalent as required.

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

vii) 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 CPTR Units etc.

viii) The armour of the cables from CP station to test station (potential measurement, reference cell & drainage cables etc.), CP station to ground bed (anode cable) and test station to pipeline shall be earthed only at CP station end and test station end respectively of the cables. The cable armour shall be insulated (by taping with insulation tape) to avoid armour carrying CP current.

8.2 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 hydrocarbons shall be avoided.

8.3 Cable to Pipe Connections

All cable connections of other than cathode drainage cables to the new pipeline shall be made by an approved exothermic process or by pin brazing. However, cable connection to charged pipelines shall be made by pin brazing. Exothermic welding shall be adopted for water pipelines. The resistance of the cable to pipe at the pin brazing connection point shall not exceed 0.1 ohm.

The cathode drainage cable shall be connected to a bolt welded to a metal plate, which is weld connected to the pipeline. The material of the plate shall be same as that of the material of the pipeline.

Pipe coating shall be repaired after connection of cable to pipeline. At cathode drainage point the cable joint including the bolt, metal plate and the 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.

8.4 Ground Bed Fencing

Where specified in project specifications/data sheet chain link fencing shall be provided around the location of each ground bed/anode lead junction box.

9.0 FIELD TESTING AND COMMISSIONING

9.1 System testing at site

Field tests as per the reviewed field testing and commissioning procedures prepared by the Contractor, shall be carried out on the equipment/systems before these are put into service. Acceptance of the complete installation shall be contingent upon inspection and test results. Field testing shall include but not be limited to the following:
i) Contractor 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 Contractor.

ii) Before the electrical facilities are put into operation, necessary tests shall be carried out to establish that all equipment and devices have been correctly installed, connected and are in good working condition as required for the intended operation. Owner/Owners representative may witness all tests. At least one week’s intimation notice shall be given before commencing the tests.

iii) All tools, equipment and instruments required for testing shall be provided by Contractor.

iv) Generally, the following minimum tests must be carried out and results shall 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.

a) Cables

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

b) E/R Probe

- Location/Identification number
- Checking of wiring as per schematics
- Resistance reading of probe
- Installed on top/bottom/side of the pipeline

c) Reference Cell

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

d) Insulating joint

- Location
- Pipe to soil potential of both protected and non-protected sides of the insulating joint before and after energisation of CP system.
e) Surge diverter

- Location/identification number.
- Rating
- Type
- Check for healthiness.

f) Polarisation Cell

- Location/Identification number
- Rating
- Check for wiring
- Check standby current drain after CP system energisation. (Current drain with respect to voltage across the cell shall be recorded).
- Details of grounding provided for the polarisation cell.

g) Anode Ground Bed

- Location/Station
- Check for actual layout and compliance with drawings.

- Resistance of each individual anode.
- Current dissipation by each individual anode.
- Total resistance of complete anode bed.
- Mutual interference.

h) Computerised test station

- Location/Identification number
- Checking of wiring as per schematics
- Checking programmed interval for collection of the field data by the computer
- Type of reference cell

i) Polarisation Coupons

- Location
- Exposed area/size of coupon.
- Coupon to soil ‘ON’ and ‘OFF’ potentials.
- Type of reference cell.
- Magnetic reed switch rating.
- Operation of magnetic reed switch with magnet.

9.2 CP Commissioning Procedure

A model commissioning procedure for a three stations CP system of a pipeline is given below for general guidance. Contractor shall develop detailed commissioning procedure as per this guideline.

i) On completion of installation of anode beds and other systems as envisaged in this specification, they shall be individually checked, tested and compared against the agreed specifications and procedure.
ii) Electrical continuity of the entire pipeline shall be verified in conformity with design.

iii) Input resistance of the pipeline at all the drainage points shall be checked and recorded.

iv) All current measuring test stations shall be calibrated and recorded using portable battery, variable resistances, voltmeters, ammeters, etc. as required.

v) Temporary protection facilities provided (if any) which do not form part of permanent CP shall be disconnected from the system & removed unless agreed otherwise.

vi) Anodes provided for grounding at the MOVs on cathodically protected portion of the pipeline shall be disconnected. Sacrificial anode where provided for the protection of the casing pipe at cased crossings shall be disconnected.

vii) The pipeline shall be allowed to depolarize for at least 72 hours after switching ‘OFF’ the protection (if any) of all other pipelines in the common ROW.

viii) Before the pipelines are put on charge by switching ‘ON’ any of the CP stations, natural pipeline to soil, casing pipe to soil and coupon to soil potential values at all the test stations of the system (coupon to soil potential at the locations of the coupon installations) shall be measured with respect to Copper/Copper Sulphate half cell.

ix) CP station no.1 shall be energised with output potential adjusted to achieve a maximum pipe to soil potential (PSP) as specified, at the test station nearest to the drainage point. Observations on either spread of protected portion of pipeline and coupons under this CP station shall be taken for PSP ‘ON’ and PSP ‘OFF’ values at each of the installed test stations (coupon to soil potential at the locations of the coupon installations). The typical switching cycle of current interrupter shall be 12 seconds ‘ON’ and 3 seconds ‘OFF’. The pipeline current values across the cross section of the pipeline shall also be determined at all the intended test stations influenced by this station.

x) CP station no.1 shall now be switched ‘OFF’, CP station no. 3 shall be switched ‘ON’ and measurement procedure as detailed in clause ix) above shall be repeated.

xi) Similarly CP station no. 1 and 3 shall now be switched ‘OFF’, CP station no.2 shall be switched ‘ON’ and measurement procedure as detailed in clause ix) above shall be repeated.

xii) All the CP stations of the system shall be switched ‘OFF’ and the pipelines shall be allowed to depolarize. All the three CP stations in the system shall then be simultaneously switched ‘ON’ and PSP values at the drainage points of pipeline shall be brought to a value of maximum PSP as specified and a complete set of observations shall be taken.

Another complete set of pipe to soil and coupon to soil observations shall be taken after lines have stayed on charge for 48 hours. If there are appreciable differences in these observations as compared to those of earlier set, a third set of observations shall be taken after 72 hours. Maximum drainage point protective potentials shall not be allowed to go beyond the maximum PSP values as specified, in any case.

Coupon to soil ‘OFF’ potential shall be measured at all locations of coupon installations by operation of magnetic reed switch in the test station. The PSP of the coupons shall be within the PSP range specified in clause 6 of this document.
The output of all CP stations shall then be so adjusted that the sites of occurrence of least negative protective potentials are not less negative than (-) 0.95V (OFF) and sites of occurrence of the most negative protective potential are not more negative than (-) 1.18V (OFF). A full set of pipe to soil, coupon to soil observations shall again be taken 72 hours after the adjustment of potentials and the protection system shall be left in this state of operation.

xiii) Care shall be exercised to ensure that power supply remains uninterrupted during the period of commissioning. In case of an interruption, the test in progress shall be repeated after allowing time for polarisation. More sets of observations shall be taken in any of the steps specified above, if advised by the Owner/Owner’s representative.

xiv) The zinc anodes for grounding of MOVs at the locations of MOVs on cathodically protected portion of the pipeline shall be reconnected to the MOVs.

xv) At cased crossings where casing is protected, sacrificial anodes provided for the casing shall be connected to the casing pipe. The casing to soil potential and anode out put current shall be measured and recorded. Where casing pipe protection is inadequate or the out put current of the anode is more than the designed current, then additional anodes shall be provided as required.

xvi) PSP values at each of the test stations of the existing pipelines shall be measured, plotted, where existing pipelines run in parallel to the new pipeline, mutual interference situations between the pipelines shall be identified and necessary mitigation measures shall be provided. Interference situations shall also be identified and mitigated by comparing different sets of readings taken at same test stations at different intervals of time under identical conditions where positive potential swing is 100 mV or more.

xvii) Current readings at all the current measuring test stations shall be measured and recorded.

xviii) Where computerized test stations are provided the computer shall be initialized/started to collect and store the field data of potentials, current readings, etc as programmed.

xix) After one month of starting the computers to collect the field data, the data stored by the computers at all the computerized test stations shall be retrieved/down loaded using the field data-retrieving computer. The data shall be analysed with the help of a station main computer.

xx) At the locations of the Electrical resistance probe installations the resistance readings of the probes shall be measured using probe reader.

xxi) Final records of testing and commissioning including graphical representation of final pipe to soil potential readings shall be compiled with interpretation in consultation with Owner/Owner’s representative and submitted.

xxii) If any deficiencies are found in the system, the same shall be rectified by the contractor, at no extra cost or time schedule impact, to the complete satisfaction of Owner/Owner’s representative. Such deficiencies shall include mitigation of stray current electrolysis and interference problems that may be found existing in the course of testing and commissioning. A set of PSP observations shall also be taken during the peak of the first dry season after commissioning the system into regular operation. Any deficiency found in the protection of the pipeline shall be rectified by the contractor at his own cost.
xxiii) If it is found during commissioning that the sites of occurrence of least negative or most negative protective potentials are less negative than (-) 0.95V (OFF) or more negative than (-) 1.18V (OFF) respectively even after 72 hours of operation, then the drainage point potentials shall be adjusted depending upon anode ground bed currents in consultation with Owner/Owner’s representative. In any case, the protective 'OFF' potential values of pipeline and polarization coupons shall not exceed the PSP value range specified in cl. 6 of this document, at any location on the pipeline.

xxiv) The reference cell shall be calibrated minimum once in 24 hours during the commissioning.

xxv) The current dissipated by individual anodes shall be measured from the anode lead junction box and corrected for equal dissipation to the extent possible keeping the total ground bed current same.

10.0 INTERFERENCE MITIGATION

10.1 Investigations shall be made for stray current electrolysis of the pipeline, mutual interference between the pipeline and foreign pipelines/structures, interference on foreign pipelines/structures due to the CP of the pipeline and ground bed, interference on metallic structures which lie in between pipeline and ground bed or near to ground bed, AC induction on pipeline due to overhead EHV/HV lines, interference due to high voltage DC lines, HVDC earthing system, electric traction, etc.

10.2 Measurements including pipe/structure to soil potentials and pipe/structure currents etc. on the pipeline/structure being CP protected and on foreign pipelines/structures, and ground potential gradient etc. shall be made to investigate the current discharge and pickup locations. In case of fluctuating stray currents, investigations shall be made continuously over a period of time and if required simultaneously at different locations to find out the stray current source(s). Recorders shall preferably be used for long time measurements.

10.3 Wherever foreign pipelines which may or may not be protected by an independent CP system run in parallel to the protected pipeline, either in the same trench or very near to the protected pipeline and are not bonded to it, investigations shall be performed for current discharge points on both the pipelines.

10.4 Mitigative measures shall be provided depending upon the type of stray current electrolysis/interference. These shall include installation of bond with variable resistor, diodes, installation of galvanic anodes for auxiliary drainage of current, adjustment/relocation (if possible) of offending interference source, provision of electrical shield etc. depending on the type of interference.

10.5 Bonding with foreign pipelines/structures as a mitigation measure shall be provided where the owners of the foreign pipelines/structures have no objection. Otherwise alternative mitigation measures shall be provided. Wherever bonding is provided for mitigation, the bonding resistor shall be adjusted for optimum value for minimum/no interference. Galvanic anodes installed as a mitigation measure shall be adequately sized for the life specified for permanent CP system.

10.6 Where overhead EHV/HV transmission lines/underground electric cables cross the pipeline or run in parallel with in or more than 25m from the pipeline, A.C. Voltage measurements shall also be made on the pipeline to find out continuous induction of voltage. In case of the
induced voltage being beyond the safe limits, the pipeline shall be grounded in line with clause no.7.9 above.

11.0 CLOSE INTERVAL POTENTIAL SURVEY

Where specified, contractor shall carry out a close interval ‘ON’/‘OFF’ potential survey over the entire length of pipeline by computerised potential logging method and identify the under protected/over protected area, any major coating damage on the pipeline, after the backfilling has been consolidated sufficiently and CP system has stabilized. Contractor shall provide required mitigation measures and rectify the under/over protected zones, identify if any, the major pipeline coating defects, required to be repaired. During the survey the reference cell shall be calibrated minimum once in 24 hours. Detailed procedures for running this survey shall be submitted for review.

Additional tests for detailed identification of coating defects shall be conducted by the contractor, if specified in the project specification/ data sheets.
पाइपलाइनों की कैथोडिक सुरक्षा प्रणाली के
उपकरण व मेटरियल
के लिए विनिर्देश

SPECIFICATION FOR
EQUIPMENT / MATERIAL FOR
CATHODIC PROTECTION
SYSTEM FOR PIPELINES
Abbreviations:

AC : Alternating Current  
BS : British Standards  
BIS : Bureau of Indian Standards  
CMRI : Central Mining Research Institute  
CP : Cathodic Protection  
CPPSM : Cathodic Protection Power Supply Module  
CPTR : Cathodic Protection Transformer Rectifier  
DC : Direct Current  
HV : High Voltage  
IS : Indian Standards  
MMO : Mixed Metallic Oxide  
MOV : Motor Operated Valves  
NACE : National Association of Corrosion Engineers  
PE : Polyethylene  
PVC : Polyvinyl Chloride  
ROW : Right of Way

Electrical Standards Committee

Convenor : Mr. J.M. Singh  
Members : Mr. R.C. Sachdeva  
           Mr. U.A. Patro  
           Mr. S.K. Gupta  
           Mr. Niraj Sethi  
           Mr. Rajnish Mahajan  
           Mr. S.K. Kaul  
           Mr. C.R. Mandal / Mr. Ashok Choudhary
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4. EQUIPMENT/MATERIAL SPECIFICATIONS
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6. TESTS AND ACCEPTANCE
7. PACKING AND DESPATCH
1.0 SCOPE

This specification covers the requirements for the design, manufacture, supply and testing of various equipment and materials for Cathodic Protection system for underground pipelines/structures. These equipment and materials shall broadly include:
- Sacrificial Anodes
- Test Stations
- Anodes for impressed current CP system
- Anode junction boxes
- Cathode junction boxes
- Permanent reference cells
- Electrical resistance probes
- Polarisation cells and surge diverters/grounding cells
- Polarisation coupons
- Computerised test stations
- Cables

Requirement of Cathodic protection TR units (CPTR unit) and cathodic protection power supply modules (CPPSM) are covered in separate specifications.

2.0 CODES AND STANDARDS

2.1 All equipment and material covered in this specification shall conform to the requirements of the latest revision of following standards:

IS 3043 Code of practice for earthing.
NACE standard RP0169 Standard recommended practice Control of corrosion on underground or submerged metallic piping system.
BS 7361, Part-I Cathodic protection, code of practice for land and marine applications.
ASTM A518 M Corrosion Resistant High Silicon Iron Castings ASTM B418 Cast and wrought galvanic zinc anodes.
ASTM B338 Specification for seamless and welded Titanium and Titanium alloy tubes for condensers and heat exchangers.
ASTM B843 Magnesium Alloy Anodes for Cathodic Protection.
IS 1554, Part-I PVC insulated (heavy duty) cables.

2.2 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.

2.3 The equipment shall also confirm to the provisions of Indian Electricity rules and other statutory regulations currently in force in the country.

2.4 In case of any contradiction between various referred standards/specifications/data sheet and statutory regulations the following order of priority shall govern:
- Statutory regulations.
- Data sheets.
- Job specification.
- This specification.
- Codes and standards.
3.0 SITE CONDITIONS

The equipment and materials shall be suitable for installation in locations having generally corrosive, warm and humid or dusty atmosphere. Service conditions shall be as specified in the project specification/data sheet. If not specifically mentioned therein, a design ambient temperature 40°C and an altitude not exceeding 1000 M above mean sea level shall be considered.

4.0 EQUIPMENT/MATERIAL SPECIFICATIONS

All equipment/material shall be brand new with state of art technology and proven field track record. No prototype equipment shall be offered.

Make and construction of all equipment/materials shall be subject to approval by Owner/Owners representative.

4.1 Sacrificial Anodes

4.1.1 Magnesium Anode

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

i) Composition

<table>
<thead>
<tr>
<th>Element</th>
<th>Weight (High potential type)</th>
<th>Weight (Low potential type)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manganese</td>
<td>0.5 - 1.3%</td>
<td>0.15 - 0.7%</td>
</tr>
<tr>
<td>Copper</td>
<td>0.02% max.</td>
<td>0.02% max.</td>
</tr>
<tr>
<td>Silicon</td>
<td>0.05% max.</td>
<td>0.1% max.</td>
</tr>
<tr>
<td>Zinc</td>
<td>-</td>
<td>2.5% - 3.5%</td>
</tr>
<tr>
<td>Aluminium</td>
<td>0.01% max.</td>
<td>5.3% - 6.7%</td>
</tr>
<tr>
<td>Iron</td>
<td>0.03% max.</td>
<td>0.003% max.</td>
</tr>
<tr>
<td>Nickel</td>
<td>0.001% max.</td>
<td>0.002% max.</td>
</tr>
<tr>
<td>Calcium</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Other metallic elements

- Each 0.05% max.
- Total 0.3% max. 0.3% max.

Magnesium Balance Balance

ii) Anode open circuit Potential 1.75 volts 1.55 volts

iii) Anode consumption rate 7.9 Kg/(A.Yr) max. 7.9Kg/(A.Yr.)Max.

4.1.2 Zinc Anode

The anode shall conform to the requirements of ASTM-B 418 standard. The metallurgical composition of anode, potential and consumption rate of anodes shall be as below. Anodes of type I shall be used for seawater, brackish water or saline electrolyte application and anode of type II shall be used for fresh water, back fill and soil applications. The anode (other than
ribbon anode) shall be packaged with special backfill. The type of ribbon anode inside the casing at cased crossing shall be suitable for the type of soil outside the casing.

i) Composition:

<table>
<thead>
<tr>
<th>Element</th>
<th>Weight (Type I)</th>
<th>Weight (Type II)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminium</td>
<td>0.1% to 0.5%</td>
<td>0.005% max.</td>
</tr>
<tr>
<td>Cadmium</td>
<td>0.025-0.07%</td>
<td>0.003% max.</td>
</tr>
<tr>
<td>Copper</td>
<td>0.005% max.</td>
<td>0.002% max.</td>
</tr>
<tr>
<td>Iron</td>
<td>0.005% max.</td>
<td>0.0014% max.</td>
</tr>
<tr>
<td>Lead</td>
<td>0.006% max.</td>
<td>0.003% max.</td>
</tr>
<tr>
<td>Others</td>
<td>0.01% max.</td>
<td>-</td>
</tr>
<tr>
<td>Zinc</td>
<td>Remainder</td>
<td>Remainder</td>
</tr>
</tbody>
</table>

ii) Anode open circuit Potential 1.1 volts 1.1 volts

iii) Anode consumption rate 11.24Kg/(A.Yr)max 11.24Kg./(A.Yr.)max.

4.1.3 The anodes shall be provided with cable tail of sufficient length to reach test station/ buried junction box, as applicable without any intermediate joint in the cable and with minimum of 0.5m cable slack provided at each anode and test station ends.

4.1.4 The anodes shall be pre packed with special backfill adequately so that the performance of the anode is not affected by the carbonates, bicarbonates, nitrates, etc, present in the soil. In any case, the thickness of back fill shall not be less than 50mm on all the sides of the anode.

4.1.5 The anodes shall be suitable for the composition/conditions of soil in which they will be installed.

4.1.6 The other details of anodes shall be as shown in the applicable EIL standard drawings.

4.1.7 The anodes for grounding of cathodically protected above ground pipelines at intermediate SV stations, pigging stations, etc, grounding of motor operated valves on cathodically protected portion of the pipeline, grounding of pipeline through polarisation cell at EHV/HV line crossings or running in parallel, etc, shall be of minimum 20 kg net weight each. The anode and cable terminations shall be suitable for the anticipated fault current at the location of installation. For pipelines protected by sacrificial anodes, the anodes for directly grounding the pipeline shall be of the same type as the one provided for the protection of the pipeline.

4.1.8 Special Backfill
The composition of special back fill for anodes shall be as below :
- Gypsum 75%
- Bentonite 20%
- Sodium Sulphate 5%

4.2 Test Stations
Test stations shall be provided along the pipeline ROW for monitoring the performance of the cathodic protection system.

i) Test station enclosure shall be made of sheet steel of at least 3 mm thickness and shall be suitable for GI pipe post mounting. Test stations shall have weatherproof enclosure having degree of protection IP-55 and hinged lockable shutter. The inner and outer surfaces of test stations shall be epoxy painted.

ii) The resistors for control of current provided in the test stations, anode/cathode junction box, etc, shall be of variable, grid coil type. The resistors shall be suitable for
operation over the design life for the permanent CP system specified in the project specification/data sheet.

iii) Number of terminals and different schemes of wiring shall be as per the applicable EIL standard drawing. Minimum twenty percent spare terminals shall be provided in each test station.

iv) At locations where solid state polarisation cells are provided, the test station size shall be suitable for mounting the polarisation cell inside the test station.

v) A nameplate of anodised aluminium with black background and white letters shall be fixed to the inner side of the test station. The nameplate shall carry the following minimum information:
   - Chainage in km.
   - Test station connection scheme.
   - Distance from pipeline in metres.
   - Direction of product flow.

vi) The constructional features of test stations shall be as per the applicable EIL standard drawings.

4.3 Anodes for Impressed Current CP System

4.3.1 High Silicon Cast Iron Anodes.

i) High silicon cast iron type anodes shall be center-connected hollow type or end connected solid type. Cable to anode joint shall be reliable and long lasting for total design life of anode. Composition of anodes shall be as below and shall also conform to ASTM A518 M-86 Gr. III.

<table>
<thead>
<tr>
<th>Element</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silicon</td>
<td>14.2 - 14.75 %</td>
</tr>
<tr>
<td>Manganese</td>
<td>1.5% max.</td>
</tr>
<tr>
<td>Carbon</td>
<td>0.7% - 1.1 %</td>
</tr>
<tr>
<td>Chromium</td>
<td>3.25 - 5.0 %</td>
</tr>
<tr>
<td>Copper</td>
<td>0.5% max.</td>
</tr>
<tr>
<td>Molybdenum</td>
<td>0.2% max.</td>
</tr>
<tr>
<td>Iron</td>
<td>Remainder</td>
</tr>
</tbody>
</table>

ii) Surface current density rating of the anode for continuous operation shall be 15 amperes/sq.m (max.) for shallow anode ground bed and 10 amperes/sq.m (max.) for deep well anode ground beds.

iii) Anode consumption rate shall not be more than 0.2 kg./Amp. Yr.

iv) The design life of anode under burial condition, at the design operating current shall be in minimum the design life of the CP system specified in the project specifications/data sheet.

v) For shallow anode ground bed sheet steel anode canisters of adequate size shall be provided for each anode. Anode canisters shall be filled with petroleum coke breeze with following specification conforming to IS: 8502, Grade-A type.

a) Chemical Composition
   - Fixed carbon content by mass : 99% min.
   - Ash by mass : 0.5% max.
   - Moisture by mass : 0.1% max.
   - Volatile matters by mass : 0.5% max.
b) Bulk density : 800 kg./M$^3$ to 1200 kg./M$^3$

c) Real density : 2.03 kg/litre min.

d) Particle size : 1 mm max, dust free

e) Resistivity : 0.1 ohm cm max at 150 PSI

vi) For deep well ground beds, anodes shall be non canistered type. Calcined petroleum coke breeze slurry conforming to clause 4.3.1 v) above shall be supplied along with the anodes.

4.3.2 Mixed Metal Oxide Coated Titanium Anode

i) Mixed metal oxide coated titanium anodes shall be of pure titanium having substrate composition of titanium of ASTM B-338, Grade I/Grade II, over laid with mixed oxide of noble metals (MMO coated). These anodes shall be dimensionally stable. The anodes shall be centre connected sealed tubular type. The design life of anode under burial condition, at the design operating current in minimum be the design life of the CP system specified in the project specifications/data sheet. The guaranteed design parameters of anode regarding current density, consumption rate, design life, rated current output, dimensions, shape, noble metal oxide coating thickness (gm/square meter), their physical and mechanical properties shall be substantiated by manufacturer’s published catalogues and backed up by type test reports. Each anode shall be supplied with anode lead cable connected to it.

ii) The anodes shall be provided with sheet steel canisters and coke breeze as per clause No. 4.3.1 (v) & (vi) above.

4.3.3 Each anode shall be supplied with anode tail cable connected to it, which shall long enough for termination on their associated anode lead junction box without intermediate joint. Anode cable tail shall be connected/jointed to the anode and the joint insulated at the anode manufacturer’s shop before despatch of anode.

4.3.4 For deep well ground beds steel pipe casing for active portion of the ground bed and non metallic pipe casing for the top inactive portion of the ground bed shall be provided. The top non metallic casing and the lower metallic pipe casing shall have threads for jointing each other. Anode supporting pipe, anode centralisers and gas venting pipes shall be provided for the ground bed.

4.4 Anode Junction Box

Depending on the size and configuration of anode ground beds, requisite main and sub anode junction boxes (where required) shall be supplied for each ground bed.

i) Each junction box shall have provision of termination of cable tails from individual anodes of the ground bed and provision of connection of anode cable coming form main anode junction box (in case of sectionised ground bed) or from CP station power source.

ii) Junction boxes shall have sheet steel enclosure of minimum 3 mm thickness and hinged lockable shutters. Junction boxes shall be weatherproof with degree of protection IP-55. It shall be epoxy painted on inside and outside surface. Junction boxes shall have anode bus of copper with nickel/ silver plated or tinned. Provision shall be made for measurement and control of individual out going circuit/anode current by providing suitable shunt and resistors of grid coil type. Disconnecting links shall be provided for each out going/anode circuit. 30% spare out going circuits shall be provided in each anode junction box. Terminals shall be of anti loosening type and provided with
identification labels. Each outgoing circuit shall be labelled clearly to indicate the circuit/sub anode junction box to which it is connected.

iii) The constructional features of junction boxes shall be as per the applicable EIL standard drawing enclosed with the data sheet for impressed current cathodic protection system for pipelines.

iv) A nameplate of anodised aluminium with black back ground and white letters shall be fixed to the inner side of the junction box. The nameplate shall carry the following minimum information:
- Ground bed current rating
- Ground bed resistance
- Connection scheme.
- Distance form pipeline in metres.
- Distance form CP station in metres.

4.5 Cathode Junction Box

Where output of the CP power supply unit is connected to multiple pipelines a cathode junction box shall be supplied for providing near the pipelines at the location of connection of the negative drainage cable to the pipelines.

i) The junction box shall have a bus bar with an incoming circuit for connecting to negative of the CP power source and separate out going circuits for collection of negative drainage current from each of the pipelines.

ii) The incoming circuit shall have a current measurement shunt. Each out going circuits shall have isolation link, variable resistance of grid coil type and a current measurement shunt. One number spare outgoing circuit shall be provided.

iii) Junction box shall have sheet steel enclosure of minimum 3 mm thickness and hinged lockable shutters. Junction box shall be weatherproof with degree of protection IP-55. The inside and outside surfaces of the junction box shall be epoxy painted. The terminals shall be of anti loosening type. Proper identification labelling shall be provided for each terminal. Each outgoing circuit label shall clearly indicate the size and identification of the pipeline to which it is connected.

iv) A nameplate of anodised aluminium with black back ground and white letters shall be fixed to the inner side of the junction box. The nameplate shall carry the following minimum information:
- Chainage in km.
- Connection scheme
- Distance form the nearest pipeline in metres.
- Direction of product flow.

4.6 GI Earth Electrodes

For earthing of above ground cathodically unprotected pipelines at intermediate SV stations, pigging stations, etc. and at terminals GI earth electrodes shall be supplied. Earth electrodes shall be 100 mm dia, 3000 mm long, and 13 mm thick conformity to IS 3043.

4.7 Permanent Reference Cells

High purity copper/copper sulphate reference cells or Zinc reference cells as specified in
project specification/data sheets, with proven high reliability shall be supplied for providing stable pipe to soil potential measurement reference at CP stations, at computerised test station locations and at locations of polarisation coupons along ROW.

Silver/silver chloride type reference cells shall be supplied for marshy area locations where water table is high and chloride ion content is more than 300 ppm.

i) The reference cells shall have high accuracy and stability and maintain the same over its design life.

ii) The permanent reference cells shall have a minimum design life of 20 years under installed/buried condition.

iii) The reference cell for high resistivity areas shall be suitable for the prevailing dry soil conditions to give maximum service life.

iv) The reference cells shall be provided with cable tail long enough for connection to test station without any joint in between.

4.8 Electrical Resistance Probe

Electrical resistance probes utilising the electrical resistance technique shall be suitable for use along the pipeline at marshy areas and at interference affected locations/vulnerable locations to monitor the external corrosion activity on the pipeline.

The material of the E/R probe element shall be of the same alloy as that of the pipeline material. Probe shall be provided with cable leads for connecting it to CP system and required for the probe resistance measurements.

Portable E/R probe reading instrument shall be supplied by contractor, as specified in the project specification/data sheet. The probe reading instrument shall be suitable for use in field and shall have IP 55, weatherproof enclosure. The probe reading instrument shall be of digital type with 3.5 digit display. The instrument shall run on rechargeable batteries. The instrument shall be able to directly read out the resistance of probes.

4.9 Polarisation Cell and Surge Diverter

4.9.1 Polarisation Cell

Polarisation cell shall be a electrolytic type or solid state device as specified in project specification/data sheets, designed to simultaneously provide isolation for DC current and low resistance path for AC current. The device shall require minimum maintenance. The solid state device shall have weather proof enclosure and shall be suitable for mounting inside a test station.

Unless other wise specified in project specification/data sheet the DC blocking voltage shall not be less than 1.2 volts. The DC leakage current at 1.2 volt shall not be more than 0.5 mA.

The device shall be suitable for continuously conducting maximum AC steady state current and short time AC short circuit current expected to flow through the pipeline under the normal operating condition/any kind of fault on the EHV/HV line at respective sites, subject to minimum ratings as indicated in clause 4.9.3 below.
4.9.2 Surge Diverter

The surge diverter when connected in parallel across the insulating joints shall protect the insulating joint against surges coming across it due to lightning strikes, electrical faults, etc, on the above ground portion of the pipeline. The surge diverter shall be of spark gap type. The device shall have weatherproof enclosure suitable for outdoor mounting. The surge diverters shall be of explosion proof type.

4.9.3 The minimum ratings of polarisation cells and surge diverters shall be as below unless otherwise specified in the project specification/data sheet.

i) Polarisation Cell
   a) Type : Solid state type/Electrolytic type
   b) Description
      - Minimum rated 50 Hz steady state current (RMS symmetrical) : 30A min at 28°C and min 2V DC
      - AC fault current (RMS symmetrical) : 5 kA min for 1 cycle
      - Ac voltage under maximum rated AC fault current : Less than 10 V peak to peak

ii) Surge Diverter
   a) Type : Spark gap, explosion proof type.
   b) Current, 8/20 micro Second wave: 100 Kilo Amp.
   c) Spark - over AC voltage
      -50 Hz : 1KV
      -Impulse (1.2/50 micro Second): 2.2 KV

iii) The polarisation cells, surge diverters, anodes, connecting cables, cable joints, etc, shall be adequately sized and suitable for the design life of permanent CP system. The anodes shall be pre packed with special backfill adequately so that the performance of the anode is not affected by the carbonates, bicarbonates, nitrates, etc, present in the soil. In any case, the thickness of backfill shall not be less than 50mm on all the sides of the anode.

4.10 Polarisation Coupons

The Polarisation Coupons shall be made from the material of the pipeline. The coupon shall have one side exposed area of 100 mm x 100 mm unless otherwise specified in project specification/data sheet. Cable connection of 10 mm2 and 4 mm2 shall be provided to the coupon for connecting it to pipeline for cathodic protection and potential measurements respectively.

Connection of coupon to pipeline shall be through a vacuum sealed magnetic reed switch housed inside the test station. The magnetic reed switch shall be rated to carry and break minimum 50 mA at 50 V DC.

Magnet for operation of reed switches shall be provided as specified in project specification/data sheet.
4.11 Computerised Test Station and Test Station Reader

4.11.1 Computerised Test Stations

The computer units for installing at computerised test stations shall be able to measure and record the field CP system parameters automatically at regular programmed intervals. The computer shall have required numbers of input ports for measurement of pipe to soil DC potentials, induced AC potentials, pipeline current, bond current, etc. In any case the number of input ports shall not be less than five. All the input measurement ports shall be protected against high voltage surges due to lightning/HV switching that may come from the pipeline.

The computer shall have a real time clock and shall indicate the date and time of the data collection along with the data. The accuracy of the internal clock shall be +/- 0.1% or better. The input data measurement accuracy shall be +/- 0.5% or better. The measurement range for the input ports for pipe to soil measurement shall be (+) 5 V to (–) 5 V DC. The measurement range for the other input ports shall be decided based on the maximum value of the input parameters measured.

Unless otherwise specified in the job specification/data sheet the computers shall be programmed to collect and store all the field parameters once daily. It shall be possible to reprogram the computer for the data collection interval/set/initialize the computers at field with the help of data retrieval computer.

It shall be possible to designate a unique identification number incorporated in to the software of each computer for identification of the unit after downloading the field data from it.

The computer shall have memory capacity suitable for storing the data measured at programmed intervals continuously for six months without downloading the data.

The battery provided in the computer shall be suitable for its operation including storing the measured data at field, as programmed, for minimum 10 years without requiring the replacement/recharging of the battery.

The computer shall have provision/plug in arrangement for retrieval of the stored data with a hand held data-retrieval computer.

The field computer shall have weatherproof enclosure. The test station housing the computer shall be of IP 55, weather proof with locking arrangement.

4.11.2 The Data Retrieval Computer

The data retrieval computer shall be of portable type suitable for use in field. The computer shall be suitable for retrieving/down loading the data collected by the field computer, field programming/setting/initializing the field computer and estimating the field computer battery capacity/life left over, when connected to the field computer. Suitable plug arrangement shall be provided on the data-retrieval computer so that it can be plugged in to the field computer for data transfer. The data-retrieval computer shall have enough memory capacity for retrieving/down loading the data collected and stored by minimum ten field computers, each having collected the field data for minimum six months continuously. The battery provided in the data-retrieval computer shall be suitable for this operation without any replacement/recharging the same during the operation.

It shall be possible to down load the data collected by the data-retrieval computer to a station computer for further analysis of the data or directly to a printer.

The data-retrieval computer shall have IP 55, weatherproof enclosure. The unit shall be provided with a carry bag suitable for carrying in field.
4.12 Miscellaneous Requirements

i) 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 surface shall be prepared by applying a coat of phosphate paint and a coat of yellow zinc chromate primer. The under surface shall be free from all imperfections before undertaking the finishing coat. After preparation of the under surface, final spray painting with two coats of epoxy based paint shall be done. Panel finish shall be free from imperfections like pinholes, orange peels, runoff paint etc.

ii) All unpainted steel parts shall suitably treated to prevent rust formation. Copper bus bars, interconnection copper link shall be tinned or nickel/silver coated.

iii) Test station/junction box cabling Adequate space shall be provided inside the test station/junction box for termination of cables. Termination shall be performed using crimped lugs. The lugs shall be of tinned copper. Requisite cable lugs shall be supplied.

4.13 Cables

4.13.1 Cables shall be of annealed high conductivity stranded copper conductor, 650/1100V grade PVC insulated, armoured, PVC sheathed conforming to IS-1554 part-I, except for reference cell, potential measurement and impressed current CP anode tail cables. The size of the copper conductor of the cables shall be as below:

i) Minimum 4 mm² for potential measurement, reference cells, 6 mm² for current measurement and 25 mm² for bonding/grounding.

ii) For sacrificial anode CP system the cable size shall be minimum 6 mm² copper for anode tail cable from anode to buried junction box and 10 mm² copper from buried junction box to test station in case of temporary CP anodes. In case of sacrificial anodes for permanent CP system the size of anode tail cable from anode to test station shall be minimum 6 mm² copper.

iii) For impressed current CP system the size of conductor of cables shall be based on the current to be carried, ground bed loop resistance and shall be minimum 35mm² copper for positive, negative drainage cables and 10 mm² copper for anode tail cables. The size of CPTR unit AC incomer cables shall be of minimum 4mm² copper conductor.

4.13.2 Impressed current CP anode tail cables shall be of minimum 10 mm², annealed high conductivity stranded copper conductor, single core, 650 voltage grade PE insulated, unarmoured, PVC sheathed. Contractor may suggest cables with alternative insulation/sheathing having proven track record for impressed current anode ground bed application, for Owner’s approval.

4.13.3 The cables for reference cells and pipeline potential measurements shall be of 4 mm² copper conductor, PVC insulated, Aluminium backed by mylar/polyster tape shielded, PVC sheathed, armoured, PVC over all sheathed type. The tape shield shall be helically applied with metallic side down, with either side 25% overlap and 100% coverage. The minimum shield thickness shall be 0.05 mm.

4.13.4 Cables for connecting various transducers from CPTR Unit/CPPSM to telemetry interface junction box shall be copper conductor, PVC insulated, twisted pair with individual pair shielded and overall shielded with Aluminium backed by mylar/polyster tape, PVC sheathed, armoured, PVC over all sheathed type.
4.13.5 Cable conductor sizes indicated above are minimum only and where necessary for proper operation of the CP system higher sized cables shall be provided.

4.13.6 Length of anode tail cables shall be sufficient for routing and terminating the cable inside anode junction box/buried junction box/test station as applicable without any intermediate joint.

5.0 EQUIPMENT FOR CLASSIFIED AREAS

Equipment for hazardous area shall be flame proof type and shall meet the requirement of IS:2148 or equivalent international standard and shall be suitable for gas group IIB, temperature class T3 (200°C). Indigenous equipment shall be certified by CMRI or any other recognised testing body and shall be approved by the concerned statutory authority. All flameproof equipment shall carry the BIS license marking as per the requirement of statutory authorities.

All Imported equipment for hazardous area may be tested and certified by an independent certifying agency of country of equipment origin and shall be approved by the concerned statutory authority in India.

6.0 TESTS AND ACCEPTANCE

6.1 Unless otherwise agreed by the Engineer-in-Charge, all the equipment/material shall be subject to inspection by EIL/Owner or by an agency authorised by the owner. All necessary information concerning the supply shall be furnished to EIL/Owner’s inspector. Two weeks notice shall be given to EIL/Owner for witnessing the final testing.

6.2 Routine tests and final acceptance tests shall be carried out at manufacturer’s works under his care and expense. Instruments and equipment required for testing shall be arranged by the manufacturer. Final acceptance shall be subject to successful testing. Type test certificates instead of conducting the tests may be accepted where specified in the project specifications.

6.3 Sacrificial Anodes

i) Inspection

   a) Visual inspection shall be carried out on all the anodes regarding surface finish excessive shrinkage, cracks, cable joint to anode cone, etc.

   b) Minimum 10% of number of anodes from each heat for conformity to dimensions and weight.

   c) The anode surface shall be free from cracks, which may reduce the performance of the anode.

Any cracks which follow the longitudinal direction of elongated anodes shall not be acceptable.

Small cracks in the transverse direction of elongated anodes and in anodes of other shapes may be accepted provided the cracks would not cause any mechanical failure during service of the anode considering that the combination of cracks and lack of bond to the anode core is detrimental.

For transverse cracks the acceptable limits shall be furnished by the bidders along with the offer.
d) The anode shall be free from excessive shrinkage. The following limits shall be used.

  Maximum 10% of the depth of anode or 50% of the depth of the anode core whichever is less. The depression may be measured for the edges of one side.

  The surface of the anodes shall be free from coatings and slag/dross inclusions etc.
  The maximum deviation from straightness shall not exceed 2%.

  The weight tolerance of individual anode may be taken as ± 5%. The total weight of the anodes shall not have negative tolerance.

  Recommended dimensional tolerance shall be as follows:
  - Length : ± 2.5%
  - Width/thickness : ± 5%

ii) One anode per heat shall be subjected to radiographic test completely to evaluate cracks, voids, slag inclusion, etc.

iii) Destructive Testing
  At least one anode per heat shall be subject to close inspection by destructive testing for slag inclusions, bond between the anode material and steel inserts. If the anode fails the test, two more anodes shall be tested. If the second lot of anodes also fails the test, all the anodes of the heat shall be rejected.

iv) Chemical Analysis
  One anode sample per heat shall be subject to chemical analysis by spectrography. Sample shall be taken in the beginning for first heat, at the end for the second heat, at the beginning for the 3rd heat and so on.

  In case the chemical composition of the tested anode do not meet the requirements of this specification, all the anodes of the heat shall be rejected. Vendor shall indicate specific method of spectrography for each element (e.g. atomic absorption/emission/photometrics etc.).

v) Electrochemical Tests
  One anode from the ordered lot shall be tested for
  - Open circuit potential
  - Consumption rate by weight loss method
  - Visual examination of corrosion pattern (uneven consumption, inter granular attack, etc.)

  Where agreed by Owner type test certificate in lieu of actual conduction of electrochemical test may be accepted.

  The anode open circuit potential shall lie with in (+) 10 MV and (-) 50 MV of the guaranteed value. The anode consumption rate shall not be less than the specified value. In case of anode closed circuit potential and/or the anode consumption rate do not meet the acceptance criteria all the anodes of the heat shall be rejected.

vi) Manufacturer’s test reports regarding reference cell calibration shall be furnished. The report shall also indicate the month and year of manufacture of reference cell.
6.4 Impressed Current Anodes

6.4.1 High silicon Cast Iron anode

i) Visual inspection
Visual inspection regarding surface finish, surface cracks & craters, shrinkage, cable joint, measurements of dimension, weight, radiographic tests etc. shall be conducted as per clause 6.3 i) above. The anode acceptance criteria shall be as specified in the clause except that no crack in the anode shall be acceptable unless the cracks are only superficial.

ii) Destructive testing
Destructive testing and acceptance criteria shall be as per clause 6.3 iii) above.

iii) Chemical analysis
Chemical analysis test and acceptance criteria shall be as per clause 6.3 iv) above.

iv) Electrochemical tests
Electrochemical tests for anode consumption, visual examination of corrosion pattern and the anode acceptance criteria shall be as per clause 6.3 v) above.

v) Spectrographic analysis
The anodes from each heat shall be tested for chemical composition by spectrographic analysis and for homogeneity, dross inclusion, voids etc. by radiography. Destructive tests shall be carried out where asked by owner based on the radiographic test results.

6.4.2 Mixed Metal Oxide Coated Titanium Anode

Contractor shall furnish list/details of the tests that will be conducted by manufacturer of anode and their acceptance criteria.

6.4.3 Petroleum coke breeze and special back fill

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

The special back fill material for the sacrificial anodes shall be tested for composition and test reports shall be submitted.

7.0 PACKING & DESPATCH

All equipment/material for CP system along with one set of final drawings shall be dispatched to site packed in wooden crates.

All the equipment shall be divided in to several sections for protection and ease of handling during transportation. The equipment shall be properly packed for transportation by ship/rail or trailer. The equipment shall be wrapped in polyethylene sheets before being placed in crates/cases to prevent damages to finish. Crates/cases shall have skid bottom for handling. Special notations such as ‘Fragile’, ‘This side up’, ‘Centre of gravity’, ‘Weight’, ‘Owners particulars’, ‘PO nos’, etc shall be clearly marked on the package together with other details as per purchase order.

The equipment may be stored out doors for long periods before installation. The package shall be completely suitable for out door storage in areas with heavy rain/high ambient temperature unless otherwise agreed.
PREPACKED ZINC ANODE

ELEVATION

ANODE TAIL CABLE

COTTON SOLDER/NUT & BOLT CONNECTION

SILVER SOLDER CONNECTION

MS CORE

ZINC ANODE

BACK FILL (SEE NOTE-3)

SECTION-AA

MS CORE

ARMOUR (SHALL NOT HAVE ELECTRICAL CONNECTION TO ANODE)

EPOXY COMPOUND

PVC INSULATION

ANODE TAIL CABLE

SILVER SOLDER CONNECTION

DETAIL-X

CHEMICAL COMPOSITION OF ANODE (% WEIGHT):

<table>
<thead>
<tr>
<th>CHEMICALS</th>
<th>TYPE-I</th>
<th>TYPE-II</th>
</tr>
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<tbody>
<tr>
<td>Al</td>
<td>0.1%–0.5%</td>
<td>0.005% MAX</td>
</tr>
<tr>
<td>Cd</td>
<td>0.025%–0.07%</td>
<td>0.003% MAX</td>
</tr>
<tr>
<td>Cu</td>
<td>0.005% MAX</td>
<td>0.002% MAX</td>
</tr>
<tr>
<td>Fe</td>
<td>0.005% MAX</td>
<td>0.0014% MAX</td>
</tr>
<tr>
<td>Pb</td>
<td>0.006% MAX</td>
<td>0.003% MAX</td>
</tr>
<tr>
<td>OTHERS</td>
<td>0.1% MAX</td>
<td>REMAINDER</td>
</tr>
<tr>
<td>Zn</td>
<td>REMAINDER</td>
<td>REMAINDER</td>
</tr>
</tbody>
</table>

BACK FILL COMPOSITION

| GYPSUM | :75% |
| BENTONITE | -- :20% |
| SODIUM SULPHATE | -- :5% |

NOTES:

1. ANODE COMPOSITION, NET WEIGHT, GROSS WEIGHT, PREPACKED ANODE WEIGHT AND DIMENSIONS (A,B,C,D,E & F) SHALL BE FURNISHED BY CONTRACTOR.

2. ANODE TAIL CABLE SHALL BE HIGH CONDUCTIVITY, STRANDED, COPPER CONDUCTOR, 650V GRADE, PVC INSULATED, PVC SHEATHED & ARMOURED.

3. THICKNESS OF BACK FILL SHALL BE ADEQUATE TO SAFEGUARD THE ANODES AGAINST EFFECT OF CARBONATES, BICARBONATES, NITRATES etc. IN SOIL. ANODES SHALL BE PROVIDED WITH MIN. 50mm THICK BACK FILL ON ALL THE SIDES OF THE ANODE OR MIN. 20kg NET, WHICHEVER IS HIGHER.

4. ANODE TYPE-I SHALL BE USED FOR SEA WATER, BRACKISH WATER OR SALINE ELECTROLYTE AND ANODE TYPE-II SHALL BE USED FOR WATER, BACK FILLS & SOIL APPLICATION.
PREPACKED MAGNESIUM ANODE

CHEMICAL COMPOSITION OF ANODE (%WEIGHT):

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<tr>
<th>ELEMENT</th>
<th>HIGH POTENTIAL</th>
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<tr>
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<tr>
<td>Mn</td>
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<td>0.15-0.7</td>
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<tr>
<td>Cu</td>
<td>0.02(max)</td>
<td>0.02(max)</td>
</tr>
<tr>
<td>Fe</td>
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<td>0.003(max)</td>
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<tr>
<td>Ni</td>
<td>0.001(max)</td>
<td>0.002(max)</td>
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<tr>
<td>Zn</td>
<td>-</td>
<td>2.5-3.5</td>
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<tr>
<td>Si</td>
<td>0.05(max)</td>
<td>0.1(max)</td>
</tr>
<tr>
<td>Ca</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

OTHER METALLIC ELEMENTS
- EACH 0.05(max)
- TOTAL 0.3(max)

Mg BALANCE

BACK FILL COMPOSITION
GYPSUM -------------- : 75%
BENTONITE----------- : 20%
SODIUM SULPHATE ---- : 5%

NOTES:
1. ANODE COMPOSITION, NET WEIGHT, GROSS WEIGHT, PREPACKED ANODE WEIGHT AND DIMENSIONS (A,B,C,D,E & F) SHALL BE FURNISHED BY CONTRACTOR.
2. ANODE TAIL CABLE SHALL BE HIGH CONDUCTIVITY, STRANDED, COPPER CONDUCTOR, 650V GRADE, PVC INSULATED, PVC SHEATHED & ARMoured.
3. THICKNESS OF BACK FILL SHALL BE ADEQUATE TO SAFEGUARD THE ANODES AGAINST EFFECT OF CARBONATES, BICARBONATES, NITRATES etc. IN SOIL. ANODES SHALL BE PROVIDED WITH MIN. 50mm. THICK BACK FILL ON ALL THE SIDES OF THE ANODE OR MIN. 20kg. NET, WHICHEREVER IS HIGHER.

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CHEMICAL COMPOSITION OF ANODE (% WEIGHT):

- Al 0.01(max)
- Mn 0.5–1.3
- Cu 0.02(max)
- Fe 0.03(max)
- Ni 0.001(max)
- Si 0.05(max)
- Zn –
- Ca –

OTHER METALLIC ELEMENTS
- EACH 0.05(max)
- TOTAL 0.3(max)

Mg BALANCE

NOTES:
1. All the dimensions are in mm.
2. Anode composition, all dimensions, net weight & gross weight shall be furnished by contractor.
3. Cable connection to anode shall be done at site.
4. Cable shall be high conductivity, stranded, copper conductor, 650V grade, PVC insulated, PVC sheathed & armoured.
NOTES :-

1. THE SHUTTER SHALL BE HINGED TYPE WITH CONCEALED LOCK & SHALL HAVE DOOR GASKET TO MAKE THE TEST STATION WEATHER PROOF (IP:55)

2. THE INNER & OUTER SURFACE OF THE TEST STATION SHALL BE EPOXY PAINTED.

3. THE NAME PLATE SHALL BE OF ANODISED ALUMINIUM WITH BLACK BACKGROUND & WHITE LETTERS & SHALL BE FIXED TO THE INNER SIDE OF SHUTTER.

4. TEST STATION SHALL BE ERECTED WITH THEIR SHUTTERS PARALLEL TO THE LINE OF AXIS & FACING THE PIPE LINE.

5. THE CHAINAGE OF TEST STATION SHALL BE WRITTEN WITH BLACK PAINT ON THE OUTER SIDE OF THE FRONT SHUTTER.

6. HEIGHT OF THE TEST STATION SHOWN ABOVE GROUND LEVEL IS MINIMUM ONLY. THE ACTUAL HEIGHT SHALL BE DECIDED BASED ON LOCAL FLOOD LEVELS TO BE ASCERTAINED.

7. CONTRACTOR SHALL FURNISH ALL THE DIMENSIONS OF THE TEST STATION.

8. ALL THE DIMENSIONS ARE IN MM.

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<th>Rev. No.</th>
<th>Date</th>
<th>Purpose</th>
<th>Prepared by</th>
<th>Checked by</th>
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TEST STATION CONNECTION SCHEMES

1. **Potential Measurement (Connection Scheme - A)**
   - **Terminals (TYP.)**
     - 3 pins: 1, 2, 4
   - **4mm² Cable**
   - **Pin Brazing (TYP.)**
   - **Pipe Line (TYP.)**

2. **Current Measurement (Connection Scheme - B)**
   - **Terminals (TYP.)**
     - 4 pins: 01, 02, 03, 06
   - **6mm² Cable**
   - **60m (TYP.)**
   - **4mm² Cable**

3. **Cased Crossing with Uncoated/Unpainted Casing (Connection Scheme - C)**
   - **Casing**
   - **Carrier**
   - **Zinc Galvanic Anode**
   - **Foreign Pipeline Crossing (Connection Scheme - D)**
   - **Shaft**
   - **Variable Resistor**
   - **25mm² Cable**

4. **Cased Crossing with Coated Casing (Connection Scheme - D)**
   - **Casing**
   - **Link**
   - **Variable Resistor**
   - **10mm² Cable**
   - **4mm² Cable**

5. **Insulating Joint (Connection Scheme - F)**
   - **25mm² Cable**
   - **Foreign Pipeline Crossing (Connection Scheme - E)**
   - **25mm² Cable**
   - **Surge Divertor**

6. **Intermediate CP Station (Without IJ on Pipe Line at the Station)**
   - **Impressed Current Drainage Point (Connection Scheme - G)**
   - **Reference Cell (TYP.)**
     - **6mm² Cable**
   - **4mm² Cable**
   - **60m (TYP.)**

7. **Terminal Station Impressed Current Drainage Point (Connection Scheme - H)**
   - **25mm² Cable**
   - **Unprotected Terminal Side**
   - **Bolt Connection to Plate Welded to Pipeline (TYP.)**
   - **Cathodically Protected Side**

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**Date and Revision Information:**
- **Reaffirmed:** 27.08.07
- **Revised and Reissued:** 08.07.02

**Prepared by:**
- BR
- ST
- JMS

**Checked by:**
- SKG
- GSH
- VPS

**Approved by:**
- Stds. Committee Convener
- Stds. Bureau Chairman

**Format No.:** 8-00-0001-F4 Rev.0

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INTERMEDIATE PIGGING STATION IMPRESSED CURRENT DRAINAGE POINT

CONNECTION SCHEME-1
TEST STATION
CONNECTION SCHEMES

CATHODE JUNCTION BOX

VARIABLE RESISTOR (TYP.)  SHUNT (TYP.)  LINK (TYP.)

35mm² (MIN.) CABLE

TO CPPSM/CPTR UNIT

BOLT CONNECTION TO PLATE WELDED TO PIPE LINE (TYP.)

TEST STATION

REFERENCE CELL (TYP.) FOR AUTO PSP CONTROL

INTERMEDIATE CP STATION MULTIPLE PIPELINES (TYP. FOR TWO PIPE LINES)

IMPRESSED CURRENT DRAINAGE POINT (WITHOUT IJs ON LINE PIPES AT THE STATION)

(CONNECTION SCHEME – J)

TEST STATION

CATHODE JUNCTION BOX

VARIABLE RESISTOR (TYP.)  SHUNT (TYP.)  LINK (TYP.)

35mm² (MIN.) CABLE

6mm² CABLE

4mm² CABLE

TO CPPSM/CPTR UNIT

REFERENCE CELL (TYP.) FOR AUTO PSP CONTROL

INSULATING JOINT (TYP.)

UNPROTECTED TERMINAL SIDE

TERMINAL STATION MULTIPLE PIPELINES (TYP. FOR TWO PIPE LINES)

IMPRESSED CURRENT DRAINAGE POINT.

(CONNECTION SCHEME – K)

3 27.08.07 REAFFIRMED
2 08.07.02 REVISED AND REISSUED

Rev. Date Purpose Prepared by Checked by
No.  

Sids. Committee Convenor Stds. Bureau Chairman
Approved by

Format No. 8-00-0001-F4 Rev.0

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TCP GALVANIC ANODE INSTALLATION

CONNECTION SCHEME - L

PIPEDLINE GROUNDING THROUGH POLARISATION CELL AND GALVANIC ANODE

CONNECTION SCHEME - M

NOTES:

1. NUMBER OF TERMINALS FOR TEST STATION OF DIFFERENT CONNECTION SCHEME SHALL BE AS SHOWN ON THE RESPECTIVE SCHEME DRAWING. TEST STATION FOR ANY OTHER SCHEME SHALL PREFERABLY BE SIMILAR TO ANY OF THE ABOVE TYPES.

2. ELECTRICAL CONNECTIONS SHALL BE CLEANED TO BRIGHT SURFACE & TIGHTENED WITH NON-OXIDE GREASE APPLIED ON MECHANICALLY MATED SURFACE.

3. FOR SCRIPICAL ANODE GROUND BED WHICH IS INTENDED FOR PERMANENT CP SYSTEM AND/OR TO BE INTEGRATED WITH PERMANENT CP SYSTEM, THE LEADS OF ALL ANODES SHALL BE Brought UP TO THE TEST STATION AND SHALL BE TERMINATED INDIVIDUALLY. ACCORDINGLY, THE NUMBER OF TERMINALS FOR TEST STATION SHALL BE DECIDED BASED ON NUMBER OF ANODES.

4. WHERE INSULATING JOINT (IJ) ON THE PIPELINE IS BURIED, THE SURGE DIVERTER MOUNTED ACROSS THE IJ SHALL BE HOUSED SUITABLY SO THAT OPERATION OF THE SAME IS NOT AFFECTED.

5. THE DISTANCE BETWEEN TWO SUCCESSIVE PIN BRAZING POINTS SHALL BE MIN. 300MM.
NOTES:

1. THE PREPACKED GALVANIC ANODE SHALL BE INSTALLED AT A MINIMUM DEPTH, EQUAL TO BOTTOM LEVEL OF THE PIPELINE.

2. THE ANODES ARE SHOWN HORIZONTALLY LAID. ALTERNATIVELY THE ANODES MAY BE VERTICALLY INSTALLED WITH TOP OF THE ANODE AT A MINIMUM DEPTH EQUAL TO BOTTOM LEVEL OF THE PIPE LINE.

3. ALL NATIVE BACKFILL SOIL SHALL BE FREE OF ROCKS, GARBAGE, PAPERS, PLASTICS ETC.

4. CABLE SHALL BE LAID WITH ENOUGH SLACKNESS TO AVOID DAMAGE TO CABLES DURING BACK FILLING ETC.

5. THIS DRAWING SHOWS TYPICAL ANODE INSTALLATION ARRANGEMENT FOR TEMPORARY CATHODIC PROTECTION SYSTEM. ANODES FOR PERMANENT CATHODIC PROTECTION SYSTEM SHALL BE INSTALLED IN A SIMILAR MANNER, BUT ANODE TAIL CABLES OF EACH ANODE SHALL BE BROUGHT INDIVIDUALLY UPTO TEST STATION & TERMINATED. NO BURIED JUNCTION BOX SHALL BE USED FOR PERMANENT CP SYSTEM.

6. ANODE TAIL CABLE SHALL NOT BE USED FOR LIFTING THE ANODE. ROPE SLINGS SHALL BE USED FOR LIFTING THE ANODE DURING INSTALLATION INTO GROUND BED.
CHEMICAL COMPOSITION OF ANODE (% WEIGHT):

<table>
<thead>
<tr>
<th>CHEMICALS</th>
<th>TYPE-I</th>
<th>TYPE-II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Al</td>
<td>0.1% - 0.5%</td>
<td>0.005% MAX</td>
</tr>
<tr>
<td>Cd</td>
<td>0.025% - 0.07%</td>
<td>0.003% MAX</td>
</tr>
<tr>
<td>Cu</td>
<td>0.005% MAX</td>
<td>0.002% MAX</td>
</tr>
<tr>
<td>Fe</td>
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</tr>
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<td>Pb</td>
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<td>0.003% MAX</td>
</tr>
<tr>
<td>OTHERS</td>
<td>0.1% MAX</td>
<td></td>
</tr>
<tr>
<td>Zn</td>
<td>REMAINDER</td>
<td>REMAINDER</td>
</tr>
</tbody>
</table>

NOTES:

1. STEEL CORE TO BE THERMIT WELD DIRECTLY TO CARRIER PIPE WITHIN CASINGS AT 4 & 8 'O' CLOCK POSITIONS. FOR CARRIER PIPE OF LESS THAN 4 INCH DIA, ANODES MAY BE PROVIDED ALONG THE LENGTH OF THE CARRIER PIPE LINE AT THE BOTTOM LEVEL.

2. SIZE OF ANODE & SPACING BETWEEN ANODES SHALL BE DECIDED BASED ON DESIGN CRITERIA. HOWEVER MINIMUM ONE ANODE SHALL BE PROVIDED BETWEEN TWO PIPE SPACERS/ CENTRALISERS PROVIDED BETWEEN CARRIER AND CASING PIPES.

3. PIPE SPACERS/CENTRALISERS ARE NOT SHOWN.

4. ANODE COMPOSITION, DIMENSION, NET & GROSS WEIGHT PER UNIT LENGTH SHALL BE FURNISHED BY THE CONTRACTOR.

5. CASING PIPE, WHERE COATED AGAINST CORROSION OF EXTERNAL SURFACE, SHALL BE PROTECTED BY GALVANIC ANODES INSTALLED AT BOTH THE ENDS OF THE CASING PIPE.

6. ANODE TYPE-I SHALL BE USED FOR SEA WATER, BRACKISH WATER OR SALINE ELECTROLYTE APPLICATION AND ANODE TYPE-II SHALL BE USED FOR WATER, SOIL APPLICATION.
NOTES:—

1. THE POLARISATION CELL, ANODES AND ASSOCIATED CABLES, CABLE JOINT ETC. SHALL AS MINIMUM BE RATED FOR THE EXPECTED FAULT CURRENT AT THE LOCATION OF THE INSTALLATION AND SIZED FOR DESIGN LIFE OF PERMANENT C.P. SYSTEM.

2. ANODE TAIL CABLES OF EACH ANODE SHALL BE TERMINATED INDIVIDUALLY IN TEST STATION.

3. THE COMPOSITION OF ZINC GALVANIC ANODE SHALL BE AS PER STANDARD 7-51-0601 (PREPACKED ZINC ANODE).

4. WHERE LIQUID ELECTROLYTE TYPE POLARISATION CELL IS SPECIFIED THE HOUSING DETAILS SHALL BE AS BELOW :-
   a. THE POLARISATION CELL SHALL BE HOUSED IN A VANDALISM PROOF HOUSING.
   b. THE CELL AND HOUSING SHALL HAVE GOOD VENTILATION (BY PROVIDING LOUVERS WITH WIRED MESH) AND SHALL BE PROTECTED AGAINST RAIN/WATER.
   c. EASY ACCESS TO POLARISATION CELL SHALL BE PROVIDED FOR PERIODIC INSPECTION.

5. IN CASE OF SOLID STATE POLARISATION CELL, THE CELL SHALL BE MOUNTED INSIDE THE TEST STATION. THE TEST STATION DETAIL FOR SOLID STATE POLARISATION CELL SHALL BE AS PER STANDARD 7-51-0605.

6. CONTRACTOR SHALL FURNISH DRAWING WITH ACTUAL DIMENSIONS AND RATINGS.
TYPICAL CONSTRUCTION
DETAILS OF HIGH SILICON
CAST IRON ANODE

PREPACKED CANISTERED ANODE

CHEMICAL COMPOSITION OF ANODE (% WEIGHT):

- Carbon: 0.7% - 1.1%
- Manganese: ≤1.5% max.
- Silicon: 14.2% - 14.75%
- Chromium: 3.25% - 5%
- Molybdenum: ≤0.2% max.
- Copper: ≤0.5% max.
- Iron: —

NOTES:

1. ANODE FOR SURFACE AND DEEP GROUND BED APPLICATION SHALL BE IDENTICAL EXCEPT FOR BACK FILL PREPACKING.
2. SHEET STEEL ANODE CANISTERS SHALL BE FILLED WITH PETROLEUM COKE BREEZE CONFORMING TO IS:8502 GRADE-A TYPE. ANODES SHALL BE PROVIDED WITH MIN. 50mm. THICK BACK FILL ON ALL THE SIDES OF THE ANODE OR MIN. 20kg NET, WHICHEREVER IS HIGHER.
3. PETROLEUM COKE BREEZE SLURRY BACKFILL SHALL BE PROVIDED IN THE WELL, SURROUNDING ANODES IN DEEP WELL GROUND BEDS.
4. ANODE TAIL CABLE SHALL BE 10 SQ. MM. HIGH CONDUCTIVITY, STRANDED COPPER CONDUCTOR, 650V GRADE, PE INSULATED, PVC SHEATED & UNARMoured.
5. ALL THE DIMENSIONS, NET WEIGHT, GROSS WEIGHT OF THE ANODE AND ALL THE DIMENTIONS, WEIGHT OF PREPACKED CANISTERED ANODE SHALL BE FURNISHED BY THE CONTRACTOR.
6. THE ACTIVE LENGTH 'la' OF ANODE SHALL BE CONSIDERED FOR CALCULATING THE SIZE/WEIGHT OF ANODE.
REFERENCE CELL INSTALLATION

BACKFILL MATERIAL (REF NOTE-7) :-

Gypsum : 75%
Bentonite : 20%
Sodium Sulphate: 5%

NOTES:-

1. REFERENCE CELL SHALL BE BACK FILLED WITH REQUIRED BACK FILL MATERIAL.
2. FOR NEW PIPELINES REFERENCE ELECTRODE SHALL BE INSTALLED APPROXIMATELY AT THE BOTTOM LEVEL OF THE PIPE LINE, 200MM AWAY FROM SURFACE OF THE PIPELINE.
3. REFERENCE ELECTRODES MAY BE INSTALLED AT THE TOP OF THE PIPELINE, APPROXIMATELY 100MM ABOVE THE PIPELINE WHERE PIPE LINE HAS ALREADY BEEN LAID.
4. REFERENCE CELL CABLE SHALL BE ROUTED ALONG THE BOTTOM LEVEL OF THE PIPELINE AND 250MM (APPROX.) AWAY FROM THE SURFACE OF THE PIPE.
5. BACKFILLED REFERENCE ELECTRODES SHALL BE SOAKED IN 20 LTRS. OF CLEAN FRESH WATER FOR 24 HOURS IMMEDIATELY PRIOR TO INSTALLATION.
6. CONTRACTOR SHALL FURNISH REFERENCE CELL DRAWING WITH ALL DIMENSIONS.
7. IN CASE OF SILVER-SILVER CHLORIDE REFERENCE CELL THE BACK FILL MATERIAL SHALL BE BENTONITE-95%, AND SODIUM CHLORIDE-5%.
8. REFERENCE CELLS WITH ALTERNATIVE CONSTRUCTIONAL DETAILS, HAVING PROVEN RELIABILITY AND SPECIFIED DESIGN LIFE MAY BE CONSIDERED WHERE APPLICABLE.
SHALLOW ANODE GROUND BED (PCP)

NOTES:
1. THE ANODE GROUND BED SHALL BE LOCATED ELECTRICALLY REMOTE FROM THE PIPE LINE WITH MINIMUM 100 MTR. AWAY FROM THE NEAREST POINT ON THE PIPE LINE.
2. NO SPlicing SHALL BE ALLOWED FOR THE CABLES.
3. CONTRACTOR SHALL FURNISH THE DIMENSIONED DRAWING SHOWING ACTUAL QUANTITY OF ANODES FOR EACH GROUND BED.
4. ALL UNARMoured CABLES SHALL BE RUN THROUGH PE SLEEVES.
5. ANODE BED MARKER SHALL BE FIXED ON BOTH SIDES OF GROUND BEDS.
6. NATIVE BACKFILL SOIL SHALL BE MOIST, FREE OF ROCKS, GARBAGE, PAPERS, PLASTICS ETC.
7. ANODES MAY BE LAID VERTICALLY IN CASE OF VERTICAL SHALLOW ANODE GROUND BED DESIGN.
8. ALL THE DIMENSIONS ARE IN MM.
1. SHUTTER SHALL BE HINGED TYPE WITH CONCEALED LOCK. THE DOOR SHALL BE PROVIDED WITH GASKET TO MAKE THE BOX WEATHER PROOF (IP:55).

2. INSIDE & OUTSIDE OF THE BOX SHALL BE 125 µ GALVANIZED AND 300 µ EPOXY TOP COATED.

3. THE HEIGHT OF THE JUNCTION BOX ABOVE GROUND LEVEL, INDICATED IN THIS STANDARD IS MINIMUM. THE ACTUAL HEIGHT SHALL BE DECIDED BASED ON LOCAL FLOOD LEVELS.

4. NUMBER OF ANODE CIRCUITS SHOWN IN THIS STANDARD ARE INDICATIVE ONLY. CONTRACTOR SHALL FURNISH DRAWING WITH ACTUAL DIMENSIONS & NUMBER OF ANODE CIRCUITS.

5. THE SIZE OF THE CONCRETE FOOTING SHOWN IS MINIMUM ONLY. CONTRACTOR SHALL PROVIDE ADEQUATELY SIZED FOUNDATION BASED ON SOIL CONDITION AND DIMENSIONS OF ANODE LEAD JUNCTION BOX.

6. ALL THE DIMENSIONS ARE IN MM.