

# पाइपलाइनों की कैथोडिक सुरक्षा प्रणाली के उपकरण व मेटिरियल के लिए विनिर्देश

## SPECIFICATION FOR EQUIPMENT / MATERIAL FOR CATHODIC PROTECTION SYSTEM FOR PIPELINES

|             |          |                                                                       |                |               |                                    |                                 |
|-------------|----------|-----------------------------------------------------------------------|----------------|---------------|------------------------------------|---------------------------------|
| 0           | 17.07.14 | ISSUED AS STANDARD SPECIFICATION<br>(OLD DOC. NO.: 6-51-0029, REV. 1) | NSB            | RC            | PPL/8/11/14                        | SC                              |
| Rev.<br>No  | Date     | Purpose                                                               | Prepared<br>by | Checked<br>by | Standards<br>Committee<br>Convenor | Standards<br>Bureau<br>Chairman |
| Approved by |          |                                                                       |                |               |                                    |                                 |

**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                          |
| ROU   | : | Right of Use                                |

**SMMS Standards Committee**

Convenor: Mr. P.P. Lahiri

Members: Mr. R. Chaudhury  
Ms. N.S. Bhattacharya  
Mr. S. Mukherjee (Construction)  
Mr. R. Muthu Ramalingam (Inspection)  
Mr. Amit Prakash (HMTD)  
Mr. Raj Kishore (Pipeline)  
Mr. A.R. Purushottam (POSD)  
Mr. B.R. Bhogal (Electrical)  
Mr. Ratan Lal Kanaujia (Project)  
Mr. R. Nanda (Piping)

## CONTENTS

|    |                                          |    |
|----|------------------------------------------|----|
| 1. | SCOPE .....                              | 4  |
| 2. | CODES AND STANDARDS .....                | 4  |
| 3. | SITE CONDITIONS .....                    | 5  |
| 4. | EQUIPMENT/ MATERIAL SPECIFICATIONS ..... | 5  |
| 5. | EQUIPMENT FOR CLASSIFIED AREAS .....     | 14 |
| 6. | TESTS AND ACCEPTANCE .....               | 14 |
| 7. | PACKING AND DESPATCH .....               | 17 |

## 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
- Polarisation cells and surge diverters/grounding cells
- Polarisation coupons
- 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 SP0169 | Control of External Corrosion on Underground or Submerged Metallic Piping Systems                          |
| 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                                                                          |
| IS/ IEC: 60079       | Electrical Apparatus for Explosive Gas Atmosphere                                                          |
| IS/ IEC: 60529       | Classification of Degree of Protection Provided by Enclosures                                              |

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 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 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 equipments/ materials 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 equipments/ materials shall be subject to approval by Owner/Owner's representative.

#### 4.1 Sacrificial Anodes

##### 4.1.1 Magnesium Anode

The anode shall conform to the requirements of ASTM B843 standard. The anode shall be of high manganese, Magnesium alloy packed with special back fill. The metallurgical composition, potential and capacity of anode shall be as below:

##### i) Composition

| <u>Element</u>                  | <u>Weight</u> |
|---------------------------------|---------------|
| Manganese                       | 0.15 - 0.7%   |
| Copper                          | 0.02% max.    |
| Silicon                         | 0.1% max.     |
| Zinc                            | 2.5% - 3.5%   |
| Aluminium                       | 5.3% - 6.7%   |
| Iron                            | 0.003% max.   |
| Nickel                          | 0.002% max.   |
| Calcium                         | -             |
| Other metallic elements (Total) | 0.3% max      |
| Magnesium                       | Balance       |

- |      |                                                                  |                    |
|------|------------------------------------------------------------------|--------------------|
| ii)  | Anode open circuit Potential<br>(Cu/CuSO <sub>4</sub> Reference) | 1.55 volts         |
| iii) | Anode Capacity                                                   | 1050 - 1200 AH/Kg. |

#### 4.1.2 Zinc Anode

The anode shall conform to the requirements of ASTM B418 standard. The metallurgical composition of anode, potential and capacity of anodes shall be as below. Anode of type I shall be used for seawater, brackish water having resistivity not exceeding 10 Ohm-m and for grounding/ earthing of pipelines. Anode of type II shall be used for ribbon anodes for protection of carrier pipes inside casing or for application in saline soil having resistivity less than 10 Ohm-m. The anode (other than ribbon anode) shall be packaged with special backfill.

- i) Composition:

|      | <u>Element</u>                                                   | <u>Weight</u><br>(Type I) | <u>Weight</u><br>(Type II) |
|------|------------------------------------------------------------------|---------------------------|----------------------------|
|      |                                                                  |                           |                            |
|      | Aluminium                                                        | 0.1% to 0.5%              | 0.005% max.                |
|      | Cadmium                                                          | 0.025-0.07%               | 0.003% max.                |
|      | Copper                                                           | 0.005% max.               | 0.002% max.                |
|      | Iron                                                             | 0.005% max.               | 0.0014% max.               |
|      | Lead                                                             | 0.006% max.               | 0.003% max.                |
|      | Others (Total)                                                   | 0.1% max.                 | -                          |
|      | Zinc                                                             | Remainder                 | Remainder                  |
| ii)  | Anode open circuit Potential<br>(Cu/CuSO <sub>4</sub> Reference) | -1.1 volts                | -1.1 volts                 |
| iii) | Anode Capacity                                                   | 790 - 810 AH/Kg.          | 790 - 810 AH/Kg.           |

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 for grounding/ earthing or for saline soil application 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 or minimum 20 Kg. net, whichever is higher.

4.1.5 The other details of anodes shall be as shown in the applicable EIL standard drawings.

4.1.6 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 either of block anode or ribbon type. Sizing and quantity of anode shall be decided so as to achieve maximum total earth resistance of 5 Ohm

for each location. The anode and cable terminations shall be suitable for the anticipated fault current at the location of installation.

#### 4.1.7 Special Backfill

The composition of special back fill for anodes shall be as below:

|   |                                     |   |     |
|---|-------------------------------------|---|-----|
| - | Gypsum (Commercial Purity)          | : | 75% |
| - | Bentonite (Commercial Purity)       | : | 20% |
| - | Sodium Sulphate (Commercial Purity) | : | 5%  |

#### 4.2 Test Stations

Test stations shall be provided along the pipeline ROU 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 weather proof 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 back ground 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.

| <u>Element</u> | <u>Weight</u>  |
|----------------|----------------|
| Silicon        | 14.2 - 14.75 % |
| Manganese      | 1.5% max.      |
| Carbon         | 0.7% - 1.1 %   |
| Chromium       | 3.25 - 5.0 %   |
| Copper         | 0.5% max.      |
| Molybdenum     | 0.2% max.      |
| Iron           | Remainder      |

- ii) Surface current density rating of the anode for continuous operation shall be 15 Amp./sq.m for shallow anode ground bed and 10 Amp./sq.m 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 <sup>3</sup> to 1200 kg./M <sup>3</sup> |
| 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.

|                                                                          |   |                                                                                                                              |
|--------------------------------------------------------------------------|---|------------------------------------------------------------------------------------------------------------------------------|
| Maximum allowable anode current density                                  | : | 100 A/m <sup>2</sup> (in coke backfill)<br>50 A/m <sup>2</sup> (soil without backfill)<br>100 A/m <sup>2</sup> (Fresh Water) |
| Allowable anode current density for continuous operation                 | : | 70 A/m <sup>2</sup> (in coke backfill)<br>30 A/m <sup>2</sup> (soil without backfill)<br>70 A/m <sup>2</sup> (Fresh Water)   |
| Maximum coating consumption (wear) rate at maximum anode current density | : | 2 mg./A-Yr in coke backfill<br>6 mg./A-Yr in fresh water                                                                     |

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 be 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 from main anode junction box (in case of sectionalised 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 weather proof 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 conforming to IS 3043.

#### 4.7 Permanent Reference Cells

High purity copper/copper sulphate 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 and at locations of polarisation coupons along ROU.

Silver/Silver Chloride/Saturated Potassium Chloride type reference cells shall be supplied for marshy area/ brackish water/ saline soil 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 8 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 Polarisation Cell and Surge Diverter

##### 4.8.1 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.

##### 4.8.2 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 lightening strikes, electrical faults, etc, on the above ground portion of the pipeline. The surge diverter shall be of spark gap type. The device shall have weatherproof enclosure suitable for out door mounting. The surge diverters shall be of explosion proof type.

- 4.8.3 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) | <u>Description</u>                                           |   | <u>Rating</u>                              |
|    | - Minimum rated 50 Hz steady state current (RMS symmetrical) | : | 30A min at 28 <sup>0</sup> 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                           | : | 1 KV                            |
|    | -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 back fill shall not be less than 50mm on all the sides of the anode.

#### 4.9 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 other wise specified in project specification/ data sheet. Cable connection of 10 mm<sup>2</sup> and 4 mm<sup>2</sup> 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.

#### 4.10 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.

#### 4.11 Cables

4.11.1 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 mm<sup>2</sup> for potential measurement, reference cells, 6 mm<sup>2</sup> for current measurement and 25 mm<sup>2</sup> for bonding/grounding.
- ii) For sacrificial anode CP system the cable size shall be minimum 6 mm<sup>2</sup> copper for anode tail cable from anode to buried junction box and 10 mm<sup>2</sup> 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 mm<sup>2</sup> 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 35mm<sup>2</sup> copper for positive, negative drainage cables and 10 mm<sup>2</sup> copper for anode tail cables. The size of CPTR unit AC incomer cables shall be of minimum 4mm<sup>2</sup> copper conductor.

4.11.2 Impressed current CP anode tail cables shall be of minimum 10 mm<sup>2</sup>, 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.

4.11.3 The cables for reference cells and pipeline potential measurements shall be of 4 mm<sup>2</sup> copper conductor, PVC insulated, Aluminium backed by mylar/ polyester 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.

4.11.4 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/ polyester tape, PVC sheathed, armoured, PVC over all sheathed type.

4.11.5 Cable conductor sizes indicated above are minimum only and where necessary for proper operation of the CP system higher sized cables shall be provided.

4.11.6 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**

All electrical and electronic instrument enclosures and its accessories for hazardous area shall be flame proof type.

The flame proof equipment shall meet the requirements as per IS/ IEC: 60079 and shall be weather proof to IP-65 also as per IS/IEC:60529.

A copy of approval from local statutory authority, as applicable such as Petroleum & Explosives Safety Organization (PESO)/ Chief Controller of Explosives (CCE), Nagpur or Director General of Mines Safety (DGMS) in India, for the electronic instruments installed in electrically hazardous area along with:

- i) Test certificate from recognized test house like Central Institute of Mining and Fuel Research (CIMFR)/ Electronics Regional Testing Laboratory (ERTL) etc. for flameproof enclosure/ intrinsic safety, as specified in the data sheet, as per relevant standard for all Indian manufactured equipments or for items requiring Director General of Mines Safety (DGMS) approval.
- ii) Certificate of conformity from agencies like Laboratoire Central Des Industries Electriques (LCIE), British Approval Service for Electrical Equipment in Flammable Atmospheres (BASEEFA), Factory Mutual (FM), Physikalisch-Technische Bundesanstalt (PTB), Canadian Standards Association (CSA), Underwriters Laboratories (UL) etc. for compliance to ATEX directives or other equivalent standards for all equipments manufactured outside India.

## **6.0 TESTS AND ACCEPTANCE**

6.1 Unless other wise agreed by the Engineer-in-Charge, all the equipment/ material shall be subject to inspection by Owner/ EIL or by an agency authorised by the Owner/ EIL. All necessary information concerning the supply shall be furnished to EIL/ Owner's inspector. Two weeks notice shall be given to Owner/ EIL 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  $\pm 5\%$ . The total weight of the anodes shall not have negative tolerance.

Recommended dimensional tolerance shall be as follows:

- |                   |   |             |
|-------------------|---|-------------|
| - Length          | : | $\pm 2.5\%$ |
| - Width/thickness | : | $\pm 5\%$   |

- 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 compositions 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

- Open circuit potential, closed circuit potential and anode capacity test shall be carried out for one anode per heat for a duration of 96 hours as per DNV-RP-B401 in the synthetic sea water conforming to ASTM D1144
- Consumption rate by weight loss method
- Visual examination of corrosion pattern (uneven consumption, inter granular attack etc.)

The anode open circuit potential shall lie within (+) 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 AND 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.