

---

# PERMANENT CATHODIC PROTECTION SYSTEM FOR CS 3LPE COATED UNDERGROUND STEEL PIPELINES FOR HARIDWAR GA

**Project No. W.000099**

**Document No.: W.00009 – G – 10731-R001**

**HNGPL Tender No.: W.000099-G10731-R001**

---

**Haridwar Natural Gas Private Limited  
Haridwar| INDIA**

---



**PUBLIC**

27 November 2023

**TECHNICAL DOCUMENTATION**

Technical Volume II of II , Rev. A

---

		<b>PERMANENT CATHODIC PROTECTION SYSTEM FOR CS 3LPE COATED UNDERGROUND STEEL PIPELINES FOR HARIDWAR GA</b>				
Sl. No.	Description	Document / Drawing No.	Rev. No.	Pages	Page No.	
<b>I</b>	<b>VOLUME I OF II</b>	<b>COMMERCIAL</b>				
1	SECTION - I INVITATION FOR BID (IFB)	W.00009 – G – 10731-R001	A	367	001	
2	SECTION - II INSTRUCTION TO BIDDERS (ITB)					
3	SECTION - III GENERAL TERMS & CONDITIONS (GCC)					
4	SECTION - IV SPECIAL TERMS & CONDITIONS (STC)					
5	SECTION - V FORMS AND FORMATS					
6	SECTION - VI SCHEDULE OF RATES (SOR)					
<b>II</b>	<b>TECHNICAL VOLUME</b>	<b>TECHNICAL SPECIFICATIONS</b>				
<b>SCOPE OF WORK</b>						
1	SCOPE OF WORK FOR PERMANENT CATHODIC PROTECTION	W.00009 G 11039 E001	A	03	004	
<b>DESIGN BASIS</b>						
2	DESIGN BASIS FOR PERMANENT CATHODIC PROTECTION	W.00009 G 11061 E001	A	10	007	
<b>PROJECT TECHNICAL SPECIFICATION (PTS)</b>						
3	PTS PERMANENT CATHODIC PROTECTION SYSTEM	W.00009 G 11077 E001	B	55	017	
<b>QAP</b>						
4	QAP SOLID STATE DECOUPLER (SSD)	W.00009 G 11000 E001	0	01	72	
5	QAP TEST LEAD POINT	W.00009 G 11000 E002	0	01	73	
6	QAP PERMANENT REFERENCE CELL	W.00009 G 11000 E003	0	01	74	
7	QAP COMPUTERISED TEST STATION UNIT	W.00009 G 11000 E004	0	01	75	
8	QAP CP CABLE	W.00009 G 11000 E005	0	01	76	
9	QAP MMO ANODE	W.00009 G 11000 E006	0	01	77	
10	QAP CABLE TO PIPE CONNECTIONS (THERMIT WELDING/PIN BRAZING)	W.00009 G 11000 E007	0	01	78	
11	QAP SURGE DIVERTER	W.00009 G 11000 E008	0	01	79	
12	QAP ANODE JUNCTION BOX	W.00009 G 11000 E009	0	01	80	
13	QAP ER PROBE AND ER PROBE READER	W.00009 G 11000 E010	0	02	81	
14	QAP CATHODE JUNCTION BOX	W.00009 G 11000 E011	0	01	83	
15	QAP POLARISATION COUPON	W.00009 G 11000 E012	0	01	84	
16	QAP CALCINED PETROLEUM COKE BREEZE	W.00009 G 11000 E013	0	02	85	
17	QAP BACKFILL MATERIAL	W.00009 G 11000 E014	0	02	87	
18	QAP TRANSFORMER RECTIFIER UNIT (TRU)	W.00009 G 11000 E015	0	03	89	
19	QAP ZINC GROUNDING CELL	W.00009 G 11000 E016	0	02	92	
20	QAP SACRIFICIAL MAGNESIUM ANODE	W.0 0009 G 11000 E017	0	02	94	
<b>RECOMMENDED VENDORS</b>						
21	LIST OF RECOMMENDED VENDORS FOR PERMANENT CATHODIC PROTECTION SYSTEM & EQUIPMENT	W.00009 G 11040 M001	0	04	96	
<b>STANDARD DRAWINGS FOR PERMANENT CATHODIC PROTECTION SYSTEM</b>						
22	IMPRESSED CURRENT CATHODIC PROTECTION SCHEMATIC	W.00009 G 21078 E001	0	01	100	
23	FABRICATION & INSTALLATION DETAILS OF Cu/CuSO4 REFERENCE ELECTRODE	W.00009 G 21078 E002	0	01	101	
24	INSTALLATION DETAILS OF CABLE LAYING (TYPICAL) FOR CATHODIC PROTECTION	W.00009 G 21078 E003	0	01	102	
25	INSTALLATION DETAILS OF DEEP ANODE GROUND BED	W.00009 G 21078 E004	0	01	103	

26	FABRICATION AND INSTALLATION DETAILS OF TEST STATION BOX	W.00009 G 21078 E005	0	01	104
27	CONSTRUCTION & INSTALLATION DETAILS OF TEST STATION BOX FOR HIGH TENSION LINE	W.00009 G 21078 E006	0	01	105
28	TEST STATION CONNECTION SCHEME (TYPICAL) DETAILS (Sheet 1 of 5)	W.00009 G 21078 E007	0	01	106
29	TEST STATION CONNECTION SCHEME (TYPICAL) DETAILS (Sheet 2 of 5)	W.00009 G 21078 E007	0	01	107
30	TEST STATION CONNECTION SCHEME (TYPICAL) DETAILS (Sheet 3 of 5)	W.00009 G 21078 E007	0	01	108
31	TEST STATION CONNECTION SCHEME (TYPICAL) DETAILS (Sheet 4 of 5)	W.00009 G 21078 E007	0	01	109
32	TEST STATION CONNECTION SCHEME (TYPICAL) DETAILS (Sheet 5 of 5)	W.00009 G 21078 E007	0	01	110
33	FABRICATION & INSTALLATION DETAILS OF CABLE ROUTE MARKER	W.00009 G 21078 E008	0	01	111
34	CABLE TO PIPE CONNECTION BY PIN BRAZING	W.00009 G 21078 E009	0	01	112
35	THERMIT WELDING DETAILS	W.00009 G 21078 E010	0	01	113
36	SPARK GAP ARRESTOR INSTALLATION	W.00009 G 21078 E011	0	01	114
37	TYPICAL INSTALLATION AND CONNECTION DETAILS OF EXTERNAL ER PROBE WITH TEST STATION	W.00009 G 21078 E012	0	01	115
38	INSTALLATION DETAILS FOR POLARIZATION COUPON	W.00009 G 21078 E013	0	01	116
39	CONSTRUCTION DETAILS OF MAGNESIUM ANODE ( 20.0 Kg / 10.0 Kg / 7.6 Kg / 5.0 Kg / 2.5 Kg )	W.00009 G 21078 E014	0	01	117
40	CONSTRUCTION DETAILS OF ZINC GROUNDING CELL (20KG)	W.00009 G 21078 E015	0	01	118
41	INSTALLATION DETAILS OF MAGNESIUM ANODE	W.00009 G 21078 E016	0	01	119
42	INSTALLATION DETAILS OF ZINC ANODE	W.00009 G 21078 E017	0	01	120



SCOPE OF WORK FOR  
PERMANENT CATHODIC PROTECTION  
SYSTEM



**HARIDWAR NATURAL GAS PRIVATE LIMITED  
(HNGPL)**



**PERMANENT CATHODIC PROTECTION SYSTEM FOR  
CS 3LPE COATED UNDERGROUND STEEL PIPELINES  
FOR HARIDWAR GA**





**TRACTEBEL ENGINEERING PVT. LTD.**

**SCOPE OF WORK – PERMANENT CATHODIC  
PROTECTION SYSTEM**

**DOC. NO. W.00009-G-11039-E001**

A	07.02.2023	Issued for Review	KRA	MCY	KNS
Rev.	Date	Subject of Revision	Prepared By	Checked By	Approved By

	<b>SCOPE OF WORK FOR PERMANENT CATHODIC PROTECTION SYSTEM</b>	
---	---	---

## 1.0 INTRODUCTION & SCOPE

Haridwar Natural Gas Private Limited (HNGPL), (hereinafter referred as Owner), has been authorised by PNGRB for setting up infrastructure and operation of City Gas Distribution Network in HARIDWAR GA of UTTARAKHAND.

Natural gas will be transported through various steel and MDPE pipeline to residential, commercial, industrial (PNG) and automobile consumers (CNG) in these cities.



Permanent cathodic protection system will be used to protect the underground pipeline sections from ionic corrosion after the complete commissioning of the pipeline for its entire design life.

Pipeline sectional details are provided in the table below:

Sl. No.	Description	Length	Break up
1	GAIL RT at JWALAPUR TO CGS HARIDWAR, FROM CGS HARIDWAR TO BAHADRABAD & CGS TO SECTOR 2	13.14 km	8" – 13.14 km
2	GANGA CANAL TO HAMARA PUMP RO	2.50 km	6" – 2.50 km
3	SECTION TOWARDS – RATANDHAN FILLING STATION RO, ROSHNABAD DRS, SECTOR-2 (VIA BHEL COLONY), KN FILLING STATION RO	42.20.km	4" – 42.20 km
<b>TOTAL LENGTH</b>		<b>57.84 km</b>	

### THE SCOPE OF WORK OF PERMANENT CATHODIC PROTECTION SYSTEM IS PROVIDED BELOW:

- AC Interference & Mitigation:
  - AC interference study and preparation of bill of material for mitigation shall be carried out by a specialist agency having at least 3+ years' experience of conducting/ designing proven mitigation systems by computer modelling or by the bidder if he has 3+ years expertise in performing such studies.
  - The AC interference specialist shall have a licensed computer modelling software like CDEGS (Current distribution, Electromagnetic field, grounding, and Soil Structure analysis software) of SES Canada or Elsyca Belgium in the company's name and subsequent proof to be submitted prior to approval.
  - In addition, a Level II Certificate issued by the software vendor for competence in carrying out the modelling and study shall be submitted by the vendor. The AC interference study will have to be completed within 4 months of the award of the contract (3 months for data collection and physical survey and 1 month for data interpretation and proposition of mitigation measures in software) to facilitate the implementation during construction phase. The mitigation of AC interference shall be designed for both operating load and design load of the powerline in normal operating and short circuit condition.
- Soil Resistivity Survey & Soil Analysis:
  - Soil resistivity test at anode ground bed locations at various depths up to 100 meters.
  - Soil Resistivity [ $\rho$ ] measurement along the entire stretch of the pipeline at an interval of 1 km.
  - Soil /Water samples will be collected from the pipeline ROW at every 10 km.

	<p>SCOPE OF WORK FOR PERMANENT CATHODIC PROTECTION SYSTEM</p>	
---	---	---

- Design, detailed engineering, supply, installation of deep/horizontal anode-beds, transformer rectifier unit (TRU), junction boxes, reference cells, computerised test station, ER probe, various types of cables, surge diverter, AC interference mitigation materials etc, testing, quality assurance (QA), quality control (QC), inspection, pre-commissioning and commissioning of the PCP system as per specification and to the satisfaction of Purchaser/ Consultant.
- Coating conductance survey at all the HDD crossings/ River crossings (locations where coating is expected to be damaged).
- The scope of the PCP contractor shall also include installation and commissioning of AC interference mitigation grounding system comprising of zinc grounding cells, copper cored AC mitigators and solid state de-coupler, AC corrosion coupons, Zn ribbon anodes as per the specification's along with associated TLP, cabling and pin brazing etc.
- Post commissioning Survey:
  - Close Interval Potential logging (CIPL) ON/OFF survey: to check the adequacy of the installed permanent cathodic protection system.
  - Direct Current Voltage Gradient (DCVG): at the locations identified in CIPL survey where the instant OFF potential does-not meet the protection criteria.
  - CAT survey for the entire pipeline length for determining the health of the coating.
  - CAT A frame at coating defect locations identified during CAT survey to size the defect.
- Maintenance of the complete system including monthly monitoring of the complete system for 3 years.
- All data required in this regard, including site surveys and CP performance parameters of the any operational foreign pipeline in the ROW, shall be taken into consideration by the CP contractor for proper engineering of the PCP systems.
- Compliance with project specifications and/or approval of any of the contractor's documents shall in no case relieve the contractor of his contractual obligations of providing permanent cathodic protection (PCP) system suitably for an operational life of 30 years.
- SCADA, Telecom, Instrumentation equipment, etc. to be used for feedback of CP parameter and desired controls may be supplied, installed and commissioned by another agency. Hence, CP contractor shall arrange necessary contact and communication port (RS 485) in the CP unit for monitoring and controlling CP parameters through SCADA.
- Project Closure & Hand over.



DESIGN BASIS FOR PERMANENT CATHODIC  
PROTECTION SYSTEM



**HARIDWAR NATURAL GAS PRIVATE LIMITED  
(HNGPL)**



**PERMANENT CATHODIC PROTECTION SYSTEM FOR  
CS 3LPE COATED UNDERGROUND STEEL PIPELINES  
FOR HARIDWAR GA**



**TRACTEBEL ENGINEERING PVT. LTD.**

**DESIGN BASIS – PERMANENT CATHODIC  
PROTECTION SYSTEM**

**DOC. NO. W.00009-G-11061-E001**

A	07.02.2023	Issued for Review	KRA	MCY	KNS
Rev.	Date	Subject of Revision	Prepared By	Checked By	Approved By



DESIGN BASIS FOR PERMANENT CATHODIC  
PROTECTION SYSTEM



**TABLE OF CONTENTS**

<b>1.0</b>	<b>INTRODUCTION .....</b>	<b>3</b>
<b>2.0</b>	<b>SCOPE.....</b>	<b>3</b>
<b>3.0</b>	<b>CODES AND STANDARDS .....</b>	<b>4</b>
<b>4.0</b>	<b>DESIGN CRITERIA - PERMANENT CATHODIC PROTECTION .....</b>	<b>5</b>
<b>A.</b>	<b>SOIL RESISTIVITY AND SOIL ANALYSIS .....</b>	<b>5</b>
<b>B.</b>	<b>ADDITIONAL DATA TO BE COLLECTED .....</b>	<b>6</b>
<b>C.</b>	<b>PCP DESIGN PARAMETERS .....</b>	<b>6</b>
<b>D.</b>	<b>PROTECTION CRITERIA .....</b>	<b>7</b>
<b>E.</b>	<b>DESIGN CRITERIA FOR MAIN EQUIPMENT .....</b>	<b>8</b>
<b>5.0</b>	<b>OTHER CP SYSTEM REQUIREMENTS:.....</b>	<b>10</b>

ΣΣΣ



## 1.0 INTRODUCTION

Haridwar Natural Gas Private Limited (HNGPL), (hereinafter referred as Owner), has been authorised by PNGRB for setting up infrastructure and operation of City Gas Distribution Network in HARIDWAR GA of UTTARAKHAND.

Natural gas will be transported through various steel and MDPE pipeline to residential, commercial, industrial (PNG) and automobile consumers (CNG) in these cities.

This document covers the basic minimum criteria for designing of the permanent cathodic protection system which is required to protect the underground steel pipeline network from the ionic corrosion.

## 2.0 SCOPE

Permanent cathodic protection system will be used to protect the below pipeline sections from ionic corrosion after the complete commissioning of the pipeline for its entire design life:

Sl. No.	Description	Length	Break up
1	GAIL RT at JWALAPUR TO CGS HARIDWAR, FROM CGS HARIDWAR TO BAHADRABAD & CGS TO SECTOR 2	13.14 km	8" – 13.14 km
2	GANGA CANAL TO HAMARA PUMP RO	2.50 km	6" – 2.50 km
3	SECTION TOWARDS – RATANDHAN FILLING STATION RO, ROSHNABAD DRS, SECTOR-2 (VIA BHEL COLONY), KN FILLING STATION RO	42.20.km	4" – 42.20 km
<b>TOTAL LENGTH</b>		<b>57.84 km</b>	

All above pipelines are 3LPE coated and thickness of for pipeline of 8",6",4" is 6.4 mm respectively.

Scope of this document is to describe the design basis and minimum technical requirement for the permanent cathodic protection of the aforementioned pipeline stretches.

Majorly, following are included in the scope of permanent cathodic protection system work:

- ❖ Soil resistivity test at proposed anode ground bed locations at various depths up to 100 m (1m, 2m, 3m, 5m, 10m, 15m, 20m, 30m, 40 m, 50 m, 60 m, 70m, 80m and 100m).
- ❖ Design, detailed engineering, testing at manufacturer works, supply, installation of deep/horizontal anode-beds, transformer rectifier unit (TRU), Cathode Junction Box (CJB), Anode Junction Box (AJB), Permanent Reference Electrode, Reference Electrode Junction Box (REJB), Computerized test station unit (CTSU), Cables, AC/DC interference mitigation material, testing, quality assurance (QA), quality control (QC), inspection, pre-commissioning and commissioning of the PCP system as per the specification's and to the satisfaction of the Owner/ Consultant.
- ❖ Coating conductance survey at all the HDD crossings/ river crossings (locations where coating is expected to be damaged).
- ❖ Installation of independent sacrificial type CP System considering Magnesium anode (20 Kg net each) at all river crossings, Major Road/ Railway crossing.
- ❖ AC/DC interference study and mitigation:

The work shall include data collection for AC/DC interference study, simulation using CDEG/ELSYCA software, installation of AC/DC interference mitigation system comprising of zinc

grounding cells, zinc ribbon anodes, deep ground beds and solid state decoupler, ac corrosion coupons along with associated TLP, cabling, pin brazing etc.

- ❖ Close interval potential logging (CIPL) ON/OFF survey: to check the adequacy of the installed permanent cathodic protection system.
- ❖ Direct current voltage gradient (DCVG): This test shall be performed at the locations identified in CIPL survey where the instant OFF potential does not meet the protection criteria.
- ❖ CAT survey for the entire pipeline length for determining the health of the coating and CAT A frame at coating defect locations identified during CAT survey to size the defect.
- ❖ Coating repair at the identified defect location
- ❖ Post installation monitoring

### 3.0 CODES AND STANDARDS

System design, manufacture, testing and inspection, installation and commissioning of the permanent cathodic protection shall comply with the codes and standards mentioned below:

<b>NACE SP-0169-2013</b>	Recommended practice control of external corrosion on Underground or Submerged Metallic Piping System
<b>NACE SP-0286-2007</b>	Recommended Practice- the electrical isolation of Cathodically Protected Pipelines
<b>NACE SP-0200-2014</b>	Cathodic Protection for Metallic Cased Crossings
<b>NACE SP-0177-2014</b>	Recommended Practice - Mitigation of AC and lightning effects on metallic structures and corrosion control systems
<b>NACE 54276</b>	Cathodic Protection Monitoring for Buried Pipes
<b>NACE SP-0572-2007</b>	Recommended practice- Design, Installation, operation and of Impressed Current Deep Ground Beds
<b>NACE TM0101-2012</b>	Measurement techniques related to criteria for Cathodic Protection
<b>NACE TM0497-2012</b>	Measurement techniques related to criteria for Cathodic Protection on Submerged Metallic Piping System
<b>ASTM B418</b>	Cast and Wrought Galvanic Zinc Anodes
<b>ASTM B843</b>	Magnesium Alloy Anodes for Cathodic Protection
<b>ASTM G57</b>	Field measurement of soil resistivity using Wenner four pin electrode method
<b>ISO 15589-1: 2016</b>	Petroleum and Natural Gas industries-CP of Pipeline Transportation Systems- on land pipelines
<b>IS 8062 part-2: 2006</b>	Code of Practice for Cathodic Protection of Steel Structures, Part II: Underground Pipelines [MTD24: Corrosion Protection]

<b>IS 3043: 2007</b>	Code of practice for Earthing
<b>BS EN50162:2004</b>	Protection against corrosion by stray current from direct current systems
<b>BS EN15280:2013</b>	Evaluation of AC corrosion likelihood of Buried Pipelines applicable to Cathodically Protected Pipelines
<b>IEEE 80</b>	Guide for Safety in Substation Grounding
<b>IS 1554 PART-1</b>	PVC Insulated heavy duty cables
<b>IS 5571-2009</b>	Guide for selection of electrical equipment for Hazardous Area
<b>IS 2148:2004</b>	Flame proof equipment for Hazardous Area
<b>IS 5572-2009</b>	Classification Of Hazardous Areas (other Than Mines) Having Flammable Gases and Vapors for Electrical Installation
<b>OISD-RP-188</b>	Corrosion monitoring of Offshore and Onshore Pipelines
<b>OISD-RP-226</b>	Natural Gas Transmission Pipelines and City Gas Distribution Networks

#### 4.0 DESIGN CRITERIA - PERMANENT CATHODIC PROTECTION

A distinct independent permanent cathodic protection system shall be provided to the external surfaces of the complete pipeline. This protection shall be with impressed current type. Design life will be 30 years.

##### A. SOIL RESISTIVITY AND SOIL ANALYSIS

The cathodic protection [PCP] system to be implemented will be based on the site data generated from the pipeline ROW as per the following:

##### 1. SOIL RESISTIVITY:

- a. Soil Resistivity [ $\rho$ ] measurement at proposed anode-bed locations shall be as below:
  - ❖ **Shallow Type Anode Bed:** Measurements to be done similarly using Wenner's 4-pin method at each location at depths of 1, 2, 3, 4, 5, 6 m.
  - ❖ **Deep Well Anode Bed:** Soil Resistivity to be measured at depths of 1m, 2m, 3m, 5m, 10m, 15m, 20m, 30m, 40 m, 50 m, 60 m, 70m, 80m and 100m.
- b. **Soil Resistivity [ $\rho$ ]** measurement along the entire stretch of the pipeline at an interval of 1 km.

##### 2. SOIL ANALYSIS:

**Soil /Water samples** will be collected from the pipeline ROW at every 10 km for the following analysis as depicted below:

- ❖ Ionic loading from an aqueous extract of the soil.
  - ❖ Sodium, potassium, calcium, magnesium [all in ppm].
  - ❖ Chloride, sulphate, sulphide, carbonate, bi-carbonate, sulphite, phosphate, nitrate, nitrite [all in ppm]
  - ❖ Microbial Loading
- Sulphate reducing bacteria [presence/absence of bacterial colonies] P<sub>H</sub>, total dissolved solids [TDS], redox potentials, moisture (%).

## B. ADDITIONAL DATA TO BE COLLECTED

The following data shall also be collected to generate design data for the evaluation of interaction/interference possibilities due to the presence of other services in ROW/in its vicinity:



- ❖ Route and types of foreign service/pipeline in and around or crossing the right of way (including the existing ones and those which are likely to come up during the contract execution) with pipe diameter, type of coating, type of cathodic protection, location of anode ground beds, output current and voltage of CP power supply unit.
- ❖ Necessary potential gradient surveys for existing anode ground beds that may interfere with the CP system of the pipelines covered under this project.
- ❖ 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.
- ❖ Crossing or parallel running of any existing or proposed HVAC (66 kV & above) or locations of distribution transformers (11kV/220kV) with SWER (single wire earth return) within 30 m of the pipeline, the following information should be collected:
  - The maximum load of the power line
  - Rated steady state current capacity
  - AC fault current rating of the pipeline
  - Lightening current rating of the area.
- ❖ Voltage rating, phases, sheathing details of the underground power cables running along the ROW /in its vicinity.
- ❖ Soil resistivity data of the entire pipeline route length shall be collected from temporary cathodic protection report for attenuation calculation and current density requirement calculation.

## C. PCP DESIGN PARAMETERS

Following parameters shall be used for design of permanent cathodic protection (PCP) system:

- ❖ **Protection Current Density**

Pipeline surrounding	Protection Current density* ( $\mu\text{A}/\text{m}^2$ )
	(For a Design Life of 30 Years with 3LPE coated pipeline)
Soil Resistivity: $\leq 10 \text{ ohm -m}$	200

	<b>DESIGN BASIS FOR PERMANENT CATHODIC PROTECTION SYSTEM</b>	
---	--	---

Soil Resistivity: > 10 ohm m to ≤ 100 ohm -m	100
Soil Resistivity: > 100 ohm -m	50

However, for pipelines operating at elevated temperatures, the current density correction factor shall be applied as 25% per 10°C rise in operating temperature above 30 °C.

\* Actual current density shall be decided based upon the soil/water corrosivity, and other environmental conditions obtained as per the detailed chemical & microbial analysis and presence or absence of interfering elements, proximity of foreign pipelines and structures resulting in interference in close vicinity of the pipeline ROW.

Wherever required for satisfactory protection of the pipeline the current density shall be suitably increased.

❖ **Other Parameters for PCP Design**



Safety factor for Current Density	:	1.3
Pipeline Natural Potential	:	(-) 0.45V
Steel Resistivity	:	2.2 X 10 <sup>-7</sup> Ω m
3LPE Coating Resistivity	:	10 <sup>8</sup> Ω-m
Specific Coating Resistance	:	>10 <sup>5</sup> Ω -m <sup>2</sup> for 1000 ohm-cm soil resistivity
Parameters for Attenuation calculation:		
Cathodic potential at drain point (V)	:	(-) 1.2 V
Cathodic potential at farthest point	:	(-) 0.85 V
Pipeline Natural Potential	:	(-) 0.45 V

**D. PROTECTION CRITERIA**

Criteria for determining the adequacy of protection to the buried pipeline are defined in NACE's code SP-0169 and the same shall be binding.

However, essential requirements for the protection of the pipeline are depicted below. All the criteria as mentioned below (as applicable) shall be complied:

- ❖ A negative pipe to soil potential (Instant OFF potential) of at least 850 mV with respect to Cu/CuSo4 reference electrode. However, in no case negative OFF potential shall not exceed 1.2 V anywhere at the pipeline to avoid hydrogen embrittlement and coating disbandment.
- ❖ A minimum of 100 mV of cathodic polarization between the structure surface and a stable reference electrode in contact with the electrolyte. The formation or decay of polarization can be measured to satisfy this criterion.
- ❖ A negative (cathodic) potential of at least 850 mV with the cathodic protection applied. This potential is measured with respect to a saturated copper/copper sulfate reference electrode in contact with the

	<b>DESIGN BASIS FOR PERMANENT CATHODIC PROTECTION SYSTEM</b>	
---	--	---

electrolyte. Voltage drops other than those across the structure-to-electrolyte boundary must be considered for valid interpretation of this voltage measurement.

- ❖ Wherever the presence of sulfides, bacteria etc. are detected, a negative polarized potential of at least 950 mV with respect to Cu/CuSo4 will be maintained.
- ❖ For Pipeline operating temperature between 40°C and 60°C, the protection potential may be interpolated considering protection potential of -850 mV at 40°C and -950 mV at 60°C.

❖ **Interference criteria:**

A Positive potential swing of 50 mV or more shall be considered as sufficient to indicate the presence of an interaction/interference situation requiring investigation and incorporation of mitigation measures.

Discretion to use any of the criteria, mentioned above, shall solely rest with the Owner/ Owner's representative.

## E. DESIGN CRITERIA FOR MAIN EQUIPMENT

### TRANSFORMER RECTIFIER UNIT (TRU)

- ❖ The Single/Three Phase, 415V / 230V input power supply is available at various CGS/DRS/DCU. TRU shall be suitable for above input power supplies.
- ❖ Rating and quantity shall be selected in such a way that the TRU(s) shall be adequate to provide complete protective current and potential throughout the pipeline.
- ❖ TRU shall be integrated with CP monitoring facility with communication facility with SCADA system through MODBUS TCP/IP protocol.
- ❖ TRU located at the hazardous area shall be suitable for hazardous area application. Enclosure shall be Ex-d type with temperature class of T3 and suitable for gas ground IIA/IIB.

### ANODE GROUND BEDS

- ❖ Ground bed shall be located at an electrically remote location from the pipeline and foreign pipeline/ other buried metallic structures.
- ❖ Nearest part of the anode bed shall be 100 meters away or as calculated based on the maximum permissible earth potential whichever is higher to maintain (safe) equal potential zone and minimize stray current interference of the neighboring pipeline & structure.
- ❖ The Anodes installed in the ground shall be in perennially moist strata, wherever possible.
- ❖ **Horizontal Ground Beds** shall be at right angles to the pipeline and electrically remote. 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.
- ❖ Anodes shall be of mixed metal oxide (MMO) coated titanium type.
- ❖ **Deep Well Ground Beds** non-canister anodes with calcined petroleum coke breeze in the well surrounding the anodes shall be provided.

**In Deep well anode bed** with respect to the first anode of the string: should be at least more than 15



## DESIGN BASIS FOR PERMANENT CATHODIC PROTECTION SYSTEM



m deep [as per NACE RP 0572 Standard] (i.e., inactive zone) and the actual depth shall be (minimum) 50-100 m deep based on the system design.

- ❖ Type of anode bed (Horizontal shallow type/Vertical deep type) shall be selected based on the soil resistivity data.

If soil resistivity is less at the upper region than the deeper region, then horizontal shallow anode bed shall be selected.

In case soil resistivity is less at the deeper region as compared to the upper region, then vertical deep anode bed will be selected.

Type of anode bed selection shall also depend upon the site condition and land availability also.

- ❖ **Chain-link fencing** shall be provided with proper markers around the anode bed and the cable route.
- ❖ Layout of the anode installation in anode bed shall be depicted in detailed engineering & construction drawings depicting 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.
- ❖ Anodes shall be supplied along with tail cables, which shall be long enough for termination on their associated anode lead junction boxes without any intermediate joints. Exact lengths and termination details shall be indicated in detailed engineering & construction drawings.
- ❖ Potential gradient around the anode bed shall be within the permissible safety requirements with regard to interference on foreign structures and its effective boundary shall be defined.
- ❖ 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.

### JUNCTION BOXES



- ❖ Required numbers of junction boxes made of sheet steel with minimum 2 mm thickness shall be provided, wherever required.
- ❖ Junction boxes located at the hazardous area shall be suitable for hazardous area application. Enclosure shall be Ex-d type with temperature class of T3 and suitable for gas ground IIA/IIB.

### REQUISITES OF CP STATIONS/ ANODE GROUND BED FOR IMPRESSED CURRENT SYSTEM

- ❖ CP stations shall be located coinciding with CGS/DRS/DCU, as far as possible.
- ❖ Possibility of using existing TRU, if any in the existing pipeline from which tapping is being taken off, shall be explored.

#### Additional requirements:

- For each station, insulating joint (IJ) shall be provided by the EPC contractor for isolating the incoming trunk line /spur line, outgoing trunk line spur line, existing consumer tapping (whichever is applicable) from the station piping, earthing grids/ pits etc.
- AC Interference Study should be performed at locations where pipeline is crossing or parallel to the high tension powerline  $\geq 33$  kV.



	<b>DESIGN BASIS FOR PERMANENT CATHODIC PROTECTION SYSTEM</b>	
---	--	---

- The pipeline shall be grounded through Solid State DC de-coupler with zinc galvanic anode, irrespective of AC induced potential in Pipeline which is either crossing or running within 100 meters in parallel with overhead EHV/ HV transmission lines of voltage grade 66 kV and above.

## 5.0 OTHER CP SYSTEM REQUIREMENTS:

<b>Current Drainage &amp; Coating Resistance measurement survey</b>	Shall be done by the contractor
<b>Electrical Resistance probes</b>	Shall be provided one for each section or High Consequence Area (to be confirmed in RFQ)
<b>Computerized Test Stations</b>	Shall be provided at the midpoint between two CP stations, also at locations which are un-approachable/vulnerable with the approval from the owner/PMC
<b>No. of Computerized Test Station.</b>	Location to be finalized in consultation with HNGPL by the CP Contractor
<b>No. of computerized test station readers/ portable data collection &amp; storage</b>	Location to be finalized in consultation with HNGPL by the CP Contractor
<b>Interval for Data Acquisition/ Storing</b>	Once every day
<b>Polarization Coupons</b>	One every 10 km and at CP Station Location
<b>Polarization Cell</b>	Solid state type with Zinc Anode at HT crossings
<b>Surge Divertor</b>	(Explosion proof type) provided across each Insulating Joint with Zinc grounding cell
<b>Anode ground bed in the name of HNGPL including installation of anode junction boxes (AJB) and ROU for anode ground bed cable laying between AJB &amp; CPTRU</b>	By the Contractor
<b>Chain link fencing around the anode ground bed</b>	Shall be carried out for full size of the acquired plot
<b>Close Interval Potential Logging Survey</b>	Shall be carried out Post Commissioning of CP system
<b>Additional tests to be conducted for identifying pipe coating defects / holidays</b>	DCVG survey followed by CAT
<b>DCVG</b>	At locations identified in CIPL survey or 10% of the Pipeline Length
<b>CAT</b>	To be conducted on complete pipeline length to assess the coating health  Note : At intervals of 50 m



	<p style="text-align: center;">PARTICULAR TECHNICAL SPECIFICATIONS (PTS) FOR PERMANENT CATHODIC PROTECTION SYSTEM</p>	
---	---	---

**HARIDWAR NATURAL GAS PRIVATE LIMITED  
(HNGPL)**



**PERMANENT CATHODIC PROTECTION SYSTEM FOR  
CS 3LPE COATED UNDERGROUND STEEL PIPELINES  
FOR GA OF HARIDWAR**



**TRACTEBEL ENGINEERING PVT. LTD.**



**PARTICULAR TECHNICAL SPECIFICATIONS -  
PERMANENT CATHODIC PROTECTION SYSTEM**

**DOC. NO. W.00009-G-11061-E001**

1	01.11.2023	Issued for Procurement	KRA	MCY	KNS
0	08.02.2023	Issued for Procurement	KRA	MCY	KNS
Rev.	Date	Subject of revision	Author	Checked	Approved

**TABLE OF CONTENTS**

<b>1.</b>	<b>INTRODUCTION.....</b>	<b>3</b>
<b>2.</b>	<b>ABBREVIATIONS: .....</b>	<b>3</b>
<b>3.</b>	<b>SITE CONDITIONS .....</b>	<b>5</b>
<b>4.</b>	<b>TENTATIVE CROSSING DETAILS.....</b>	<b>5</b>
<b>5.</b>	<b>SOIL RESISTIVITY AND SOIL ANALYSIS.....</b>	<b>6</b>
<b>6.</b>	<b>ADDITIONAL DATA TO BE COLLECTED .....</b>	<b>6</b>
<b>7.</b>	<b>AC INTERFERENCE STUDY .....</b>	<b>7</b>
<b>8.</b>	<b>CATHODIC PROTECTION DESIGN PARAMETERS .....</b>	<b>9</b>
<b>9.</b>	<b>CATHODIC PROTECTION DESIGN CRITERIA .....</b>	<b>10</b>
<b>10.</b>	<b>PERMANENT CATHODIC PROTECTION - SYSTEM DETAILS .....</b>	<b>10</b>
<b>11.</b>	<b>INTERFACING WITH SCADA.....</b>	<b>35</b>
<b>12.</b>	<b>TEST STATIONS .....</b>	<b>36</b>
<b>13.</b>	<b>INSTALLATION.....</b>	<b>38</b>
<b>14.</b>	<b>TESTING AND INSPECTION AT WORKS.....</b>	<b>40</b>
<b>15.</b>	<b>PACKING AND TRANSPORT .....</b>	<b>42</b>
<b>16.</b>	<b>SYSTEM TESTING AND COMMISSIONING.....</b>	<b>42</b>
<b>17.</b>	<b>COMMISSIONING.....</b>	<b>44</b>
<b>18.</b>	<b>SYSTEM MONITORING .....</b>	<b>46</b>
<b>19.</b>	<b>DRAWINGS AND DOCUMENTS .....</b>	<b>46</b>
<b>20.</b>	<b>INSTRUMENTS, TOOLS AND SPARES .....</b>	<b>47</b>
<b>21.</b>	<b>POST C.P. COMMISSIONING SURVEYS.....</b>	<b>50</b>
<b>22.</b>	<b>AMC (ANNUAL MAINTENANCE CONTRACT) FOR A PERIOD OF 3 YEARS .....</b>	<b>53</b>
<b>23.</b>	<b>AS BUILT DOCUMENTATION.....</b>	<b>54</b>
<b>24.</b>	<b>SURVEY &amp; IDENTIFICATION OF LAND FOR AGB.....</b>	<b>55</b>

	<b>PARTICULAR TECHNICAL SPECIFICATIONS (PTS) FOR PERMANENT CATHODIC PROTECTION SYSTEM</b>	
---	---	---

## 1. INTRODUCTION

Haridwar Natural Gas Private Limited (HNGPL), (hereinafter referred as Owner), has been authorized by PNGRB for setting up infrastructure and operation of City Gas Distribution Network in HARIDWAR GA of UTTARAKHAND.

Natural gas will be transported through various steel and MDPE pipeline to residential, commercial, industrial (PNG) and automobile consumers (CNG) in these cities.

This document will cover the basic minimum requirement for permanent cathodic protection (PCP) system and all the equipment which are required to protect the underground steel pipeline network from the ionic corrosion.

Details of pipeline along with proposed location of Smart transformer rectifier unit (TRU) are as follows:

Sl. No.	Description	Total Length for Each Stretch	Break up	Proposed Locations for Installation of TRU	Total No. Of TRU's Proposed	No. of Anodes Proposed per Anode Bed
1	GANGA CANAL TO HAMARA PUMP RO	2.50 km	6" – 2.50 km	TRU-1 at CGS HARIDWAR	1	Min 8 to 10
	GAIL RT at JWALAPUR TO CGS HARIDWAR, FROM CGS HARIDWAR TO BAHADRABAD & CGS TO SECTOR 2	13.14 Km	8" – 13.14 km			
	SECTION TOWARDS – RATANDHAN FILLING STATION RO, ROSHNABAD DRS , SECTOR-2 ( VIA BHEL COLONY ) , KN FILLING STATION RO	42.30 Km	4" – 42.20 km			
	<b>Total</b>	<b>57.84 km</b>		<b>TRU-1 at CGS HARIDWAR</b>	<b>1</b>	<b>8 to 10</b>
<b>OUTPUT RATING OF Smart TRU for HARIDWAR GA is as follows:</b> TRU'S-1 ARE 50Vdc/50Adc						

The TRU is (230Vac input) smart type with inbuilt RTU, GSM based modem and display unit is given below:

All the above pipelines are 3LPE coated and thickness of for pipeline of 8",6",4" is 6.4 mm respectively.

*\*Note: The location for installation of TRU will be solely dependent on actual site conditions based on land and power supply availability .*

## 2. ABBREVIATIONS:

3LPE	:3 Layers Poly Ethylene
AC	:Alternating Current



PARTICULAR TECHNICAL SPECIFICATIONS  
(PTS) FOR PERMANENT CATHODIC  
PROTECTION SYSTEM



AJB	:Anode Junction Box
CAT	:Current Attenuation test
CIPL	:Closed Interval Potential Logging
CJB	:Cathode Junction Box
CMRI	:Central Mining Research Institute
CPC	:Cathodic Protection consultant
CPPSM	:Cathodic Protection Power Supply Module
CPTR	:Cathodic Protection Transformer Rectifier Unit
CSE	:Copper Sulphate Electrode
CTSU	:Computerized test Station unit
CT	:Current Transformer
DC	:Direct Current
DCVG	:Direct Current Voltage Gradient
DT	:Dispatch Terminal
EHV	:Extra High Voltage
ER Probe	:Electrical Resistance Probe
FBE	:Fusion bonding Epoxy
GPS	:Global Positioning Satellite system
GSM	:Global System for Mobile Communications
HDD	:Horizontal Directional Drilling
HMWPE	:High Molecular Weight Polyethylene
HV	:High Voltage
ICCP	:Impressed current Cathodic Protection
IPS	:Intermediate Pigging station
IR	:Insulation resistance
MIJ	:Monolithic Insulation Joint
MMO	:Mixed Metal Oxide
MOV	:Motor Operate Valve
MV	:Medium Voltage
NACE	:National Association of Corrosion Engineers
PCP	:Permanent Cathodic Protection
PSP	:Pipe to Soil Potential
PT	:Potential Transformer
PVC	:Polyvinyl Chloride
PVDF	:Polyvinyl dyne Fluoride
REJB	:Reference electrode junction box

ROU	:Right of Use
ROW	:Right of Way
RT	:Receiving Terminal
SV Station	:Sectionalized Valve Station
TCP	:Temporary Cathodic Protection
TLP	:Test Lead Point
UPS	:Uninterruptible power supply
XLPE	:Cross Linked Polyethylene

**3. SITE CONDITIONS**

The cathodic protection equipment shall be designed for the following site conditions:

Min / Max. Temperature of the pipeline: (-) 20<sup>0</sup> C to (+) 65<sup>0</sup> C



Design Ambient Temperature for electrical & CP equipment shall be (+) 50<sup>0</sup> C and an altitude not exceeding 1000 meters above mean sea level shall be considered.

Relative Humidity	90%
Atmospheric Pollution	To withstand the site conditions, dust, vapour
Hazardous area classification for plant	Zone 2, Gas Group IIA, IIB Temp. Class T3
Control Room / Electrical Room/Guard Room	Safe Area

**4. TENTATIVE CROSSING DETAILS**

The GA of Haridwar– Uttarakhand State		
Sl. No.	Characteristic	Details
1	Cased Crossings	5 no's
2	Foreign Pipeline Crossings	5 no's
3	Insulation Mono-Block	11 nos
4	Valves Intermediate SV	8 nos
5	HDD- River/Nadi Crossings, Canals, Nala, Railway, NH/SH	6 nos.
6	HT Line Crossings $\geq 33$ kV *	To be checked by the contractor
7	HT line $\geq 33$ kV parallel to the pipeline within lateral separation of 30 mtr	To be checked by the contractor

\*Notes:

	<b>PARTICULAR TECHNICAL SPECIFICATIONS (PTS) FOR PERMANENT CATHODIC PROTECTION SYSTEM</b>	
---	---	---

1. Nos. of crossing as indicated in the table above are indicative which shall be further verified by the contractor during detail design.
2. There are multiple 11 kV HT lines parallel and crossing the pipeline, the location of any distribution transformer with SWER (single wire earth return) to be checked at site.

## 5. SOIL RESISTIVITY AND SOIL ANALYSIS

Permanent Cathodic Protection system should be based on site data generated from the pipeline ROW as per following parameters:

- **SOIL RESISTIVITY:**

a. At proposed **anode-bed locations:**

Measurements will be done using Wenner's 4-pin method at each location at depths of 1, 2, 3, 4, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 60, ..... 100 m -

**Note : At each CP station location soil resistivity shall be measured upto 100 m depth for 3 plots, for selection of the anode bed for the lowest resistivity plot.**

b. **Soil Resistivity [ $\rho$ ]** measurement along the entire stretch of the pipeline at an interval of 1 km.

- **SOIL ANALYSIS:**

**Soil /Water samples** will be collected from the pipeline ROW at every 10 km for the following analysis as depicted below:

- Ionic Loading from an aqueous extract of the soil.
- Sodium, Potassium, Calcium, Magnesium [all in ppm].
- Chloride, Sulphate, Sulphide, Carbonate, Bi-Carbonate, Sulphite, Phosphate, Nitrate, Nitrite [all in ppm]
- Microbial Loading
- Sulphate Reducing Bacteria [Presence/absence of bacterial colonies]  $P_H$ , Total Dissolved Solids [TDS], Redox Potentials, Moisture (%).

## 6. ADDITIONAL DATA TO BE COLLECTED

The following data shall be collected in order to generate design data for evaluation of interaction/interference possibilities due to presence of other services in ROW/in vicinity.

Additional data shall be collected from various sources like Purchaser/ Consultant/power authorities/ foreign facility owner, pipeline alignment sheets and from the field survey to be done by CONTRACTOR.

The contractor shall be responsible for collecting the following data from the site to predict and mitigate the occurrence of any interference – AC or DC on the pipeline:

- 1 Type of Foreign Service / pipeline/ HT line and year of laying & commissioning.
- 2 Diameter and pipeline coating in case of foreign pipeline (parallel or crossing) including spacing between the pipelines.



PARTICULAR TECHNICAL SPECIFICATIONS  
(PTS) FOR PERMANENT CATHODIC  
PROTECTION SYSTEM





- 3 Depth of laying.
- 4 Type of existing cathodic protection systems (Impressed Current / Sacrificial).
- 5 Location and type of anode Groundbed (Deep Well / Shallow) and distance of the existing anode ground bed.
- 6 Location of existing CP power supply units and their output voltage, current, pipe to soil potential readings.
- 7 Location of existing test stations.
- 8 Remedial measures taken by the Foreign Service / pipeline to prevent AC/DC interference/corrosion.
- 9 Graphical representation of existing structure / pipe to soil potential records.
- 10 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.
- 11 Where pipeline is likely to pass near any existing ground bed (within 100 m approx) , anode-bed potential gradient survey shall be carried out prior to the laying of the pipeline.
- 12 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.
- 13 Information on electrified and non-electrified traction line (along with information regarding, operating voltage, AC / DC type etc.), crossing or parallel to the pipeline. Information of abandoned tracks near ROW having electrical continuity with existing tracks shall also be recorded.

## 7. AC INTERFERENCE STUDY

The AC interference study is required to be performed by a specialist party. The data required to perform the AC interference study is:

- Existing or proposed EHV/HV (33 kV & above) AC/DC overhead power lines along with details of voltage, AC/DC type etc, crossing or parallel to the pipeline, phase configuration, number of circuits and other line parameters.
- Voltage rating, phases, sheathing details of underground power cables along ROW or in its vicinity.
- Tower footing, earthing distance from tentative ROU should be recorded for ascertaining safe distance.
- Fault current rating of each HT line,
- Designed load current, operating load current
- Location of grounding of tower and substation location etc. to be obtained from power companies.
- Multi-layer soil resistivity near the area of AC tower parallel or crossing.

The AC interference study shall have to be completed within 4 months of the award of the contract in order to facilitate the implementation during construction phase. The study shall include the calculation of the following:

	<b>PARTICULAR TECHNICAL SPECIFICATIONS (PTS) FOR PERMANENT CATHODIC PROTECTION SYSTEM</b>	
---	---	---

- Induced voltages on pipeline under steady state operating condition of the transmission line
- Induced voltages on pipeline under fault conditions
- Ground Potential (GPR) during fault conditions
- AC current density/soil resistivity measurement

The above estimations shall be made by computer modelling based on data collected from the field comprising of :

- Visual inspection of ROW,
- Data collection from Powerline operators and
- Multi layer soil resistivity
- Preparation of BOM
- Post mitigation verifying the induced voltage/ current density

The scope of the specialist agency includes designing mitigation model to ensure that the below specified criteria is met:

- The maximum pipe to soil induced voltage must be less than 15V AC RMS for steady state condition of power line.
- Under fault condition, the permissible touch & step voltages must be limited to the levels defined in IEEE-80 latest revision for human safety.
- Total coating stress voltage (inductive & conductive) within 3kV AC for 3LPE coating, to prevent coating damages.
- The AC current density should not exceed a time-weighted average of:

30 A/m<sup>2</sup> if DC current density exceeds 1 A/m<sup>2</sup>

100 A/m<sup>2</sup> if DC current density is less than 1 A/m<sup>2</sup>

Hence , The AC current density limit over a 24 hour duration should be lower than 30 A/m<sup>2</sup> on a 1 cm<sup>2</sup> coupon, if the DC current density exceeds 1 A/m<sup>2</sup>.

Hence , The AC current density limit over a 24 hour duration should be lower than 100 A/m<sup>2</sup> on a 1 cm<sup>2</sup> coupon, if the DC current density exceeds 1 A/m<sup>2</sup>.

## **7.1 AC INTERFERENCE MITIGATION REPORT**

The AC interference mitigation report shall provide a proper bill of material of components to be installed with locations for installation by the contractor. The mitigation recommended should be for both the operating load of the pipeline and the design load. The bill of material shall include:

1. Recommending the type of grounding: distributed vertical zinc ground anodes, horizontal zinc ribbon anode, multiple zinc ribbon anodes, independent deep ground beds.

The grounding system shall be de-coupled with the ICCP system using suitably located and rated solid state decouplers.

2. Recommending locations of TLP's where AC corrosion coupons / Polarization coupons shall be installed for monitoring the induced potentials and AC current densities for safe operation of the pipeline.



3. Recommending locations of additional TLP's.
4. Preparing complete Bill of Materials for AC interference mitigation.

The mitigation plan shall be approved by PMC / Owner.

The scope of the specialist agency also includes verification of the induced voltage/ current density after the mitigation performed by the CP contractor. Also, POST Software modulation, the RAW files should be handed over to HNGPL.

## 8. CATHODIC PROTECTION DESIGN PARAMETERS

Unless expressly varied and otherwise specified in the project specifications, following parameters shall be used for design of permanent cathodic protection (PCP) system.

### 8.1 PROTECTION CURRENT DENSITY

Pipelines having three layer polyethylene coating.

Pipeline surrounding	Protection Current density
	Permanent CP ( $\mu$ A/m <sup>2</sup> ) (For 30 Years Life)
Soil Resistivity <10 ohm –m	<b>200</b>
10 ohm m < Soil Resistivity <100 ohm –m	<b>100</b>
High resistivity area (more than 100 $\Omega$ -m)	<b>50</b>

However, for pipelines operating at elevated temperatures, the current density correction factor shall be 25% per 10<sup>0</sup> C rise in operating temp above 30<sup>0</sup> C.

Pipe to soil potential shall not be more negative than (-) 1.5V (“ON”) or (-) 1.2V (“OFF”) w.r.t. Cu-CuSO<sub>4</sub> reference electrode.

\*Actual current density to be adopted shall be decided based upon soil/water corrosivity and other environmental conditions obtained as per the detailed chemical & microbial analysis and presence or absence of interfering elements, proximity of foreign pipelines and structures resulting in interference in close vicinity of pipeline ROW.

Where considered necessary for satisfactory protection of pipeline the current density shall be suitably increased by contractor with appropriate justifications.

### 8.2 OTHER PARAMETERS FOR DESIGN

Other parameters to be considered for PCP:

Safety factor for current density : 1.3

Pipeline natural potential	:	(-) 0.45V*
Steel resistivity	:	$2.2 \times 10^{-7} \Omega \text{ m}$
Maximum loop resistance		
Soil resistivity < 20000 $\Omega \text{ cm}$	:	1 $\Omega$ ,
Soil resistivity > 20000 $\Omega \text{ cm}$	:	max 2 $\Omega$ on confirmation from owner
Specific Coating Resistance soil resistivity	:	10000 $\Omega\text{-m}^2$ for 1000 ohm cm
 Parameters for Attenuation calculation:		
Cathodic Polarisation at drain point (V)	:	(-) 1.25V
Cathodic Polarisation at farthest point	:	(-) 0.85 V
Pipeline natural potential	:	(-) 0.45 V

Instant OFF PSP should not exceed -1.2 V at any point of time.

Unless otherwise specified in project specification the design life of permanent CP shall be 30 year.

\*Note: To be measured from upcoming/existing structure in the same soil matrix.

## 9. CATHODIC PROTECTION DESIGN CRITERIA

Criteria for determining the adequacy of protection to buried pipeline are defined in NACE's code SP-0169-2013 and the same shall be binding. However, essential requirements as mentioned of protection are reproduced below. All the criteria as mentioned below (as applicable) shall be satisfied:

- A negative polarized potential (Instant OFF potential) of at least 850 mV
- A minimum of 100 mV of cathodic polarization between the structure surface and a stable reference electrode contacting the electrolyte. The formation or decay of polarization can be measured to satisfy this criterion.
- A negative (cathodic) potential of at least 850 mVCSE with the cathodic protection applied. This potential is measured with respect to a saturated copper/copper sulfate reference electrode contacting the electrolyte. Voltage drops other than those across the structure-to-electrolyte boundary must be considered for valid interpretation of this voltage measurement.
- Wherever the presence of sulfides, bacteria etc. are detected, a negative polarized potential of at least 950 mVCSE is to be maintained.
- For pipeline operating temperature between 40°C and 60°C, the protection potential may be interpolated considering protection potential of -850 mVCSE at 40°C and -950 mVCSE at 60°C.
- Interference criteria: A positive potential swing of 50 mV or more shall be considered as sufficient to indicate the presence of an interaction/interference situation requiring investigation and incorporation of mitigation measures.

Discretion to use any of the criteria, listed above, shall solely rest with the Owner/ Owner's representative.

## 10. PERMANENT CATHODIC PROTECTION - SYSTEM DETAILS

The PCP system shall include the following major equipment/ sub-systems for impressed current cathodic protection system and equipment for AC/DC interference mitigation unless otherwise specified.



PARTICULAR TECHNICAL SPECIFICATIONS  
(PTS) FOR PERMANENT CATHODIC  
PROTECTION SYSTEM



- Cathodic Protection Smart Transformer Rectifier Unit with built in GSM Modem, RTU and display unit. Transformer rectifier unit of rating (CPTRU) DC 50V/50A with single/three phase AC incomer power supply and built-in current interrupter and GPS based timer with 4-20 mA converters for SCADA interface.
- MMO tubular anodes and anode ground beds in calcined petroleum coke breeze back-fill.
- Computerized test station (CTSU) unit
- Anode/cathode junction boxes with shunts and resistors
- Permanent Reference Cu-CuSO<sub>4</sub> Electrodes
- Pin brazing for pipe to cable connection (epoxy encapsulated)
- Surge diverter/ Grounding cell across Insulation Mono - blocks
- Solid State Decoupler cells at A.C. Interference locations
- ER probes for external corrosion monitoring minimum 1 No. for this project
- Interconnecting cables
- Markers (for cable route, anodebed etc.)
- Polarization coupons
- Any other material not mentioned but required to carry out effective PCP system for the pipeline.

### 10.1 EQUIPMENT

All equipment shall be new and (PCP) contractor to source these only from approved manufacturers of reputed make with proven track record and approved by the owner for the supply for this project. Equipment offered shall be field proven.

Equipment requiring specialised maintenance or operation shall not be acceptable hence should be avoided, as far as possible, and prototype equipment shall not be accepted.

Make and construction of all materials shall be subject to owner's approval.

The detailed specification of each system and equipment shall be furnished by the contractor. However, certain minimum requirements for the major equipment's are highlighted in this document.

### 10.2 EQUIPMENT LOCATION IN HAZARDOUS / NON HAZARDOUS AREA

As far as possible equipment including Power source (CPTRU), anode/cathode junction boxes, test station etc. shall be located in safe area.

However, **all equipment located in hazardous areas shall be of flame proof type as per IS:5572, IEC 79 for gas groups IIA & IIB and temp. Class T3 (200<sup>0</sup> C).**

All equipment's to be installed & located in Hazardous area should conform and comply with BIS 2148 and IEC 79 (or equivalent) code requirements.

All indigenous flame proof equipment should be certified by CMRS. All flame proof equipment of indigenous origin should also be BIS marked.

### 10.3 CPTRU



PARTICULAR TECHNICAL SPECIFICATIONS  
(PTS) FOR PERMANENT CATHODIC  
PROTECTION SYSTEM



Impressed current cathodic protection transformer rectifier unit has an AC input and DC output power. Transformer shall be of double wound, air cooled type with an electrostatic shield between the windings. The transformer insulation shall be Class F. The winding size shall be based on maximum current density of 1.6 Amps/sq. mm of copper conductor. TRU shall be floor mounted & suitable for indoor use and to be dust and vermin proof IP55 enclosure.

Inbuilt 100% spare capacity for current demand, from each [TRU], should be a special feature of all [TRU] to be installed for this project.

The CP Transformer Rectifier [TR] Unit's scheme for protection, monitoring, control, metering and indication shall be designed to meet requirements of this specification. The control shall be achieved by using thyristors and fully solid-state logic only. The various features of the unit will be as per the details provided in the data sheet in this specification.

Rectifier shall be silicon type of approved make with adequate cooling arrangement and with moisture and humidity resistant finish. It shall be mounted on spindles or other suitable supports. It shall have configuration suitable for full wave rectification. Adequate filtering in the form of L-C filtering circuit shall be provided on the output side to smoothen out the D.C. output to limit ripple content to less than 5% at rated output.

The input and output of rectifier shall be protected by fast acting fuses of suitable ratings. Lightning Arrestors/Surge Suppressors shall also be provided across D.C. output terminals and A.C. input terminals to protect the rectifier against surges. Each diode and SCR shall be provided with suitable surge suppressors.

The T/R unit shall be provided with two modes of working as under:

A mode selector switch shall be provided to select the desired mode of operation. Both the modes shall be independent of each other and failure of the unit in one mode shall not affect the working of the unit in other mode. A brief description of these modes is given below.

**A) Auto Ref. Mode**



The unit will be generally working in this mode. The operation of the unit in this mode shall be controlled by a reference signal. The output D.C. voltage of the unit in this mode shall vary right from 0V to rated voltage and from 0A to rated current to maintain the reference signal within  $\pm 15$  mV of the set value under all operating conditions.

The response of the unit shall be instantaneous to suppress extremely fast acting external stray currents if present. The typical reference regulation in this mode shall be within  $\pm 15$  mV under all conditions.

Fully solid-state Automatic Reference Selector logic shall be provided to select the lowest of the Three Reference Inputs automatically. Facility shall also be provided for Manual selection of any one out of the three reference inputs for control. Suitable metering arrangement shall also be provided to monitor all the three external reference signals as well as the internal reference signals independently.

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

Independent ultra-fast acting electronic current limit circuit shall be provided to limit the output current of the unit in Auto mode to any value from 0 A to rated value as desired by the operator. The current limit circuit will be capable of protecting the unit even under dead short circuit across output. The unit

	<b>PARTICULAR TECHNICAL SPECIFICATIONS (PTS) FOR PERMANENT CATHODIC PROTECTION SYSTEM</b>	
---	---	---

will be capable of sustaining dead short circuit across output indefinitely without degrading or damaging any internal components in this mode.

**B) Automatic Voltage-Current Control mode (AVCC mode)**

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

The output voltage of the unit shall be adjustable to any value from 0 V to rated voltage by means of a stepless voltage setter. The set voltage shall be maintained within  $\pm 0.25V$  of the set value for change in DC input voltage within specified limits and change in load from 0 A to full load.

The output current of the unit shall also be adjustable to any value from 0 A to rated current by means of a step less current setter. The current shall be regulated within  $\pm 0.5A$  of the set value for change in DC input voltage within specified limits and change in load from zero to the rated value. The response of both current controller and voltage controller shall be ultra fast, instantaneous type. The current limit circuit will be capable of protecting the unit even under dead short circuit across output. The unit will be capable of sustaining dead short circuit across output indefinitely without degrading or damaging any internal components in this mode.

**C) SPECIAL REQUIREMENTS**

Built-in Microprocessor Based Programmable & GPS Synchronisable Current Interrupter:

Current interruption facility will be provided by means of a built-in contactor & microprocessor based GPS synchronisable digital timer with real time clock & ON/OFF time display. The timer will have facility for adjusting the ON time & OFF time from 0 to 999 sec. by means of digital setting facility. Timer will have START & STOP facility thru local keypad or through remote potential free contacts. The timer will have facility for Synchronisation to Master Timer or similar Timer in another unit.



**D) SCADA Monitoring Facility:**

A) 4-20mA Isolated Converter Modules and digital RS485 link using MODBUS RTU protocol for monitoring of the following Parameters

- i) P.S.P.
- ii) DC output Voltage
- iii) DC output Current

B) Potential Free Digital contacts for Monitoring of the following Alarms Pipeline under-protected

- i) Pipeline overprotected
- ii) Reference fail
- iii) Unit working in AUTO REF Mode
- iv) Unit working in AVCC Mode
- v) Unit Working in Manual mode
- vi) CP unit input DC supply fail
- vii) CP unit working
- viii) Current interrupter ON

	<b>PARTICULAR TECHNICAL SPECIFICATIONS (PTS) FOR PERMANENT CATHODIC PROTECTION SYSTEM</b>	
---	---	---

- ix) Current interrupter OFF
- x) Current interrupter REST

**E) OPTIMUM RATED CAPACITY**

Minimum DC voltage output to be 50V and DC current output to be 50A.

**F) TESTING AND INSPECTION**

The manufacturer shall provide all the necessary facilities to carry out full performance test on the C.P. rectifiers in his premises at his expense.

**G) GUARANTEE**

The manufacturer will have to guarantee the successful working of the units for a period of 24 months from date of installation & commissioning of the unit at user premises.

**H) PACKAGING**

The unit to be packed in all-weather proof packaging for transporting to site by the manufacturer before dispatch.

**STANDARD SMART CP RECTIFIER UNIT**

<b>1</b>	Type	Floor mounted, Indoor-IP55, AC operated transformer rectifier unit for impressed current CP system
<b>2</b>	Cooling	Natural cooling (AN)
<b>3</b>	Transformer Insulation	Vacuum pressure Impregnated Insulation, Class-F
<b>4</b>	A. C. Input Voltage	415V/240V AC $\pm$ 10%, 3/1 Ph., 50Hz $\pm$ 3%, AC.
<b>5</b>	A. C. Input Current	To be filled by vendor
<b>6</b>	D. C. Power Output	To be filled by vendor
<b>7</b>	KVA rating of Transformer	To be filled by vendor
<b>8</b>	D. C. Output Voltage	To be filled by vendor
<b>9</b>	D. C. Output Current	To be filled by vendor
<b>10</b>	Factor of safety for Diodes/SCRs	Voltage - 300% factor of safety, Current- 400% factor of safety
<b>11</b>	Full load efficiency of the unit	Not less than 70% at 50V/50A DC output & 230V AC Input
<b>12</b>	Full load power factor	Not less than 0.8 lagging
<b>13</b>	Insulation Level	2KV for 1minute
<b>14</b>	Peak Inverse Voltage	
	A) Diode	To be filled by vendor
	B) SCR	To be filled by vendor



**PARTICULAR TECHNICAL SPECIFICATIONS  
(PTS) FOR PERMANENT CATHODIC  
PROTECTION SYSTEM**



<b>15</b>	Filtering circuit	L.C. Filter
<b>16</b>	Ripple & Hum	Less than 5% at rated load
<b>17</b>	Surge Diverters for diodes/SCRs Metal oxide varistors/capacitors/R-C Networks	Metal Oxide Varistors/Capacitors/R-C Networks
<b>18</b>	Lightning Arrestor	At both Input & output side of the T/R unit. Type 1+2 spark gap based device complying to IEC 61643-11 with lightning impulse (10/350 $\mu$ s) current capability shall be installed at the input power supply
<b>19</b>	R.M.S. Voltage Rating	To be filled by vendor
<b>20</b>	Peak Discharge Current Rating	To be filled by vendor
<b>21</b>	Protection	(1) 2 pole MCB in AC Input  (2) 2 pole MCB in DC output  (3) HRC Fuses in AC Input & DC Output (4) Glass cartridge fuses in the live line of all Lamps, Auxiliary power lines to control Circuit (5) Ultra fast acting electronic over current limit circuit & short circuit protection for output. (6) Reference fail indication and automatic setting of DC Output voltage to preset value under this condition
<b>22</b>	Reference Electrode	(1) 3 numbers  (2) Automatic Reference Selector Logic shall be provided to automatically select the lowest (least protected) reference signal out of three reference signals fed to the unit simultaneously.  Facility shall also be provided to select one out of three Ref. electrodes by means of a switch  (Note: Facility for connection of 8No's. reference will be provided at terminal strip)
<b>23</b>	Control Element	The DC output will be controlled using latest solid-state SCR's. These SCR's will be controlled by the commands from the control circuits.  All the Electronic circuits will be assembled on plug-in type control cards.



**PARTICULAR TECHNICAL SPECIFICATIONS  
(PTS) FOR PERMANENT CATHODIC  
PROTECTION SYSTEM**



<b>24</b>	Mode of Operation	<p><b>a) Auto Ref. Mode:</b> The operation of the unit in this mode will be fully Automatic and will be controlled by the reference electrode feedback. The Unit will automatically maintain reference voltage or P.S.P within <math>\pm 15\text{mV}</math> of the set value under all conditions</p> <p><b>b) CVCC or AVCC Mode: (Manual Mode)</b> This will be the second mode of operation. In this mode the unit can be operated in either constant voltage or constant current mode. In constant voltage or Current mode the DC output voltage or current will be adjustable from zero to rated value in step less manner by means of voltage/current setter potentiometer.</p>
<b>25</b>	Reference fail safe feature	In the event of failure of all the reference electrodes, the DC output voltage of the unit will get set to a preset value. This preset voltage is adjustable from 0 to rated value.
<b>26</b>	Ref. (P. S. P.) Voltage setting Range in Auto Ref. Mode	+0.3V to -1.5V wrt
<b>27</b>	Ref. Voltage Regulation in Auto Mode	Better than $\pm 15\text{mV}$
<b>28</b>	Voltage Setting Range in CVCC Mode	0 to 50V
<b>29</b>	Voltage regulation in CVCC (Manual) Mode	Better than $\pm 0.25\text{V}$
<b>30</b>	Current Limit setting Range	0 to 50A
<b>31</b>	Current Regulation in current limit mode	Better than $\pm 0.5\text{A}$
<b>32</b>	Annunciations \ Indication	<ul style="list-style-type: none"> <li>a) AC Supply ON</li> <li>b) Unit working in Auto mode</li> <li>c) Unit working in AVCC mode</li> <li>d) Under protection</li> <li>e) Over protection</li> <li>f) Reference 1,2,3 Lowest</li> <li>g) Reference 1,2,3 fail</li> <li>h) Current limit</li> </ul>
<b>33</b>	Metering	3-1/2 Digit 48mm X 96mm meters for Input Voltage Input current Output Voltage Output Current P.S.P
<b>34</b>	REMOTE SCADA MONITORING AND CONTROL	Following signals/contacts shall be provided using: Hardwired 4-20mA signals & potential free contacts and through RS485 digital link with MODBUS RTU protocol.







**PARTICULAR TECHNICAL SPECIFICATIONS  
(PTS) FOR PERMANENT CATHODIC  
PROTECTION SYSTEM**



		<p>I. Alarm status monitoring for the following:</p> <ul style="list-style-type: none"> <li>a) Pipeline Under protected</li> <li>b) Pipeline over protected</li> <li>c) All Ref. fail</li> <li>d) Unit in Auto</li> <li>e) Unit in CVCC Mode</li> </ul> <p>II. Analog signal monitoring for:</p> <ul style="list-style-type: none"> <li>a) P.S.P: -4V to 4V DC</li> <li>b) DC Output voltage: 0 to 50 VDC</li> <li>c) DC Output current: 0 to 50 A</li> </ul> <p>Remote Contacts for:</p> <ul style="list-style-type: none"> <li>a) Interrupter Timer Start &amp; Stop</li> <li>b) AC supply fail</li> </ul>
<b>35</b>	Enclosure/Construction	Floor Mounted Indoor type to be fabricated with 2mm MS sheet confirming to IP-55 degree of protection. Lockable doors shall be provided in the front and back.
<b>36</b>	Max Ambient Temperature	55°C
<b>37</b>	Humidity	95°C with no condensation
<b>38</b>	Painting	Powder coated RAL 7032, Siemens Gray
<b>39</b>	Dimensions	As per Manufacturer standard
<b>40</b>	Earthing	Inbuilt Copper Earth bar with suitable bolts
<b>41</b>	Lifting Hooks	4No's
<b>42</b>	Cable Entry	Bottom
<b>43</b>	Current Interruption	<p>Current interruption facility will be provided by means of a built-in contactor &amp; microprocessor based GPS synchronisable digital timer with real time clock &amp; ON/OFF time display.</p> <p>The timer will have facility for adjusting the ON time &amp; OFF time from 0 to 999 sec. by means of digital setting facility.</p> <p>Timer will have START &amp; STOP facility through local keypad or thru remote potential free contacts.</p> <p>The timer will have facility for synchronisation to master timer or similar timer in another unit.</p>
<b>44</b>	GSM Modem	The GSM based remote monitoring unit for Transformer Rectifier (TR) monitoring, is a highly accurate, compact, low power, low cost, micro controller based unit with built in GSM Modem which enables continuous Centralized Monitoring of TR parameters and at the same time notification for any alarm occurrence at central station as

	<b>PARTICULAR TECHNICAL SPECIFICATIONS (PTS) FOR PERMANENT CATHODIC PROTECTION SYSTEM</b>	
---	---	---

		<p>well on the configured cell numbers.</p> <p>This system enables easy &amp; wireless centralized monitoring of all TR parameters like TR Voltage, TR Current, and Reference Potential and A.C Interference voltage (optional).</p>
45	RTU	<p>For monitoring of parameters and analysis of material corrosion, RTU is able to acquire, process, store and transmit analog or digital signals to a PC central station using GSM and GPRS standard communication.</p>

#### 10.4 ANODE GROUND BEDS

- Anode ground beds shall be installed at every CP Station and located around minimum 100 meter away from pipeline ROW to ensure adequate remoteness which shall also be calculated and submitted in the design document.
- The anode ground bed locations shall be selected after conducting the soil resistivity test:

Proposed location of Anode Ground bed (For impressed current CP system) at proposed CP stations;

To be decided by CP system contractor based on detailed engineering, availability of power source and land. At each CP station location soil resistivity shall be measured upto 100 m depth for 3 plots, for selection of the anode bed for the lowest resistivity plot. Horizontal shallow depth anode bed shall be considered where soil resistivity upto 2m depth is lower compared to higher than 2m depth, deep well anode bed shall be considered where soil resistivity at higher than 2m depth is lower compared to surface soil resistivity upto 2m depth.

The Anode Ground Bed of the newer pipeline should be:

Preferably located on the other side of foreign pipeline at remote earth with respect to first pipeline.

At least two (3) plots to be selected at each anode bed location and soil resistivity to be measured at these locations is as follows:



**Deepwell anodebed:** at depth 1, 2, 5, 10,15,20,25,30,35,40,45,50,60,70,80,90,100 meter depending on anodebed depth.

Anode lead cable in between each MMO tubular anode and AJB for shallow depth horizontal anode bed shall be PVDF insulated and HMWPE sheathed cable.

In case of deep well anode bed, string anode lead cable shall be 1x50 sq.mm EPR/CSPE insulated cable or PVDF insulated and HMWPE sheathed cable.

Anode ground bed resistance should be ideally 1 ohm (max). In case anode ground bed for foreign pipeline is existing within 100m of the proposed pipeline ROW and cause interference to proposed pipeline, Effort should be made to relocate the anode bed with the consent of the owner

##### 10.4.1 DEEP WELL TYPE ANODEBED:

	<b>PARTICULAR TECHNICAL SPECIFICATIONS (PTS) FOR PERMANENT CATHODIC PROTECTION SYSTEM</b>	
---	---	---

- Deep ground beds are installed where the soil resistivity at the upper levels of the earth strata is high and by installing the anodes deep into the ground where the soil resistivity is low / water table is high, better current distribution is achieved. The deep ground beds require extreme care during installation to ensure long term performance.
- The deep well anodes bed shall be provided with dual feed MMO string anodes (minimum 8 nos) with anode tail cable of minimum size 16 mm<sup>2</sup> EPR/CSPE of suitable length upto anode junction box for permanent cathodic protection system. The anode string arrangement shall also include centralizers, vent pipe, dead weight, nylon rope etc from the approved vendor as per specification.
- Depending on the soil resistivity the deep anode bed shall be designed for a depth varying from 30-100 meter.

The casing pipe of the deep anode bed shall be MS type of minimum dia 200 mm.

The minimum inactive length of the deep anode bed from the ground surface shall be 15 m and the same shall be achieved by installing a rigid PVC pipe of dia 300 mm over the casing MS pipe.

The requirement of the active and inactive length of the casing pipe of the deep anode ground bed shall be calculated in the design phase.

- The annulus space in the casing pipe where the MMO anode string has been installed shall be filled with calcined petroleum coke breeze of a bulk density greater than 1040 kg/m<sup>3</sup>.
- The calcined petroleum coke breeze shall be filled in the annulus space by pumping from the bottom of the well and not pouring from the top.
- PCP contractor to indicate the location of anode beds along pipeline ROW and install cable route markers prior to handing over the requisite ownership documents to Owner at the time of handing over of the ICCP system.
- For Deep well type anode bed, a plot of size 5 m x 5 m (Min.) for anode ground bed and a plot of size 100m x 1 m (approx.) for laying of cable shall be used.

Chain-link fencing shall be provided with proper marker around the anode bed and cable route.

Layout of anode installation in anode bed shall be depicted 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.

Three plots shall be identified for each anode bed and investigated individually and best one out of these three shall be selected based on the observations/data.

Ground water depth data shall be collected from Geographic survey of India to ensure that the anode bed location is appropriate, and anode shall be preferably located at permanent water table environment for the deep well anode bed. The anode ground bed resistance for shallow horizontal/deep well anode bed shall be restricted to 1 ohm (max). However, in case of very high soil resistivity at anode ground bed location, the upper acceptance limit of anode bed resistance may be relaxed at the sole discretion of the Purchaser/ Consultant.

## **10.5 ANODES:**

### **10.5.1 MIXED METAL OXIDE (MMO) ANODES:**

The permanent cathodic protection system shall have mixed metal oxide (MMO) tubular anodes in single configuration for shallow beds or in string configuration for deep anode beds.



PARTICULAR TECHNICAL SPECIFICATIONS  
(PTS) FOR PERMANENT CATHODIC  
PROTECTION SYSTEM



These anodes shall be of noble metals (group VIII) mixed metal oxide coated on titanium substrate. The MMO anodes shall be dimensionally stable.

The characteristics of the MMO tubular anodes to be installed in shallow or deep ground bed shall be as follows:

- Shape and Dimension : Vendor to furnish
- Weight : Vendor to furnish
- Anode Material : Titanium substrate (ASTM B 861 Grade -I ) coated with mixed metal oxide (MMO) of noble metals of Group-VIII.
- Current output of the anode (in calcined coke breeze) : 5.0 Amp
- Maximum current density (in calcined coke breeze) : 100 Amp / m<sup>2</sup>
- Coating Consumption rate : 2mg/ Amp yr (max)
- Coating resistivity : 6 x 10<sup>-5</sup> Ω cms.
- Type of joint : Crimp connection & end sealing
- Contact resistance of anode to cable joint : 1 milli-Ω {maximum}
- MMO coating thickness : ≥ 6 gms/m<sup>2</sup>
- Anode consumption Rate : 1 mg/Amp. Yr.
- Length of cable : As Required so as to reach JB
- Design life : 30 Years
- Pull out strength :200 kg (min.) or breaking strength of cable.
- Anode fabrication :Vendor to furnish
- Anode to cable connection details :Vendor to furnish
- Anode to cable joint insulation details :Vendor to furnish

The anodes to be installed with a inter-anode spacing (minimum) of 5m and shall be electrically remote approximately 100mtr away from the pipeline [to be ascertained by calculations].

However, the actual distance will be as per site conditions & calculations. For Deep Well Anode bed, the first anode should be at least more than 15 mtr deep [as per NACE RP 0572 Standard] and the actual depth shall be as per Approved Design. However, for Deep Well Anode bed instead of Single [MMO] anodes and String Anodes shall be used.

- [MMO] Anode to cable [Kynar insulated annealed copper 10/16 mm<sup>2</sup>] jointing and insulation shall be done by anode manufacturer at his shop.
- Anode to cable jointing and insulation shall be done by anode manufacturer at his shop.



**PARTICULAR TECHNICAL SPECIFICATIONS  
(PTS) FOR PERMANENT CATHODIC  
PROTECTION SYSTEM**



- Dimension & weight of all anodes will be checked & recorded. Negative tolerance will not be acceptable.
- Routine & type test certificates of cable manufacturer should be furnished for anode lead cable as per IEC 502 – 1983 or relevant BIS code. Length and identification tag should be verified by measurement.
- Each anode to cable joint shall be tested for its electrical contact resistance & its value in  $\Omega$  shall be recorded.
- First anode to cable joint shall be subjected to accelerated ageing test & destructive test to determine pullout strength of cable to anode joint as well as effectiveness of the joint insulation.
- Manufacturer shall furnish detailed dimensioned fabrication drawing of anodes as well as details of cable connection & its insulation sealing to owner for approval. Manufacturer of anode will commence only after this Approval from owner.
- Vendor shall furnish for Owner’s Approval the following information  
Type & Make of Heat Shrink cap & its properties
  - procedure for making the joint
  - procedure for accelerated ageing test
  - Vendor shall submit all test reports for Owners review.

**10.5.2 MAGNESIUM ANODE**

The anode shall conform to the-requirements of ASTM (1) B-843 standard. The anode shall be of high manganese, magnesium alloy packed with special back fill. The metallurgical composition, potential and consumption of anode shall be as below:

i) Composition:

Element	Weight (High potential)	Weight (Low potential type)
Manganese	0.5 - 1.3 %	0.15 - 0.7 %
Copper	0.02 % max.	0.02 % max.
Silicon	0.05 % max.	0.1 % max.
Zinc	-	2.5 % - 3.5 %
Aluminium	0.01 % max.	5.3 % - 6.7 %
Iron	0.03 % max.	0.003 % max
Nickel	0.001 % max.	0.002 % max.
Calcium	-	-
<b>Other metallic elements</b>		
Each	0.05 % max.	-

Total	0.3 % max.	0.3 % max.
Magnesium	Balance	Balance
ii) (Low Potential) Anode closed circuit potential	(-) 1.55 volts with respect to Cu/CuSo4 electrode	
iii) (High Potential ) Anode closed circuit potential	(-) 1.75 volts with respect to Cu/CuSo4 electrode	
iv) Anode consumption rate	7.9 kg / Amp. Yr. Max.	

### 10.5.3 ZINC ANODE

The anode shall conform to the-requirements of ASTM B-418 standard. The anode (other than ribbon anode) shall be packaged with special back fill. The metallurgical composition of anode, potential and consumption rate shall be as below:

i) Composition

<u>Element</u>	<u>Weight %</u>
Aluminium	0.003-0.005 % max.
Cadmium	0.0075-0.003 % max.
Copper	0.002 % max.
Iron	0.002 % max.
Silicon	0.005 % max..
Lead	0.005 % max.
Zinc	Remainder
ii) Anode closed circuit potential	(-) 1.1 volts w.r.t. CSE
iii) Anode consumption rate	11.24 kg/ Amp. Yr) Max.

- Contractor shall furnish spectrographic analysis from each heat both for zinc and magnesium anodes trace elements & chemical Analysis for [Mg, Zn] contents along with electrochemical test results.

- ***Special Backfill***

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

Gypsum	75 %
Bentonite	20 %
Sodium sulphate	5 %

- The anodes shall be provided with cable tail of sufficient length to reach junction box/test station as applicable without tension and no joint in between splicing.

- ***Tolerance in Fabrication of Anodes***

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.

- The anode shall be free from excessive shrinkages. The limits shall be as follows:

Maximum 10% of the depth of anode or 50% of the depth of the anode cores whichever is less. The depression may be measured from 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 on individual anodes may be taken as + 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	$\pm 5 \%$

#### 10.5.4 ZINC RIBBON ANODE

Sl No	Properties	Value
1	Size	Min 12.7 x 14.28 mm
2	Weight	Min 0.89 kg/ m
3	Diameter of core	3.3 mm ( max)

#### 10.6 CALCINED PETROLEUM COKE BREEZE

Carbon backfill for **Deep Well Anode bed** shall conform to the following specifications as per the applicable standard:

**Chemical Composition:**

- Moisture (on Dry Basis)	0.05 %
- Fixed Carbon	99.35 %
- Bulk density	1040kg/ m <sup>3</sup>
- Particle Size	Ranging from 0.1mm to 1 mm
- Ash	0.6%
- Volatiles	nil (950degree C)*

\*Hydrogen/hydrocarbons nil due to calcination temperature in excess of 1200 degree C

Test Certificate shall be furnished including the following:

1. Make of coke breeze
2. Batch no.

3. Chemical composition
4. Bulk density and Real density
5. Particle size analysis
6. Resistivity (ohm-cm)

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

## 10.7 ANODE JUNCTION BOX

Anode junction box (AJB) shall have provision of termination of cable tails from individual anodes in case of horizontal shallow ground bed or main anode cable in case of deep well ground bed and provision of connection of anode header cable coming from TRU.

AJB shall have sheet steel enclosure of minimum 3 mm thickness and hinged lockable shutters. AJB shall be weatherproof with degree of protection IP-55. The enclosure shall be hot dip galvanized to a thickness of 125 microns followed with grey shade of epoxy painting inside and outside to a thickness of 300 microns surface.

AJB 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 labeled clearly to indicate the circuit/sub anode junction box to which it is connected.



A nameplate of anodized aluminum with black background 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 meters.
- Distance form CP station in meters.

### DATASHEET FOR ANODE JUNCTION BOX

1	D.C. Input Voltage	50V Maximum
2	D.C. Input Current	50A Maximum
3	Output Circuit Configuration	Anode Bus output distributed into circuit in line with the number of anodes for current measuring shunt and resistor.
4	Shunt type	Manganin Alloy
5	Shunt and resistor Rating	5Amp/75mV & 1 ohm, 100W
6	Terminal Board Material	Phenolic Bakelite sheet.



	<b>PARTICULAR TECHNICAL SPECIFICATIONS (PTS) FOR PERMANENT CATHODIC PROTECTION SYSTEM</b>	
---	---	---

7	Insulation Level in bent terminals and body	1.5 KV for 1 minute at 50Hz.
8	Busbar	Tinned Copper Bus Bar – 25mm x 5mm
9	Input & Output Terminals	Stainless Steel Stud with double nut and washer
10	Enclosure	<p>Completely enclosed, Outdoor type, pole mounted, Natural Air Cooled, IP-55, The enclosure is provided with two terminals for earthing.</p> <p>The enclosure is made of sheet steel with min 3 mm sheet thickness provided with Neoprene sealing gasket. The shutter and external fitted nut / bolts are SS</p>
11	Cable entries	Cable entries are sealed through proper visco-elastic sealant to prevent entry of moisture.
12	Painting	Two coats of Epoxy Paint / Powder Coating

## 10.8 CATHODE JUNCTION BOX

A cathode junction box (CJB) shall be installed for connecting the pipeline to the CPTRU unit. CJB shall have a bus bar with an incoming circuit for connecting to negative of the CPTRU and separate outgoing circuits for collection of negative drainage current from each of the pipelines. The incoming circuit shall have a current measurement shunt. Each outgoing circuit shall have isolation link, variable resistance of grid coil type and a current measurement shunt. One number spare outgoing circuit shall be provided.



CJB shall have sheet steel enclosure of minimum 3 mm thickness and hinged lockable shutters. CJB shall be weatherproof with degree of protection IP-55. The enclosure shall be hot dip galvanized to a thickness of 125 microns followed with grey shade of epoxy painting inside and outside to a thickness of 300 microns surface. CJB shall have cathode bus of copper with nickel/ silver plated or tinned. The terminals shall be of anti loosening type.

Proper identification labeling 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. A nameplate of anodized aluminum with black background 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 from the nearest pipeline in meters.

### Datasheet for Cathode Junction Box

1	Output Circuit Configuration	Cathode Bus output distributed into 2 + 1 circuits in line with current measuring shunt. The reference electrode are terminated & further extended to TRU.
---	------------------------------	--

	<b>PARTICULAR TECHNICAL SPECIFICATIONS (PTS) FOR PERMANENT CATHODIC PROTECTION SYSTEM</b>	
---	---	---

2	Shunt type	Manganin Alloy
3	Shunt Rating	10Amp/100mV
4	Terminal Board Material	Phenolic bakelite sheet.
5	Insulation Level in between terminals & body	1.5 KV for 1 minute at 50Hz.
6	Busbar	Tinned Copper Bus Bar – 25mm x 5mm
7	Input & Output Terminals	Stainless Steel Stud with double nut and washers
8	Enclosure	Completely enclosed, Outdoor type, back-plate Wall / Structure mounted, Natural Air Cooled IP55 The enclosure is provided with two terminals for earthing. The junction box and glands are CCE and CMRS certified.  The enclosure is made of sheet steel minimum 3 mm thick with shutter provided with Neoprene sealing gasket. The shutter and external fitted nut / bolts are SS.
9	Cable entries	The cable entries in the junction box shall be sealed so as to prevent moisture.

## 10.9 REFERENCE ELECTRODE (CU-CUSO4)

### PERMANENT REFERENCE ELECTRODE (CU-CUSO4)

Three nos. of Cu-CuSO<sub>4</sub> reference electrodes for each pipeline shall be installed at CP stations and shall be extended to the CPTR unit. One reference electrode shall be provided at each corrosion coupon location.

1. Permanent & Portable reference cell shall be of approved make & type.
2. The reference cells with proven high reliability shall be supplied for providing stable pipe to soil potential measurement reference at CP stations, test station locations etc.
3. The reference cells shall have high accuracy and stability and maintain the same over its design life.
4. The permanent reference cell shall have a minimum design life of 20 years under installed / buried conditions.
5. The reference cell for high resistivity areas shall be suitable for prevailing dry soil conditions to give maximum service life.
6. The reference cells shall be provided with tail cable long enough for connection to test station without any joint in between.

#### Data sheet for Copper - Copper Sulfate Permanent Reference cell

Sl No	Description	Values
1	Make (Select one from the approved	



**PARTICULAR TECHNICAL SPECIFICATIONS  
(PTS) FOR PERMANENT CATHODIC  
PROTECTION SYSTEM**



	vendor enclosed elsewhere in the tender)	
2	Model	Vendor to furnish
3	Design Temperature Range:	(-) 20 Deg C to 70 Deg C
4	Design Life:	20 yr (min)
5	Half cell material	Copper (99.99%) and saturated copper sulfate solution
6	Dimensional details	Vendor to furnish
7	Diameter (mm/ Inch)	Vendor to furnish
8	Overall length(mm/ Inch)	Vendor to furnish
9	Weight (Kg)	Vendor to furnish
10	Active electrical contact surface area(mm2/ Ft2)	Vendor to furnish
11	Cable	Cross linked Polyethylene insulated, stranded copper conductor, 600V grade, Max temperature 90°C
12	Cable Size(Sq.mm./ AWG)	Vendor to furnish
13	Cable length supplied with each reference cell	Vendor to furnish
14	Cable colour	Vendor to furnish
15	Purity of reference electrode metal	99.99% (laboratory grade)
16	Purity of electrolyte chemistry	100.00% (laboratory grade)
17	Potential measured against a Calomel Reference/ Standard Hydrogen Electrode at 25°C	Vendor to furnish
18	Recommended for burial	Soil
19	Calibration certificate	Vendor to furnish



Testing & Inspection: Requirement As per QAP enclosed elsewhere in the tender

**PORTABLE HALF CELL**

Portable Cu-CuSO4 reference cells shall be provided for measurement of Pipe to Soil potential for the pipeline .

Data sheet for Copper- Copper Sulphate Portable Reference cell

Sl No	Description	Values
1	Make(Select one from the approved vendor enclosed elsewhere in the tender)	
2	Model	
3	Design Temperature Range:	(-) 20 Deg C to 70 Deg C
4	Design Life:	20 yr (min)
5	Half cell material	Copper(99.99%) and saturated copper sulfate solution
6	Dimensional details	Vendor to furnish
7	Diameter (mm/ Inch)	Vendor to furnish
8	Overall length(mm/ Inch)	Vendor to furnish
9	Weight (Kg)	Vendor to furnish
10	Active electrical contact surface area(mm2/ Ft2)	Vendor to furnish
11	Cable	Cross linked Polyethylene insulated,

	<b>PARTICULAR TECHNICAL SPECIFICATIONS (PTS) FOR PERMANENT CATHODIC PROTECTION SYSTEM</b>	
---	---	---

		stranded copper conductor, 600V grade, Max temperature 90°C
12	Cable Size(Sq.mm./ AWG)	Vendor to furnish
13	Cable length supplied with each reference cell	Vendor to furnish
14	Cable colour	
15	Purity of reference electrode metal	99.99%(laboratory grade)
16	Purity of electrolyte chemistry	100.00%(laboratory grade)
17	Potential measured against a Calomel Reference/ Standard Hydrogen Electrode at 25°C	Vendor to furnish
18	Recommended for burial	Soil
19	Electrode Filling solution	Vendor to furnish
20	Calibration certificate	Vendor to furnish

### 10.10 SOLID STATE DECOUPLER & GROUNDING CELL

At the crossing or parallel run of pipeline and overhead HT line of 66 KV and above, the pipeline shall be grounded through solid state de-coupler /device for blocking cathodic protection polarisation DC voltage while allowing a conducting path for steady state AC current, AC induced fault current and lightning surges. The solid state polarisation cell shall be grounded through a zinc grounding cell minimum weight 20 kg( 2 plate), which shall either be of a 2 or 4 plate design to ensure the overall ground resistance to be less than 5 ohm.

The grounding system comprising of a combination of DC de-coupler and grounding cell shall be decided based on the AC interference mitigation report, to ground any surges in the pipeline potential that may appear in case of faults (phase to phase or phase to ground) in overhead transmission line.

Solid State Decoupling Device with tubular zinc anodes shall be installed near HT line crossings and at MOV locations in the mainline.

The solid-state polarisation cell/device shall be installed in a vandal proof steel housing by the contractor.

The pipeline shall be grounded through Solid State DC de-coupler with zinc galvanic anode, irrespective of AC induced potential in Pipeline which is either crossing or running within 100 meters in parallel with overhead EHV/ HV transmission lines of voltage grade 33 kV and above.

Unless otherwise specified the minimum rating of grounding cell and polarisation cell shall be as below:

#### i. Grounding Cell (Zinc)-Solid anode

-	Type	:	2 or 4 plate type
-	Current rating	:	Suitable to pass more than 10 kA surge
-	Dimension of Zinc Anode	:	As per vendor
-	Bare weight	:	20 Kg( 2 plate )
-	Weight of backfill	:	70 Kg.
-	Prepackaged weight	:	110 Kg.
-	Open Circuit potential	:	-1.05 to -1.11V (W.r.t. Cu-CuSO <sub>4</sub> )
-	M.S. Insert Dimension	:	As per vendor
-	Tolerance	:	Length ±2.5%, Width ±5%, Thickness ±5%
-	Current capacity	:	750 Amp Hr/Kg
-	Actual consumption	:	11.2 Kg/Amp-Year

ii. **Solid state DC Decoupler**

- Type : *Solid state device*
- Block DC Voltage (Blocking level) : (-) 2 Volts to (+) 2 volt
- AC rms steady state current rating at 50 Hz : 45 Amp
- Fault current capacity at 50 Hz (0.5 sec) : 5 kA
- Lightning surge current rating (10X 350 μs /8X 20 μs waveform) :100kA
  
- Mounting : Flat surface

The Zinc (Zn) grounding cell shall be sized for the life of the permanent CP system and the surge magnitude taking into account the current discharge from the anodes. The grounding system shall have minimum resistance to earth to restrict the pipeline voltage (PSP) as per NACE protection criteria.

**10.11 SURGE DIVERTER**

Spark gap surge diverter shall be connected across each monolithic isolation joint to protect it from high voltage surges.

Across each IJ on Pipeline at stations CGS/DT/RT/SVs/IP etc., Surge Diverter shall be provided.

Protection of Insulating Joints: Electrical earthing through Zn grounding along with Solid State DC Decoupling devices on protected side. The Unprotected side shall be provided with earthing only.

Surge diverter shall be provided for the protection of insulating joints located at the ends of the pipeline/at terminals & in between.

The total system including cable, cable termination, anodes/surge diverters shall be suitable for the anticipated fault current magnitude at the location of its installation. The surge diverters shall be of spark gap type and explosion proof type. The diverter to be provided with suitable length of cable so as to connect across the IJ's without any joint.

Surge diverters shall have the following minimum rating:

Description	Rating
Type	Spark gap, explosion proof type
Current (10/350 micro second)	100 kA
Power frequency spark over AC voltage – 50 Hz	Max 0.5 kV
Spark over AC voltage - Impulse (1.2/50 micro second)	1.25 kV
Nominal Current (8/20 μs)	100 kA
Power frequency sparkover voltage, 50Hz	≤ 0.5 kV
Class of Lightning current carrying capability	H
Tested as per standard	EN/IEC 62561-3
Pre-wired cable length	Specific length based on pipeline diameter

**10.12 ELECTRICAL RESISTANCE PROBES**

Electrical resistance probes (ER 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



PARTICULAR TECHNICAL SPECIFICATIONS  
(PTS) FOR PERMANENT CATHODIC  
PROTECTION SYSTEM



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.

The material of the ER 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.

External Corrosion Sensing probe and reader should be very sensitive even to read minute corrosion rates to a tune of 1 mil per year

One no. probe for the project (between two CP stations) is recommended. The location for installation of ER probe location shall be decided at site after post commissioning survey in consultation with consultant/OWNER.

The requirement also includes software package (licensed copy) with detailed procedure for installation of the software, etc. required for analysing of data to find corrosion rate as per the Project Specific Requirement and Data sheets.

The scope also includes one day training of the personnel on operation, maintenance & corrosion analysis of the ER probe system.

### 10.13 POLARIZATION COUPONS

Additional Polarization Coupons apart from those installed during the TCP system shall be provided at the following locations:

1. At every CP Station and
2. Midway between two CP Stations.

The polarization coupons shall be provided with a permanent reference Copper-Copper Sulphate electrode placed very close to the coupon (made of pipe alloy) so that IR drop free potential could be monitored.

Coupons of size 100X100mm shall be cut from a coated pipe. The cut-out coupon shall be grinded on all its edges to strip the loose metal, if any. HNGPL shall provide the coated pipe for preparation of coupons. One face of the coupon that corresponds to the internal surface of the pipe will be having pipeline coating. The cable connecting to coupon shall be thermit welded and to be sealed with epoxy for encapsulation.

The coupon shall be installed at bottom 1/3rd portion of the pipeline and approx 300mm away from the pipe surface where an artificial coating defect of 1cm<sup>2</sup> is created and exposed to soil. Two cables one for connection to pipeline for protection and other for potential measurement shall be provided for each coupon. The protection cable shall be connected through a magnetic reed switch inside the test station to enable measurement of coupon "Instant OFF" potential.

One permanent reference electrode Cu/CuSO<sub>4</sub> shall be installed next to the coupon at a spacing of 150 mm from the coupon opposite to the pipeline.

### 10.14 AC CORROSION COUPONS

AC corrosion coupons shall be installed at the locations of HT line crossings where high induced potential is recorded on the pipeline. The location of AC corrosion coupons shall be decided after AC interference study.



PARTICULAR TECHNICAL SPECIFICATIONS  
(PTS) FOR PERMANENT CATHODIC  
PROTECTION SYSTEM



Wherever the pipeline is either crossing or running parallel with overhead EHV/HV transmission lines of voltage grade 33 kV and above, AC interference mitigation study to be performed and accordingly AC corrosion coupons and other equipment's shall be decided.

AC Corrosion Coupons are accurately sized to provide the ability to measure maximum AC current discharge from a pipeline in areas subject to interaction from overhead AC power transmission systems. The value so recorded provides a vital indication as to whether AC corrosion could be occurring on the pipeline.

The coupon consists of a **steel disc with an exposed area of 1cm<sup>2</sup>**, fitted into thick red PVC housing to give an impression of a holiday. The purpose of the AC corrosion coupon is to identify the corrosion current density, which will help in classifying the intensity of corrosion. The connection between the coupon and the cable is properly encapsulated to stop the ingress of moisture.

#### 10.15 PAINTING

The sheet steel used for fabrication of TLP's / pipe support structures shall be thoroughly cleaned and degreased to remove mill scale, rust, grease and dirt and shall be pickled and then rinsed to remove any trace of acid.

The cleaned steel surface shall then be primed by applying a coat of phosphate paint and a coat of yellow zinc chromate primer. The primed surfaces shall be free from all imperfections before undertaking the finished coat.

After preparation of the priming the steel surface, spray painting with two coats of final paint shall be done. The final paint shall be 1 Coat of 2 Pack high build epoxy with Polyamide hardener cure @100  $\mu$  DFT/coat followed by 1 Top coat of Acrylic Polyurethane finish paint @40  $\mu$  DFT/coat. The finished junction box/ TLP's shall be dried in oven in dust free atmosphere.

The final finished coat be free from imperfections like pin holes, orange peels, run off paint etc. All unpainted steel parts shall be cadmium plated to prevent rust formation.

#### 10.16 CATHODIC PROTECTION CABLES



Cables shall be of annealed high conductivity stranded copper conductor, 650/1100V grade XLPE insulated, armored, FRLS PVC sheathed conforming to IS-7098, 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:

**Anode and Cathode header cable:** 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 of size 35mm<sup>2</sup> for positive, negative drainage cables – PVC /PVC armored.

**MMO Anode tail cable – discrete anode:** The MMO anode tail cable shall be of size 10 mm<sup>2</sup> XLPE insulated, PVC sheathed. The cable shall be un-armored.

**MMO Anode string for deep/Horizontal ground bed:** The MMO anode string cable shall be of size minimum 16mm<sup>2</sup> PVDF insulated, HMWPE sheathed. The cable shall be un-armored.

**Reference electrode cable / Polarization coupon Cable/monitoring / Potential measurement:** The cables for reference cells and coupon shall be of size 6 mm<sup>2</sup> and shall be PVC aluminum backed by mylar / polyester tape shielded PVC sheathed and shall be un-armored

	<b>PARTICULAR TECHNICAL SPECIFICATIONS (PTS) FOR PERMANENT CATHODIC PROTECTION SYSTEM</b>	
---	---	---

**Cathode cable:** The negative drain cable from pipelines to the CJB shall be of size 25 mm<sup>2</sup> PVC or XPLE sheathed, PVC sheathed armored.

**Bonding cable:** 1c x 25 mm<sup>2</sup> unarmoured cable for bonding, polarisation cell / grounding cell and surge diverter connection purpose.

Length of anode tail cables shall be sufficient for routing and terminating the cable inside anode junction box/ test station as applicable without any intermediate joint.

### 10.17 COMPUTERISED TEST STATION UNITS (CTSUS)

Each CTSU (Computerised Test Station Unit) is a Microprocessor based low CMOS circuitry with built in RTC, installed near a Computerised Test Station to acquire and store the complete CP System performance data available for each Test station. CTSUs are typically designed for outdoor applications and are IP-65 protected. The CTSU shall be provide with built in GSM modem for remote monitoring of data.

Once stored, the data can be downloaded as under:

- a) By a remote computer by telephone, cellular phone or radio link/OFC.
- b) By portable handheld data reader using local communication port.

Key features of the CTSU are as under:

SI No	Property	Description
1	GSM Based Remote Monitoring Data Logger for CTSU.	Micro controller based intelligent CP Test Station Data Monitoring System with built-in GSM Modem.
2	Analog Inputs	<p>Logger should have 4 Nos. High accuracy, High Input Impedance, 16-bit resolution Input channels with high common mode rejection ratio (CMRR), as under:</p> <p>CH-1 : -4V to +4V DC (for DC PSP)</p> <p>CH-2 : 0V to 25 V AC (for PSP AC Interference Monitoring)</p> <p>CH-3 : 0A to 100 A DC (for Pipeline Current Monitoring)</p> <p>CH-4 : Battery Level (for Internal Battery Status Monitoring)</p> <p>The typical accuracy of each channel is + 1.0% of F.S. + 1 digit</p> <p>All the Channels should have complete Galvanic Isolation between each other</p>
3	GSM Interface & Data Transmission	<p>The CTSU logger should have built-In GSM Modem for broadcasting data to the Central Station at the programmed periodic interval. The Data is to be transmitted in the form of SMS.</p> <p>Data should be transmitted to Central Monitoring station &amp; an additional mobile phone. Both the data transmission Mobile nos. Should be easily programmable as desired by the user.</p>







**PARTICULAR TECHNICAL SPECIFICATIONS  
(PTS) FOR PERMANENT CATHODIC  
PROTECTION SYSTEM**



SI No	Property	Description
4	Data Storage:	<p>The CTSU Data Logger should have built-in Non volatile memory for local storage of Data. It is possible to store about 250,000 Data readings for each channel i.e. a Total One Million readings for all four channels in the Local memory of the Data Logger.</p> <p>Locally stored data should be retained up to 10 years without any external power.</p> <p>The locally store data could be downloaded on a field reader using the USB communication port provided.</p>
5	Data Logger.	The Data Logger will be supplied with Data downloading software. The logger software should download the Data in standard MS Excel sheet and generate tabulated Reports and Graphs.
6	Logging & Broadcast Interval	The Periodic Data Logging & SMS broadcast interval will be programmable from 1 data sample per hour to 1 data sample in 24 Hours.
7	Local Display	<p>The CTSU Data Logger should have a 2 Line 16 x 2 LCD display for entering local settings and viewing TS parameters locally.</p> <p><b>Following Local settings should be done using a Laptop:</b></p> <ul style="list-style-type: none"> <li>· Setting Date/ Time</li> <li>· Setting Start Time for Periodic sending of data to the Central station &amp; additional Mobile No.</li> <li>· Setting Periodic logging Interval</li> <li>· Entering different Mobile numbers for Data transmission.</li> <li>· Setting field ID of the Data Logger.</li> </ul> <p><b>The LCD Display will also display the following Parameters</b></p> <ul style="list-style-type: none"> <li>· DC Reference Potential (PSP)</li> <li>· AC Reference Potential (AC PSP)</li> <li>· Pipeline Current</li> <li>· GSM Signal Strength</li> <li>· GSM SIM registration status</li> </ul>
8	Time Stamping :	The Data Logger unit will have a precise and accurate Real Time Clock (RTC) for exact time stamping of data

	<b>PARTICULAR TECHNICAL SPECIFICATIONS (PTS) FOR PERMANENT CATHODIC PROTECTION SYSTEM</b>	
---	---	---

SI No	Property	Description
9	Power Supply :	The CTSU Data Logger should be a battery operated device operating on built-in Internal rechargeable Lithium ion Battery.
10	Enclosure	<p>The CTSU Data Logger unit should be housed in a compact &amp; sturdy non corroding weatherproof (IP:55) enclosure.</p> <p>Overall dimensions : 130mm x 130mm x 75mm (Approx)</p> <p>Mounting : Wall mounting inside C.P. Test Station</p> <p>Cable Entry : From Bottom</p> <p>The above indicated Enclosure Size is including the Internal Battery.</p>
11	Operating Environment	<p>Temperature : -10 degree C to 75 degree C</p> <p>Humidity : 99% (RH)</p>
12	Communication Port	The CTSU Data Logger should have a USB port through which the logged data could be downloaded onto the field reader laptop.



Compliance: The CTSU Data Logger shall be complying to IEC – 60068-2-1 / IEC – 60068-2-2 /IEC – 60068-2-30 / IEC – 60068-2-78

Centralised Monitoring (Additional Optional Feature):

The CTSU Data Logger with built-in GSM modem should be able to communicate directly with the Central Station PC over the GSM network.

The Data Logger should send the Test Station Data with exact time stamp to the Central Station Computer at the programmed Periodic Interval. At the Central Station end the data should be received directly into a PC installed with the GSM Frond End Communication (FEC) module and centralized remote monitoring software.

Recording Rate	To be configured from 1 reading per second to 1 reading per 365 days.
Battery backup	Lithium battery back up option allowing CTSU ECU to retain data for 10 years on a single charge.
Timing	Status input sampling time 10m sec to 2.5 m-sec.
Power requirement	The CTSU to be powered by 24 ±15% Volts DC
The CTSU shall be able to read and record.	PSP and current data of pipeline & foreign pipeline/pipelines upto 10,000 sets to be stored till downloaded
Inputs available	Minimum 10 nos. [5 inputs for PSP & 5 inputs for current.)
Protection against	Voltage/current surges expected along the pipeline & foreign structure.
Test Station Reader (TSR)	Portable type suitable for field transport & handing. Unit enclosure is weather proof, IP55.
Input battery for TSR	Internal rechargeable battery provided.

	<b>PARTICULAR TECHNICAL SPECIFICATIONS (PTS) FOR PERMANENT CATHODIC PROTECTION SYSTEM</b>	
---	---	---

## 11. INTERFACING WITH SCADA

The CPTRU unit shall be provided with provisions for proper interfacing with SCADA system through RS 485 serial link for various signals as described in the table below:

SrNo	DESCRIPTION	MONITORING (M) /CONTROL (C)	DIGITAL (D) / ANALOGUE (A)	NO. OF SIGNALS	TAG NO.
1	CPTRU OUTPUT VOLTAGE	M	AI	1	CPTRU-V
2	CPTRU OUTPUT CURRENT	M	AI	1	CPTRU-A
3	PIPELINE OVER PROTECTED	M	DI	1	PL-OV
4	PIPELINE UNDER PROTECTED	M	DI	1	PL-UV
5	ALL REFERENCE	M	DI	1	REFC-F
6	REFERENCE CELL-1 VOLTAGE	M	AI	1	REFC1-V
7	REFERENCE CELL-2 VOLTAGE	M	AI	1	REFC2-V
8	CPTRU IN AUTO MODE	M	DI	1	CPTRU-AU
9	CPTRU IN AVCC MODE	M	DI	1	CPTRU-AVCC
10	CPTRU IN MANUAL MODE	M	DI	1	CPTRU-MAN MAN
11	CURRENT INTERRUPTER START	C	DO	1	CI-ST
12	CURRENT INTERRUPTER STOP	C	DO	1	CI-STP
13	CURRENT INTERRUPTER RESET	C	DO	1	CI-RST

**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. Analogue signals shall be 4-20 mA, galvanically isolated.
3. Provision for minimum two nos analogue and two nos of digital input signal to SCADA System shall be available for future use.

**12. TEST STATIONS**

Test station enclosure shall be made of metal-clad cold rolled, sheet steel of at least 3 mm thickness for Non-Hazardous area and Aluminium Alloy LM-6 of requisite thickness for Hazardous area and shall be suitable for GI pipe post mounting. Test stations shall have weatherproof enclosure having degree of protection IP-55 with vandal proof arrangement. Flame proof type Ex'd' suitable for installation in Zone-I, Gas Group IIA & IIB wherever installed in hazardous areas and hinged lockable shutter. The inner and outer surfaces of test stations shall be epoxy painted. All TLPs installed in safe area shall be weatherproof type. The TLPs to be installed in hazardous area shall have flame proof and weather proof enclosure suitable for installation in zone-I/II, Gas Group IIA/IIB. Minimum IP-55 shall be applicable for all outdoor equipment.

Test stations are generally installed by the temporary cathodic protection system contractor/laying contractor. However, following types of test stations shall be used if mentioned specifically in the SOR.

Type of Test Station	Purpose
<b>Type-A</b>	<b>Potential measurement test station.</b> There are two cables of 1c x 6 sq mm from pipeline to the test station. The minimum number of terminals on the terminal plate is four (4). Two for connection of cable and two spare.
<b>Type-B</b>	<b>Galvanic Anode test station</b> This test station is same as potential measurement test station, however it has two extra terminals for Galvanic (magnesium /zinc anodes). The minimum numbers of terminals on the terminal plate are six (6). Four for connection of cables and two spare
<b>Type A+1</b>	<b>Current Measurement Test Station</b> There are two cables of 1c x 6 sq mm from pipeline to the test station and two cables of 1c x 10 sq mm from pipeline to test station. The minimum number of terminals on the terminal plate is six (6). Four for connection of cables and two spare.
<b>Type-D</b>	<b>Cased Crossing with casing test station</b> There are two cables of 1c x 6 sq mm from carrier pipeline to the test station and two cables of 1c x 6 sq mm from casing pipe to test station. In addition to the above there are also galvanic anodes connected to the casing pipe for protection. The minimum number of terminals on the terminal plate is ten (10). Four for connection of cables, two for anodes and rest spare.

	<b>PARTICULAR TECHNICAL SPECIFICATIONS (PTS) FOR PERMANENT CATHODIC PROTECTION SYSTEM</b>	
---	---	---

<b>Type- E</b>	<b>Foreign Pipeline Crossing Test Station/Bond Box</b> There is one cable of 1c x 6 sq mm from each pipeline to the test station and one cables of 1c x 25 sq mm from pipeline to test station for bonding with resistors and shunts. The minimum number of terminals on the terminal plate are eight (8). Six for connection of cables, resistors etc and two spare.
<b>Type-F</b>	<b>Insulating Joint test station</b> There two cables of 1c x 6 sq mm and 1c x 25 sq mm each, one from underground section of the pipeline and other from the above ground side of the pipeline to the test station .The minimum number of terminals on the terminal plate are six (6). four for connection of cables and two spare.
<b>Type-H</b>	<b>High Tension Line Test Station</b> This test station shall be vandal proof type and the size should be suitable to install DC decoupling device in it. There are two cables one of 1c x 6 sq mm and other of 1c x 25 sq mm from the pipeline into the test station, one end of the 25 sq mm cable is connected to DC decoupling device and to the other connection of the device Zinc grounding Cell with 1c x 25 sq mm cable are connected for grounding the AC current.
<b>Type –A+PC</b>	<b>Polarization Coupon Test Station</b> The Test station shall be same as potential measurement test station, with minimum 6 terminals for cable connection and two spare. There are two cables of 1c x 6 sq mm from pipeline to the test station.  Two cables of 1c x 6 sq mm from polarization coupon, one for connection to pipeline for protection and other for potential measurement. The protection cable shall be connected through a magnetic reed switch inside the test station to enable measurement of coupon 'OFF' potential.  A permanent reference electrode shall be installed adjacent to the coupon in a manner so as to measure the representative potential of the coupon.

The test stations shall be installed with the front of the test station facing the pipeline. The name plate of test stations shall in minimum carry following information.



- Test station number
- Chainage in km
- Test station connection scheme type
- Distance from pipeline in meters
- Direction of product flow
- Danger sign for Type-H Test Station

Terminal blocks and different scheme of wiring as required shall be provided in the test station as per the test station connection scheme sketch.

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.

The coated casing pipe to be provided with 20 kg Magnesium anodes connected to the pipeline via TLP ( TYPE-D) at all river crossings, Major Road/ Railway crossing.

Installation of independent sacrificial type CP System considering Magnesium anode (20 Kg net each)

	<b>PARTICULAR TECHNICAL SPECIFICATIONS (PTS) FOR PERMANENT CATHODIC PROTECTION SYSTEM</b>	
---	---	---

- Note : Type D TLP with 1 no. 20 kg Mg anode. Note: Possibility of using installed similar type TLP at the time of TCP will be explored first. If the condition of the existing similar type TLP are not in usable condition, new one shall be installed. However, Mg anodes shall be installed everywhere.

The carrier pipe to be provided with Zinc ribbon anodes at 4-8 O'clock position in the interval of 2 meter (max.), where the casing pipe is coated. Zn ribbon anodes shall be provided at coated cased crossings only.

### **13. INSTALLATION**

Layout of anodes installation in anode bed shall be depicted in the drawing showing anodes installation details, anode grouping, anode wiring etc. It is expected that more than one type of such layout like vertical ground bed installation, horizontal installation in shallow depth & deep well anode bed may be required for different locations of cathodic protection stations.

Location, layout(s) & quantity of anodes for ground beds at different locations for mainline cathodic protection system is also the responsibility of the contractor. Contractor shall furnish complete procedure for all the proposed ground bed installation.

Soil resistivity survey for the anode bed shall be conducted in presence of OWNER/CONSULTANT/ OWNERS REPRESENTATIVE's representative and data shall be furnished along with design calculations for obtaining approval from OWNER/CONSULTANT/ OWNERS REPRESENTATIVE.

Type of anode bed for PCP shall be selected based on soil resistivity of respective station, necessary calculations APPROVED by owners / consultant and based on statutory / code requirements.

#### **13.1 ANODE BED**

The deep ground anode bed shall be installed minimum 100 meters away from the pipeline. The site will be selected ensuring that there is water available in the bore hole where the deep ground is being installed to prevent drying out of the anode bed. The deep ground bed shall have MMO tubular anodes (minimum 5 nos.) arranged in a string form. The centre to centre spacing of the MMO tubular anode shall be 3 meters. The depth of the deep well shall be approximately 70-100 meters with inactive length of 15 meters. Whole of the active length should be in the low resistivity ground beneath the water table.

The deep well shall be lined with 8.625" steel casing pipe right up to the top. A 12" PVC casing will be installed to make column inactive for a depth of 15 meters.

Deep ground bed installation shall comprise of the following:

##### **Casing Installation**

Once the required depth is achieved and drill-stem resistance measured using an appropriate method, the casing string installation shall follow. The casing installation to be done in the following order:

- Install the 8" dia API casing complete with end cap at bottom.
- Install the intermediate 12" dia. UPVC casing (inserted over the steel casing).

##### **Anode and Vent Pipe Installation**



PARTICULAR TECHNICAL SPECIFICATIONS  
(PTS) FOR PERMANENT CATHODIC  
PROTECTION SYSTEM



After the casing materials have been installed, the MMO tubular string anode and vent pipe shall be installed as follows:

Continuity and insulation of the anode string for any damage prior to installation shall be physically checked.

Anode string shall be laid out near the drilled hole with the anode lead cable uncoiled in an orderly fashion. Attach a centralizer to the centre of each anode. • Select the first anode and securely tie the anode to the nylon suspension rope using plastic tie.

The 1” perforated vent pipe shall be tied to the anode centralizer ensuring that the anode and the vent pipe are not touching each other so as to facilitate calcined petroleum coke breeze backfill compacting around the anode string . The bottom of the vent pipe shall be installed with threaded end cap. Lower the anode string with the vent pipe in a careful manner so as not to damage any component and ensure that anode cables do not take any weight during lowering.

The distance of the first anode from the bottom of the hole/vent pipe shall be strictly as per approved design.

Perforated vent pipe shall be installed for the entire length of the active column and non-perforated for the in-active column. The vent pipe, complete with end cap shall be installed to the full depth of the hole and 1 m length shall be left protruding from the concrete pit for later completion.

Lack of ventilation can lead to gas blockage of anodes and eventual system failure. The vent pipe is perforated through throughout the active column and solid through the inactive column. Standard perforations range from 0.006 inch wide slots to 1/4 inch diameter holes and are commonly placed every 6 inch of pipe length. To prevent plugging with inactive column backfill. Perforations should end even with top anode.

#### **Coke Breeze Backfill filling**

Prior to filing of the calcined petroleum coke breeze backfill in the annulus of the casing pipe, it must be ensured that the anode cable leads have been routed through the appropriate casing exit fitting and must be protected from any damage during the backfilling procedure.

The filling of the coke breeze backfill will be carried out under the supervision of experienced CP engineer.

The required backfill material shall then be slurry mixed and pumped properly into the borehole up to the specified depth and as per the design.

The slurry backfill material shall be filled from the bottom of the borehole and care shall be taken during this procedure to ensure that the coke breeze is uniformly distributed and no voids occur within the backfill column. Once the desired level of coke breeze column is achieved allow the back fill to settle for 12 hours.

#### **Routing and Termination of Anode Cable**

After complete installation of the deepwell anode ground-bed, a concrete plinth shall be cast around the ground bed as per approved drawing. The plinth shall include provision for conduits required for cable routing (Anode & Positive Header cables) and installation of anode junction box.

### **13.2 CABLE LAYING**

Cables shall be laid in accordance with approved layout drawings to be prepared by the contractor. No straight through joint shall be permitted in a single run of cable. Cable route shall be carefully measured and cables cut to required length.



PARTICULAR TECHNICAL SPECIFICATIONS  
(PTS) FOR PERMANENT CATHODIC  
PROTECTION SYSTEM



All cables inside station / plant area shall be laid at a depth of 0.75 meter. Cables outside station/plant area shall be laid at a depth of 1.5 meter. Cables shall be laid in sand under brick cover, back filled with normal soil. Outside the station / plant area the routes shall be marked with polyethylene cable warning mats placed at a depth of 0.9 meter from the finished grade.

All underground unarmoured cables forming part of permanent CP system shall run through PE sleeves. Cables along the pipeline shall be carried along the top of the pipe by securely strapping it with adhesive tape or equivalent as required.

RCC or GI pipes of proper size shall be provided for all underground cables for road crossings.

Cables shall be neatly arranged in trenches in such a manner that crisscrossing is avoided and final take off to equipment is facilitated.

Cable root markers shall be installed aboveground at suitable intervals.

In no case cables shall pass from below underground pipeline. All cables shall be placed above underground pipeline and tightened with tape.

### 13.3 CABLE TO PIPE CONNECTIONS

All cable connections to the pipeline including charged foreign pipeline shall be made using an (Owner) approved exothermic process e.g.: Pin Brazing & in exceptional cases with prior approval of Owner cadwelding.

The pin brazing to have the following characteristics:

- Extremely low contact resistance  $\leq 0.1 \Omega$ .
- Low transition resistance 7.5 to 14  $\mu\Omega$  per brazed joint
- High mechanical strength Binding strength 490 N/mm<sup>2</sup>  
Shear Strength 245 N/mm<sup>2</sup>
- Brazing temperature 650<sup>o</sup> C
- Time per braze 2 Seconds
- Weather Effect Suitable for all weather operation
- Life 30 Years

In no case cable shall be connected at the seam of the pipe. Repairing of coating including restoration shall be carried out as per approved procedure to the full satisfaction of Engineer-in-Charge/ Site Engineer without any cost to owner.

### 13.4 CIVIL WORKS

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

## 14. TESTING AND INSPECTION AT WORKS





PARTICULAR TECHNICAL SPECIFICATIONS  
(PTS) FOR PERMANENT CATHODIC  
PROTECTION SYSTEM



Owner/ Owner's representative shall visit the works during manufacturing of various equipment (Anodes, Cables, Junction Boxes, Test Lead Points etc.) to assess the progress of work as well as to ascertain that only quality raw material and fabrication technology is used for the same. All necessary assistance during such inspections shall be provided by the contractor/fabricator to owner's representative.

The minimum testing, inspection requirements for all components/ equipment shall conform to the requirements as defined in the relevant codes and standards. Detailed inspection and testing procedures along with the acceptance criteria, including various stages where hold points, review etc shall be for owners inspection, shall be prepared by CONTRACTOR for Owner's approval.

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

Owner reserves the right to ask for inspection of all or any item under the contract and witness all tests and carry out inspection or authorise his representative to witness test and carry out inspection.

CONTRACTOR shall notify the Owner or Owner's representative at least 20 days in advance giving exact details of tests, dates and addresses of locations where the tests would be carried out.

CONTRACTOR shall carry out pre-commissioning operations after completing installation of the system including all pre-commissioning checks, alternation and setting of all instruments, control and protective devices. CONTRACTOR including supply of all labour, materials and consumables shall carry out reliability and performance tests etc.

Before the electrical facilities are placed in operation, Contractor shall carry out suitable tests to the satisfaction of OWNER/CONSULTANT/ OWNERS REPRESENTATIVE that all equipment, devices, wiring and connection have been correctly installed, connected and are in good working condition as required for intended operation.

Following test / checking shall be conducted before putting into operation. Test / checking shall be made as per the proforma given below. Proforma given below are for guidelines only. The testing proforma for each item of CP unit is to be developed by the Contractor. These testing/ checking data shall be a part of the commissioning data to be included in the technical document.

**CPTR unit:**

- Insulation resistance primary to earth, secondary to earth and primary to secondary.
- Polarity check
- Check neutral connection
- Equipment earthing
- Check surge suppression device.
- Checking of indicating and metering circuits.
- Checking of all instruments, meters etc.
- Checking of auto PSP /manual control features and Current Interrupter & GPS sync feature.
- Checking of all operational protection features as per specification

**Cables**

- Cable no.
- Voltage grade
- Conductor cross section

- Continuity check
- Voltage test
- Insulation resistance values between core and earth and two cores.
- All control cables shall be tested by 500 V megger and all low tension power cables shall be tested by a 1000 V megger.

Copies of all test results shall be submitted as specified and as approved by the OWNER/CONSULTANT/ OWNERS REPRESENTATIVE. The Contractor shall duly attest these copies of test results .

The Contractor shall provide skilled labour, personnel, tools, equipment and instruments required for testing. The equipment that has been tested to the satisfaction of OWNER/CONSULTANT/ OWNERS REPRESENTATIVE shall be provided with a tag. The tag shall be dated and signed by Contractor and OWNER/CONSULTANT/ OWNERS REPRESENTATIVE.

**15. PACKING AND TRANSPORT**

All equipment/ material shall be protected for inland/ marine transport, carriage at site and outdoor storage during transit and at site. All packages shall be clearly, legibly, and durably marked with uniform block letters giving the relevant equipment/ material details.

Each package shall contain a packing list in a water proof envelope. Copies of the packing list, in triplicate, shall be forwarded to owner prior to despatch. All items of material shall be clearly marked for easy identification against the packing list.

**16. SYSTEM TESTING AND COMMISSIONING**

Contractor shall furnish the detailed field testing and commissioning procedure for approval. Field tests as per the approved procedures shall be carried out on the equipment / systems before being put into service. The acceptance of the complete installation shall be contingent upon inspection and field test results being satisfactory.

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

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

All tools, equipment and instruments required for testing shall be provided by CP CONTRACTOR.

Generally following tests shall be carried out and recorded in format given in subsequent clauses.

- |            |   |   |
|------------|---|---|
| Checking   | : | Visual inspection, comparison with drawings and specifications.     |
| Inspection | : | Detailed physical inspection & dimensions measurement               |
| Testing    | : | Simulation tests of equipment to determine its operational fitness. |

**i. Cables**

- Cable no.
- Voltage grade



PARTICULAR TECHNICAL SPECIFICATIONS  
(PTS) FOR PERMANENT CATHODIC  
PROTECTION SYSTEM



- Conductor cross section
- Continuity check
- Voltage test
- Insulation resistance values between core and earth and two cores.
- All control cables shall be tested by 500 V megger and all low tension power cables shall be tested by a 1000 V megger.

ii. **Reference Cell**

- Location
- Type of cell
- Potential reading
- Installation standard

iii. **Polarization Coupons**

- Location
- Exposed area/size of coupon
- Type of reference cell
- Coupon to soil "ON" & "OFF" potential
- Magnetic reed switch rating & its operation with magnet

iv. **Sacrificial Anode**

- Location/Identification
- Check for actual layout and compliance with drawings
- Resistance of each individual Anode
- Current dissipation by each individual anode with respect to anode voltage
- Total resistance of complete anode bed

v. **Electrical Resistance Probe**

- Location/Identification number
- Checking of wiring as per schematics
- Resistance reading of probe
- Location of installed probe.

vi. **CTSU (Computerized test station Unit)**



- Location/Identification Number
- Check for wiring
- Checking programmed interval for collection of the field data by the computer
- Type of reference cell

vii. **Insulating Joints**

- Checking of insulating joint for leakage, before and after energisation of C.P by means of insulating joint tester. Structure-to-electrolyte potential of both protected and non-protected sides of insulating joint shall be checked before and after energisation of CP system. Surge divertor shall be connected thereafter.

viii. **Solid State decoupler**

- Location/ identification number

	<b>PARTICULAR TECHNICAL SPECIFICATIONS (PTS) FOR PERMANENT CATHODIC PROTECTION SYSTEM</b>	
---	---	---

- Rating
- Check for continuity
- Check for wiring
- Check for standby current drain with CP energisation (current drain with respect to voltage across the device/cell shall be recorded).

**ix. Grounding Cell**

- Location
- Type (no. of anodes)
- Ratings
- Resistance of the grounding system

**x. Surge diverter**

- Location/ identification number
- Ratings
- Check for healthiness

**xi. Anode ground beds**

- Location/ test station number
- Current Output of each Anode
- Current output of the ground bed
- Anode groundbed resistance
- Check for its actual layout and its compliance with drawings.
- Resistance of each individual anode.
- Remote earth location and mutual interference of any with the nearby structure.

Copies of all test results shall be submitted as specified and as approved by the OWNER/CONSULTANT/ OWNERS REPRESENTATIVE. The Contractor shall duly attest these copies of test.

The Contractor shall provide skilled labour, personnel, tools, equipment and instruments required for testing. The equipment that has been tested to the satisfaction of OWNER/CONSULTANT/ OWNERS REPRESENTATIVE shall be provided with a tag. The tag shall be dated and signed by Contractor and OWNER/CONSULTANT/ OWNERS REPRESENTATIVE.

**17. COMMISSIONING**

*The CP contractor shall submit detailed commissioning procedure as per the guideline below:*

- On completion of installation of anode beds and other systems as per the specification, the anodes/equipment's shall be individually checked, tested and compared against agreed specifications and procedure. Electrical continuity of the entire pipeline shall be verified in conformity with the design.



PARTICULAR TECHNICAL SPECIFICATIONS  
(PTS) FOR PERMANENT CATHODIC  
PROTECTION SYSTEM



- Input resistance of the pipeline at all drain points shall be checked and recorded.
- All current measuring test stations shall be calibrated and recorded using portable battery, variable resistances, voltmeters, ammeters, etc as required.
- TCP facilities provided (if any) which do-not form a part of the PCP system shall be disconnected from the system & removed unless agreed otherwise.
- Sacrificial anodes where provided for casing pipe at cased crossings shall be disconnected.
- The pipeline shall be allowed to depolarize for a time period of at least 72 hrs after disconnecting the sacrificial anodes.
- Before cathodic protection is applied on pipelines by switching ON the TRU at CP stations, natural PSP, casing pipe PSP and Coupon to soil potential values at all test stations of the system shall be measured w.r.t. Cu/CuSO<sub>4</sub> half cell.

**Commissioning procedure for pipeline having two CP stations is given below; CP contractor shall develop detailed commissioning procedure accordingly:**

- CP station no 1 shall be energized with output potential adjusted to achieve a maximum pipe to soil potential as specified at 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 values at each of the installed test stations.  

The pipeline current values across the cross section of the pipeline shall also be determined at all the intended test stations influenced by the TRU.
- CP station 1 shall now be switched OFF, CP station no 2 shall be switched 'ON' and measurement procedure as specified above shall be repeated.
- Both CP stations of the system shall be switched OFF and pipeline shall be allowed to depolarize. All CP stations shall then be simultaneously switched on and the PSP values at drainage points of the 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 the lines have been charged for 48 hours. If there are appreciable differences in the observations then the same activity to be repeated after 72 hours. Maximum drainage point potentials shall not be allowed to go beyond maximum PSP values.
- Coupon to soil OFF potential shall be measured at all locations of coupon installations by operation of magnetic reed switch in test station.
- The output of CPTRU then should be adjusted that the potential at all locations remain in the range of -0.85V to -1.2V OFF. A full set of observations should again be recorded after 72 hours after the adjustment of potentials and the system should be left in the same state of operation.
- For test-stations whereby comparing different sets of readings taken at same test-station at different intervals of time under identical conditions a positive potential swing exceeding 50 mV has been identified, the location is considered to under stray current interference and suitable mitigation measures should be provided by the Contractor.
- Make sure that the power supply remains un-interrupted during the period of commissioning, in case of interruption the test in progress should be repeated after allowing suitable time for polarization.
- At cased crossings the sacrificial anodes for casing pipes can be reconnected and casing to soil potential and anode output current to be recorded.
- Current readings at the current measuring test stations shall be measured and recorded.



PARTICULAR TECHNICAL SPECIFICATIONS  
(PTS) FOR PERMANENT CATHODIC  
PROTECTION SYSTEM



- xi. In case of remote monitoring of CP system the system should be initiated to store the data of potentials.
- xii. Final records of testing and commissioning including graphical representation of final pipe to soil potential readings shall be compiled with interpretation in consultation OWNER's QA team.
- xiii. If any deficiencies are found in the system the same shall be rectified at no extra cost. Such deficiencies shall include mitigation of stray current electrolysis and interference problems that may be existing in the course of testing and commissioning. A set of observations should also be taken in the peak of first dry season after commissioning the system into regular operation. Any deficiencies found in the protection of pipeline should be rectified by contractor at its own cost.
- xiv. The current dissipated by individual anodes shall be measured from anode lead junction box and corrected for equal dissipation to the extent possible keeping the total ground bed current same.
- xv. In case of insufficient protection as per the CP design criteria on any portion of the pipe line, CP CONTRACTOR shall carry out necessary additions/ modifications to the provided protection in consultation with the ENGINEER so that NACE criteria is met.
- xvi. Post Commissioning of ICCP system Interference detection and mitigation will be checked and only after achieving full interference mitigation post commissioning surveys shall be carried out.
- xvii. Finished records of testing and commissioning including graphical representation of final step of structure to electrolyte potential readings shall be completed with interpretation in consultation with OWNER/CONSULTANT/ OWNERS REPRESENTATIVE and furnished as desired by the OWNER/CONSULTANT/ OWNERS REPRESENTATIVE. All the commissioning data shall be a part of technical documentation.

## 18. SYSTEM MONITORING

The Permanent CP system provided shall be monitored at all stations for three months for healthiness/ adequacy of protection of permanent CP or for design life.

During this period if any deficiency/ interference in protection system is noticed the same shall be rectified / augmented by additional anodes as required. The monitoring report shall be submitted regularly to Owner for his review / information.

## 19. DRAWINGS AND DOCUMENTS

General

Within two weeks from the date of issue of PURCHASER ORDER, CONTRACTOR shall submit six copies of the list of all drawings/ data manuals/procedures for approval, identifying each by a number and descriptive title and giving the schedule date. This list shall be revised and extended, as necessary, during the progress of work.

All drawings and documents shall be in English and shall follow metric system. Number of copies of each submission shall be as follows unless otherwise specified.

A concise & composite C P design report to be submitted for CONSULTANT/OWNER approval.

The report to include site survey data collection methodology, all data tabulated collected and collated, design calculation formulae used with all details, stepwise design calculations with all parameters and assumptions if any, bill of quantities [B.O.Q.], construction drawings, QA/QC methodology, list of vendors for each item, construction, testing, commissioning and post commissioning survey methodologies, post commissioning monitoring methodology and data recording formats and frequency.

Within two weeks after award of work, CONTRACTOR shall submit the list of all drawings, data, manuals, procedures, schedule for approval, identifying each by a number and descriptive title and giving the schedule data. This list shall be revised and extended, as necessary, during the progress of work.

<u>Submission</u>	<u>No. of copies</u>
a. For review / approval	4 copies
b. Final/ As built drawings execution/ construction	4 copies + 2 set of(CD) / Soft Copies
c. Drawings issued for execution/ construction	4 copies + 2 set of(CD) / Soft Copies
d. Operation/ Maintenance manual, vendor data	4 copies + 2 set of(CD) / Soft Copies

*All drawings shall show the following particulars in the lower right hand corner, in addition to CONTRACTOR'S Name :*

- a. OWNER's name
- b. Project title
- c. Title of drawing
- d. Scale
- e. Date of drawing
- f. Drawing number
- g. Space for OWNER's reference.

In addition to the information provided on the drawings, each drawing shall carry revision number, date of revision and brief details of revisions carried out.

## **20. INSTRUMENTS, TOOLS AND SPARES**

CONTRACTOR shall include a minimum list of all instruments, tools and tackles necessary for proper installation, testing, commissioning, operation and maintenance (O&M), monitoring of cathodic protection (PCP) systems and associated equipment that are to be deployed at site during the execution of PCP system. A list of such instruments, tools and tackles is given below:

S.No.	Description	Quantity
1.	<b>Corrosion voltmeter</b>	1 No.
2	<b>Multi-combination meter</b>	1 No
3	<b>CPL survey data logger</b>	1 No
4	<b>DCVG survey kit</b>	1 No
5	<b>Holiday detector</b>	1 No
6	<b>PIPE LOCATOR</b> The pipe locator of proven design of approved make with IP-54 weather protection shall be provided.  The pipe locator shall be light weight consisting of a receiver and a transmitter	1 No



**PARTICULAR TECHNICAL SPECIFICATIONS  
(PTS) FOR PERMANENT CATHODIC  
PROTECTION SYSTEM**





	<p>with accessories such as headphones, receiver &amp; transmitter clamps, rechargeable battery pack.</p> <p>The locator shall have features like adjustment of transmitter power to adjust output signal, standby mode, frequency selection etc.</p> <p>The locator shall be provided dynamic overload protection, peak / null mode, simultaneous detection of power and radio signals. Both the transmitter and receiver shall be fully digital.</p> <p>The transmitter and receiver shall adhere to the following minimum technical specifications:</p> <p><b>Description Specification</b></p> <p>Sensitivity: 5 micro A at 1 m (33 kHz)</p> <p>Depth accuracy : + 2.5% tolerance 0.1 m to 3 m (Line)</p> <p>Maximum depth : 6 m line</p> <p>Selectivity: 120 dB/Hz</p> <p>Current direction fault finding :220 Hz to 4 kHz</p> <p>Battery life : Rx : 30 hours intermittent</p> <p>Tx : Typically 15 hours</p> <p>Environment : IP 54</p>	
7	Elcometer for coating thickness measurement	1 No
8	Soil resistivity meter	1 No
9	Sincorder	1 No
10	CP Software( for remote monitoring)	1 No
11	Electrician tool box with tool set	1 No
12	CAT /CAT A frame survey equipment	1 No

Above list depicts the minimum requirement only. If any other equipment, instruments, special tools and tackles are required for successful commissioning of the project during the contract period as well as during the AMC, the same shall also be used.



**20.1 TRU SPARES**



	<b>PARTICULAR TECHNICAL SPECIFICATIONS (PTS) FOR PERMANENT CATHODIC PROTECTION SYSTEM</b>	
---	---	---

Following TRU spares shall be maintained during the entire contract period as well as during the AMC period and the same shall be handed over to HNGPL at the end of the contract period:

SI No	Instrument	Unit	Qty
			HNGPL GA
1	D.C.Voltmeter	Nos	2 Each
2	D.C.Ammeter	Nos	2 Each
3	A.C.Voltmeter	Nos	2 Each
4	A.C.Ammeter	Nos	2 Each
5	Diodes	Nos	2 Each
6	SCR's	Nos	2 Each
7	D.C.Fuses for output side	Nos	2 Each
8	HRC fuse for Diodes	Nos	2 Each
9	A.C.fuses for input side	Nos	2 Each
10	D.C.Lightening arrestor	Nos	2 Each
11	A.C.Circuit breaker(MCB)	Nos	2 Each
12	Electronic Control Cards each type	Nos	5 Percent of the Total Quantity for HNGPL
13	Filter circuit capacitor	Nos	2 Each
14	Signal light assembly for annunciation	Nos	2 Each
15	R.C. Surge Diverter	Nos	2 Each
16	Control transformer	Nos	5 Percent of the Total Quantity for HNGPL
17	Coarse voltage control switch	Nos	5 Percent of the Total Quantity for HNGPL
18	Coarse current control switch	Nos	5 Percent of the Total Quantity for HNGPL
19	Fine voltage control switch	Nos	5 Percent of the Total Quantity for HNGPL
20	Fine current control switch	Nos	5 Percent of the Total Quantity for HNGPL
21	Auto Manual Mode selector switch	Nos	5 Percent of the Total Quantity for HNGPL

	<b>PARTICULAR TECHNICAL SPECIFICATIONS (PTS) FOR PERMANENT CATHODIC PROTECTION SYSTEM</b>	
---	---	---

22	Toggle switches	Nos	2 Each
23	Assorted Glass cartridge fuses	Nos	2 Each

## 20.2 TRAINING

Within a period of 2 months from the date of commissioning of CP system, Contractor shall arrange a training programme to train 10 numbers Owner's Personnel in two batches for a duration of 2 days each. Cost of training shall be considered in the site handover charges.

The training programme shall include all aspects of power supply packages & Impressed current CP system including operation & Maintenance of CP unit, DG set, PLC system, data logger, pipe locator, surveys etc.

It is expected that experience persons preferably from the manufacturer of the unit shall be selected for providing faculty assistance.

Selection of faculty member shall be with the specific approval of Engineer-in-charge. Contractor shall submit the Training schedule at least one month in advance along with proposed list of faculty members. Venue and the dates of Training shall be with the approval of Owner.

## 21. POST C.P. COMMISSIONING SURVEYS

- Surveys are carried out to evaluate performance of Corrosion system - comprising of corrosion protective coating and Cathodic Protection system for pipelines.
- Contractor has to submit the detailed procedures for line locating work, carrying out CIPL, CAT, DCVG and Soil resistivity Surveys. Contractor should submit the list of manpower employed with them along with experience, qualification, name, age etc. The work shall commence only after the OWNER/CONSULTANT/ Owners representative approves the procedures submitted by the Contractor.
- If any particular point or stretch indicates conflicting or fluctuating results, the survey shall be repeated or survey may be carried out at closer intervals as directed by EIC/ site representative.
- The survey data / record / report shall be submitted in two sets of CDs and also computerized print outs with graphical representation like histogram of data, indicating clearly the hot spot areas, well coated areas, bad coated areas, very bad coated areas, nearest markers correlated to chainage etc. along with % IR, coating refurbishment priority to OWNER/CONSULTANT/ Owners representative. The document support of handing it over to OWNER/CONSULTANT/ Owners representative shall be submitted along with the bill for a group, as a prerequisite for release of payment.
- Work shall be carried out as per standard practice and International Standards and specifications.

*Following listed scope shall be part of survey but not limited as below:*

1. Inspection of CP rectifier and ground bed and calibration of measuring instruments on CP unit before start of actual survey job.
2. Checking the interference at pipeline crossing locations and suggesting remedial measures if any required. Identification of cathodically protected portion and vulnerable stretches.
3. Analysis of survey data along with other data / CP parameters / previous survey results.
4. Identification of causes of interference and suggesting methods of mitigation in those spots where interference has been clearly identified from the survey.
5. Suggesting requirement of any other coating surveys for further analysis of data in stretches where it is difficult to assess interference or coating problem.



### 21.1 CLOSE INTERVAL POTENTIAL LOGGING (CIPL) SURVEY

- Post commissioning of the C.P. System, after 30 days of Line polarization, a Close Interval Potential Logging (CIPL) survey will be conducted, as per procedure, approved by the Owner.
- The CP contractor to make sure that prior to the survey all the magnesium/zinc anodes connected to the pipeline must be disconnected.
- For the survey, data logger of repute & current interrupter (if not available in the TRU) will be used by experienced and trained manpower. All the survey data and findings of under-protected, over-protected zones, short etc. shall be handed over to the owner as part of final technical Documentation. Suitable remedial measures to be recommended for achieving adequacy of protection throughout the pipeline length. This CIPL survey Data will serve as basis for future comparative evaluations of the Protective system adequacy.
- Specifically, at all the cased crossing locations, all the magnesium anodes must be disconnected and then survey to be performed to check the shortening of casing and carrier pipe.

### 21.2 DIRECT CURRENT VOLTAGE GRADIENT (DCVG) SURVEY



- Based on the CIPL survey reports the under-protected, over-protected zones locations are identified. On these locations DCVG survey shall be conducted for finding coating defects.
- After identification of the coating defects, the mainline EPC contractor shall carry out coating repair as per approved methodology. The CP contractor shall then again conduct DCVG test at the repaired sections to confirm all coating repair have been rectified.
- Prior to commencement of DCVG survey, the survey procedure shall approved from the Owner. Only proven survey equipment shall be used and trained, experienced manpower to be used.
- All survey data to be submitted to owner as part of technical documentation.

### 21.3 COATING CONDUCTANCE SURVEYS

- For evaluating the 3LPE coating resistance, coating conductance survey to be conducted, post commissioning of the C.P. system at A1 type TLP's and across HDD sections. Although same coating specifications are used throughout the length of the pipeline, effective electrical strength thereby its ability to resist flow of current would reasonably vary based on the terrain, construction defects, soil resistivity along the pipeline length.
- For conducting coating conductance surveys, potential ( $\Delta V$ ) & ( $\Delta I$ ) current are to be measured at two consecutive "A1" type (current measurement test stations) test lead points ,w.r.t remote earth using Cu-CuSO<sub>4</sub> reference electrode, alternatively with current interrupter "ON" & "OFF" at each measurement point.
- The difference of the two  $\Delta I$  will be the C.P. current being collected by this section of the pipeline. The difference of the two  $\Delta V$  will be the average change in pipeline potential within the test section owing the current received from C.P. System.

The above procedure to be repeated for all "A1" type TLP for evaluating coating conductance value for different sections along the pipeline. All the data obtained is to be handed over to the owner & will form part of final technical documentation.

### 21.4 CURRENT ATTENUATION SURVEY

	<b>PARTICULAR TECHNICAL SPECIFICATIONS (PTS) FOR PERMANENT CATHODIC PROTECTION SYSTEM</b>	
---	---	---



- The objective of Current Attenuation Survey, is to make a comparative analysis of the electrical isolation property of coating along the length of pipeline.  
The Technique of the survey is to inject a high power frequency (audio) on the pipeline through test lead posts, using a high power AC transmitter.  
The signal strength can be measured using a hand held microprocessor based receiver, placed exactly above the pipeline on the ground.  
The instrument records the depth of the pipeline centre from the bottom of the receiver and the current. Thus by measuring current at two points, one can calculate the rate of current attenuation between two points.
- The current loss for each interval is then converted to signal in decibel/km. The current loss is expected to attenuate logarithmically along the length of the pipeline. The higher the current loss, the worse is the coating.
- Current attenuation shall be taken at 100 m interval and in fault area further lower span should be selected to know the coating condition. Depth of pipeline shall also be recorded.

## 21.5 AC INTERFERENCE

- The mitigation of AC interference CP contractor engaged by the Pipeline contractor shall procure and install the following material as per approved BOM submitted by Specialist agency:
  - Additional TLP's
  - AC corrosion coupons
  - Polarization coupons
  - Grounding Anodes with required backfill.
  - Solid state de-couplers
- Conducting AC / DC data logging at installed TLP's with AC corrosion coupons / Polarization coupons for 24 hours or more as directed by PMC / Owner to check the effectiveness of the mitigation measures and ensuring that induced potential / current densities does not exceed the safe limits as mentioned in the relevant clauses in the tender.

## 21.6 DC INTERFERENCE



- DC interference due to HVDC power lines, current from foreign / parallel lines in the ROW and DC railway traction.  
The data collected as per the approved methodology shall include details of overhead HVDC power line voltage rating, minimum/maximum separation of parallelism, length of parallelism, number and angle of overhead power line, foreign pipelines/ pipelines in the ROW with common anode ground beds, railway crossings, soil resistivity, coating conductance and any other factors as may be applicable on a case by case basis.
- The data collected will be used as inputs to the customized software for predicting likely hazardous voltages for AC induction and DC interference causing stray current corrosion.
- Measurements including pipe to soil potential (PSP) and pipeline current etc. on the pipeline/ structure being CP protected shall be made to investigate the current discharge (into surrounding soil electrolyte) and collection locations.

	<b>PARTICULAR TECHNICAL SPECIFICATIONS (PTS) FOR PERMANENT CATHODIC PROTECTION SYSTEM</b>	
---	---	---

- In case of fluctuating stray currents investigation shall be made continuously over a period of time and if required simultaneously at different locations to find out the stray current source. For long time measurements, recorders shall preferably be used.
- Where foreign pipeline (unprotected or protected by independent CP system) runs parallel to the pipeline in same trench or very near to the pipeline, and is not bonded to the pipeline then investigation shall be made for current pickup & discharge points on both the pipelines.
- In case of DC interference, a positive potential swing of more than 50 mV is sufficient to indicate the presence of an interference situation requiring investigation and incorporation of mitigation measures.
- Mitigation measures shall be provided depending on type of DC interference. These shall include installation of bond with variable resistor and 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.
- Between an existing pipeline & upcoming pipeline a concrete raft (size to be approved by owner as per OISD) is to be provided as a barrier.
- Bonding with foreign pipeline/ structure as a mitigation measure shall be provided where the owner of the pipeline/ structure has no objection, otherwise alternative mitigation measure shall be provided. Wherever bonding is provided for mitigation the bonding resistor shall be adjusted for optimum value for minimum / no interference so that no net current flows from one to the other pipeline. Galvanic anodes installed as a mitigation measure shall be sized for the life specified for permanent CP.
- The recommendations after the interference study will be implemented by CP contractor during PCP system installation.
- After successful installation of the mitigative measures AC and DC interference will again be measured/surveyed and if found still in un-acceptable limits or fluctuating a continuous computerized data logging will be done for 24 hours or more at these locations, the interference mitigation experts will have to visit site again to evaluate the reasons of this un-acceptable levels of AC &/or DC interference despite implementation of earlier recommendations and suggest further requisite mitigative measures required to achieve (P-S-P) within specified limits and hazard free (to operational personnel) and the pipeline.
- At the time of handing over the installed (ICCP) system to HNGPL the pipeline needs to be free of interference.
- PCP Contractor will have to seek and obtain necessary permission from other utilities for resistance bonding for interference mitigation. HNGPL will give letter of authorization to PCP Contractor for approaching various utilities for approval / permissions. These permissions from all or any of these agencies, in original, will be handed over to HNGPL at the time of system handover by the CP Contractor.
- Before commencement of site surveys, the survey procedure shall be got duly approved from the Owner.

**22. AMC (ANNUAL MAINTENANCE CONTRACT) FOR A PERIOD OF 3 YEARS**

- Annual Maintenance Contract for Monitoring & Maintenance of Cathodic Protection (CP) System shall comprise off:
  - **Monthly TR-Unit Monitoring & Maintenance**
    - A. Visual inspection of CP unit, cleaning with vacuum cleaner, checking of earthing, cables, connections, Nut -bolts etc.
    - B. Removal of vegetation in and around CP unit.

	<b>PARTICULAR TECHNICAL SPECIFICATIONS (PTS) FOR PERMANENT CATHODIC PROTECTION SYSTEM</b>	
---	---	---

C. Checking and replacement of all protective devices (fuses/ circuit breakers/ lightning arrestor/ digital or analog Voltmeter/ Amperemeter etc.) for their satisfactory operations and replacements thereof, if found defective.

D. Submission of Reports with recommendation from NACE Level 2 (min) CP Specialist or CP Expert for any preventive/Breakdown Action Required if any.

➤ **Monthly ON-PSP Monitoring**

A. To carry out ON PSP monitoring at test station (including status of insulating Joints, Sacrificial Anode Voltage, Anode Current drawn, Casing Status, Spark Gap Arrestor, Grounding Cell, Bonding Status with Foreign Pipeline, or Polarisation cell or Krirk Cell etc. section wise with recommendations (NACE Level 2 (min) CP Specialist or CP Expert) for any Preventive/Breakdown Action required if any.

B. Maintenance or replacement of damage TLP cable thimble, drawing plate, nut bolt, proper cleaning.

➤ **Half Yearly ON-OFF PSP Monitoring**

A. To carry out ON- PSP at test Station Including Installation of current interrupter (with GPS Synchronizer) wherever required (including status insulating joints, Sacrificial Anode Voltage, Anode current drawn, Casing Status, Surge Arrestor, Grounding cell, Bonding Status with Foreign Pipeline, or Polarisation cell (SSD ) or Krirk Cell etc. section wise with recommendations (NACE Level 2 (min) CP Specialist or CP Expert) for any Preventive/Breakdown Action required if any.

➤ **Monthly ON PSP in common ROU**

A. To carry out ON PSP monitoring at test station (including status of insulating Joints, Sacrificial Anode Voltage, Anode Current drawn, Casing Status, Spark Gap Arrestor, Grounding Cell, Bonding Status with Foreign Pipeline, or Polarisation cell (SSD ) or Krirk Cell etc. section wise with recommendations (NACE Level 2 (min) CP Specialist or CP Expert) for any Preventive/Breakdown Action required if any.



➤ **Monthly Monitoring & Maintenance of Anode Bed**

A. To carry out Anode bed (horizontal or deepwell) monitoring of CP Unit (Any Make type TR/Solar/CPPCM/CPVCM etc.) at particular location with recommendations (From NACE Level 2 (min) CP Specialist or CP Expert) for any Preventive/Breakdown Action required if any.

➤ **Rectification & replacement of faulty TRU cards, AGB's, JB's , Cables , Anodes , AC Mitigation systems , Test Stations & any other equipment/part to ensure proper & healthy functioning of CP System.**

**23. AS BUILT DOCUMENTATION**


- All as-built documentation including O&M manual, monitoring methodology & formats etc. to be submitted by CONTRACTOR after completion of post commissioning surveys, to CONSULTANT/OWNER for approval. At the time of handing over the system to CONSULTANT/OWNER all documents pertaining to land [for anode bed location] and right to lay

	<b>PARTICULAR TECHNICAL SPECIFICATIONS (PTS) FOR PERMANENT CATHODIC PROTECTION SYSTEM</b>	
---	---	---

cable & subsequent use for O&M purposes, from anode bed to power source, to be handed over by the CONTRACTOR to CONSULTANT/OWNER.

**24. SURVEY & IDENTIFICATION OF LAND FOR AGB**

- Survey & Identification of Land for AGB . Applicable if Land is not available within the existing CGS/CNG Stations.
- ( Includes liasoning with the Land Owner , concerned govt authority , feasibility wrt TRU Location, Pipeline )

		<b>QUALITY ASSURANCE PLAN SOLID STATE DECOUPLER (SSD)</b>		Doc No: W.00009-G-11000-E001 Rev. 00 Date: 08.02.2023			
S.NO.	DESCRIPTION / TYPE OF INSPECTION	REFERENCE DOCUMENT	FORMAT OF RECORD	INSPECTION BY			Remarks
				M	TPIA	CA	
1	Compliance with approved Drawing & Data sheet	Approved Drawing & Data Sheet	Inspection Report	P	RW	RW	
2	Manufacturer Test Certificate (IP 55)	Approved Drawing & Data Sheet	Test Certificate	S	R	R	
3	Inspection release note	Approved Drawing & Data Sheet	IRN	H	P	R	
<b>LEGEND:</b>							
R:Review		H-Hold		M-Manufacturer		RW: Random Witness	
P:Performed		CA - Control Authority		W:Witness		S : Submission	
TPIA: Third Party Inspection Agency		Control Authority : Owner/Engineer or their Authorised Inspection Agency					
<b>Note:</b>	1. The Above Testing and acceptance criteria are minimum requirements, however, equipment supplier shall ensure and that the product also comply to the additional requirements as per Technical specifications and data sheets.						
	2. The supplier shall submit their own detailed QAP prepared on the basis of the above for approval of Owner/Owner's representative and TPIA.						
	3. Supplier shall submit Calibration certificates of all Instruments/Equipment to be used for Inspection and Testing to TPIA with relevant procedures and updated standards for TPIA review/Approval.						
	4. TPIA will have Right to Inspect minimum 10% of all manufacturing activities on each day or as specified above.						
	5. TPIA along with Owner/Owner representative shall review/approve all the documents related to QAP/Quality manuals/Drawings etc.submitted by supplier.						
	6. TPIA shall also Review the Test certificates submitted by the manufacturer.						
	7. Contractor shall in coordination with Supplier/Sub vendor shall issue detailed Production and Inspection schedule indicating the dates and the locations to facilitate Owner/Owner's representative and TPIA to organise Inspection.						





**TRACTEBEL**  
ENGIE

**QUALITY ASSURANCE PLAN  
TEST LEAD POINT**

Doc No: W.00009-G-11000-E002



Rev. 00 Date: 08.02.2023



S.NO.	DESCRIPTION / TYPE OF INSPECTION	REFERENCE DOCUMENT	FORMAT OF RECORD	INSPECTION BY			Remarks
				M	TPIA	CA	
1	Compliance with approved Drawing & Data sheet, fitness test, terminal to body resistance.	Approved Drawing & Data Sheet	Inspection Report	P	W	W	
2	Visual Inspection: 100%	Approved Drawing & Data Sheet	Inspection Report	P	W	W	
3	Dimensional Check: 100%	Approved Drawing	Inspection Report	P	W	W	
4	Manufacturer Test Certificate (IP 55)/ Flameproof (Exd) if applicable	Approved Drawing & Data Sheet	IP 55 Test Certificate	S	R	R	
5	Document / Marking	Approved Drawing & Data Sheet	IRN	H	P	R	



**LEGEND:**

R:Review	H-Hold	M-Manufacturer	S : Submission
P:Performed	CA-Control Authority	W:Witness	RW:Random Witness
TPIA: Third Party Inspection Agency	Control Authority : Owner/Engineer or their Authorised Inspection Agency.		

<b>Note:</b>	1. The Above Testing and acceptance criteria are minimum requirements, however, equipment supplier shall ensure and that the product also comply to the additional requirements as per Technical specifications and data sheets.
	2. The supplier shall submit their own detailed QAP prepared on the basis of the above for approval of Owner/Owner's representative and TPIA.
	3. Supplier shall submit Calibration certificates of all Instruments/Equipment to be used for Inspection and Testing to TPIA with relevant procedures and updated standards for TPIA review/Approval.
	4. TPIA will have Right to Inspect minimum 10% of all manufacturing activities on each day or as specified above.
	5. TPIA along with Owner/Owner representative shall review/approve all the documents related to QAP/Quality manuals/Drawings etc.submitted by supplier.
	6. TPIA shall also Review the Test certificates submitted by the manufacturer.
	7. Contractor shall in coordination with Supplier/Sub vendor shall issue detailed Production and Inspection schedule indicating the dates and the locations to facilitate Owner/Owner's representative and TPIA to organise Inspection.

 		<b>QUALITY ASSURANCE PLAN PERMANENT REFERENCE CELL</b>		Doc No: W.00009-G-11000-E003 Rev. 00 Date: 08.02.2023			
S.NO.	DESCRIPTION / TYPE OF INSPECTION	REFERENCE DOCUMENT	FORMAT OF RECORD	INSPECTION BY			Remarks
				M	TPIA	CA	
1	Compliance with approved Drawing & Data sheet	Approved Drawing & Data Sheet	Inspection Report	P	RW	RW	
2	Manufacturer Test Certificate (IP 55)	Approved Drawing & Data Sheet	Test Certificate	S	R	R	
3	Inspection release note	Approved Drawing & Data Sheet	IRN	H	P	R	
<b>LEGEND:</b>							
R:Review		H-Hold		M-Manufacturer		RW: Random Witness	
P:Performed		CA - Control Authority		W:Witness		S : Submission	
TPIA: Third Party Inspection Agency		Control Authority : Owner/Engineer or their Authorised Inspection Agency					
<b>Note:</b>	1. The Above Testing and acceptance criteria are minimum requirements, however, equipment supplier shall ensure and that the product also comply to the additional requirements as per Technical specifications and data sheets.						
	2. The supplier shall submit their own detailed QAP prepared on the basis of the above for approval of Owner/Owner's representative and TPIA.						
	3. Supplier shall submit Calibration certificates of all Instruments/Equipment to be used for Inspection and Testing to TPIA with relevant procedures and updated standards for TPIA review/Approval.						
	4. TPIA will have Right to Inspect minimum 10% of all manufacturing activities on each day or as specified above.						
	5. TPIA along with Owner/Owner representative shall review/approve all the documents related to QAP/Quality manuals/Drawings etc.submitted by supplier.						
	6. TPIA shall also Review the Test certificates submitted by the manufacturer.						
	7. Contractor shall in coordination with Supplier/Sub vendor shall issue detailed Production and Inspection schedule indicating the dates and the locations to facilitate Owner/Owner's representative and TPIA to organise Inspection.						

 		<b>QUALITY ASSURANCE PLAN COMPUTERISED TEST STATION UNIT</b>		Doc No: W.00009-G-11000-E004			
				Rev. 00 Date: 08.02.2023			
S.NO.	DESCRIPTION / TYPE OF INSPECTION	REFERENCE DOCUMENT	FORMAT OF RECORD	INSPECTION BY			Remarks
				M	TPIA	CA	
1	Compliance with approved Drawing & Data sheet	Approved Drawing & Data Sheet	Inspection Report	P	RW	RW	
2	Manufacturer Test Certificate (IP 55)	Approved Drawing & Data Sheet	Test Certificate	S	R	R	
3	Inspection release note	Approved Drawing & Data Sheet	IRN	H	P	R	
<b>LEGEND:</b>							
R:Review		H-Hold		M-Manufacturer		RW: Random Witness	
P:Performed		CA - Control Authority		W:Witness		S : Submission	
TPIA: Third Party Inspection Agency		Control Authority : Owner/Engineer or their Authorised Inspection Agency					
<b>Note:</b>	1. The Above Testing and acceptance criteria are minimum requirements, however, equipment supplier shall ensure and that the product also comply to the additional requirements as per Technical specifications and data sheets.						
	2. The supplier shall submit their own detailed QAP prepared on the basis of the above for approval of Owner/Owner's representative and TPIA.						
	3. Supplier shall submit Calibration certificates of all Instruments/Equipment to be used for Inspection and Testing to TPIA with relevant procedures and updated standards for TPIA review/Approval.						
	4. TPIA will have Right to Inspect minimum 10% of all manufacturing activities on each day or as specified above.						
	5. TPIA along with Owner/Owner representative shall review/approve all the documents related to QAP/Quality manuals/Drawings etc.submitted by supplier.						
	6. TPIA shall also Review the Test certificates submitted by the manufacturer.						
	7. Contractor shall in coordination with Supplier/Sub vendor shall issue detailed Production and Inspection schedule indicating the dates and the locations to facilitate Owner/Owner's representative and TPIA to organise Inspection.						

 		<b>QUALITY ASSURANCE PLAN</b> <b>CP CABLE</b>		Doc No: W.00009-G-11000-E005 Rev. 00 Date: 08.02.2023			
S.NO.	DESCRIPTION / TYPE OF INSPECTION	REFERENCE DOCUMENT	FORMAT OF RECORD	INSPECTION BY			Remarks
				M	TPIA	CA	
1	Compliance with approved Data sheet	Approved Data Sheet	Inspection Report	P	W	W	
2	Visual Inspection: 100%	Approved Data Sheet	Inspection Report	P	W	W	
3	Voltage Test, Conductor Cross Section, Insulation Test	Approved Data Sheet	Inspection Report	P	W	W	
4	Continuity Check	Approved Data Sheet	Inspection Report	P	W	W	
5	High Voltage & IR Test	IS-7098	Inspection Report	P	W	W	
6	Manufacturer Test Reports	Approved Data Sheet	Test Report	S	R	R	
7	Document / Marking	Approved Data Sheet	IRN	H	P	R	
<b>LEGEND:</b>							
R:Review		H-Hold		S : Submission		M-Manufacturer	
P:Performed		CA-Control Authority		W:Witness		RW:Random Witness	
TPIA: Third Party Inspection Agency		Control Authority : Owner/Engineer or their Authorised Inspection Agency					
<b>Note:</b>	1. The Above Testing and acceptance criteria are minimum requirements, however, equipment supplier shall ensure and that the product also comply to the additional requirements as per Technical specifications and data sheets.						
	2. The supplier shall submit their own detailed QAP prepared on the basis of the above for approval of Owner/Owner's representative and TPIA.						
	3. Supplier shall submit Calibration certificates of all Instruments/Equipment to be used for Inspection and Testing to TPIA with relevant procedures and updated standards for TPIA review/Approval.						
	4. TPIA will have Right to Inspect minimum 10% of all manufacturing activities on each day or as specified above.						
	5. TPIA along with Owner/Owner representative shall review/approve all the documents related to QAP/Quality manuals/Drawings etc.submitted by supplier.						
	6. TPIA shall also Review the Test certificates submitted by the manufacturer.						
	7. Contractor shall in coordination with Supplier/Sub vendor shall issue detailed Production and Inspection schedule indicating the dates and the locations to facilitate Owner/Owner's representative and TPIA to organise Inspection.						



**QUALITY ASSURANCE PLAN  
MMO ANODE**

Doc No: W.00009-G-11000-E006



Rev. 00 Date: 08.02.2023



S.NO.	DESCRIPTION / TYPE OF INSPECTION	REFERENCE DOCUMENT	FORMAT OF RECORD	INSPECTION BY			Remarks
				M	TPIA	CA	
1	Compliance with approved Drawing & Data sheet	Approved Data Sheet	Inspection Report	P	RW	RW	
2	Inspection as per vendor's ITP	Vendor's ITP	Inspection Report	P	R	R	
3	Document / Marking	Approved Drawing & Data Sheet	IRN	H	P	R	



**LEGEND:**

R:Review	H-Hold	M-Manufacturer		
P:Performed	CA-Control Authority	RW:Random Witness		
TPIA: Third Party Inspection Agency	Control Authority : Owner/Engineer or their Authorised Inspection Agency			

<b>Note:</b>	1. The Above Testing and acceptance criteria are minimum requirements, however, equipment supplier shall ensure and that the product also comply to the additional requirements as per Technical specifications and data sheets.
	2. The supplier shall submit their own detailed QAP prepared on the basis of the above for approval of Owner/Owner's representative and TPIA.
	3. Supplier shall submit Calibration certificates of all Instruments/Equipment to be used for Inspection and Testing to TPIA with relevant procedures and updated standards for TPIA review/Approval.
	4. TPIA will have Right to Inspect minimum 10% of all manufacturing activities on each day or as specified above.
	5. TPIA along with Owner/Owner representative shall review/approve all the documents related to QAP/Quality manuals/Drawings etc.submitted by supplier.
	6. TPIA shall also Review the Test certificates submitted by the manufacturer.
	7. Contractor shall in coordination with Supplier/Sub vendor shall issue detailed Production and Inspection schedule indicating the dates and the locations to facilitate Owner/Owner's representative and TPIA to organise Inspection.

 		<b>QUALITY ASSURANCE PLAN</b> <b>CABLE TO PIPE CONNECTIONS (THERMIT WELDING / PIN BRAZING )</b>		Doc No: W.00009-G-11000-E007 Rev. 00 Date: 08.02.2023			
S.NO.	DESCRIPTION / TYPE OF INSPECTION	REFERENCE DOCUMENT	FORMAT OF RECORD	INSPECTION BY			Remarks
				M	TPIA	CA	
1	Compliance with approved Drawing & Data sheet	Approved Data Sheet & Drawing	Inspection Report	P	RW	RW	
2	Manufacturer Certificates	Approved Data Sheet & Drawing	Test Certificate	S	R	R	
<b>LEGEND:</b>							
R:Review		H-Hold	S : Submission	M-Manufacturer			
P:Performed		CA-Control Authority	W:Witness	RW:Random Witness			
TPIA: Third Party Inspection Agency		Control Authority : Owner/Engineer or their Authorised Inspection Agency					
<b>Note:</b>	1. The Above Testing and acceptance criteria are minimum requirements, however, equipment supplier shall ensure and that the product also comply to the additional requirements as per Technical specifications and data sheets.						
	2. The supplier shall submit their own detailed QAP prepared on the basis of the above for approval of Owner/Owner's representative and TPIA.						
	3. Supplier shall submit Calibration certificates of all Instruments/Equipment to be used for Inspection and Testing to TPIA with relevant procedures and updated standards for TPIA review/Approval.						
	4. TPIA will have Right to Inspect minimum 10% of all manufacturing activities on each day or as specified above.						
	5. TPIA along with Owner/Owner representative shall review/approve all the documents related to QAP/Quality manuals/Drawings etc.submitted by supplier.						
	6. TPIA shall also Review the Test certificates submitted by the manufacturer.						
	7. Contractor shall in coordination with Supplier/Sub vendor shall issue detailed Production and Inspection schedule indicating the dates and the locations to facilitate Owner/Owner's representative and TPIA to organise Inspection.						

 		<b>QUALITY ASSURANCE PLAN SURGE DIVERTER</b>		Doc No: W.00009-G-11000-E008 Rev. 00 Date: 08.02.2023			
S.NO.	DESCRIPTION / TYPE OF INSPECTION	REFERENCE DOCUMENT	FORMAT OF RECORD	INSPECTION BY			Remarks
				M	TPIA	CA	
1	Compliance with approved Drawing & Data sheet	Approved Data Sheet & Drawing	Inspection Report	P	RW	RW	
2	Manufacturer Certificates	Approved Data Sheet & Drawing	Test Certificate	S	R	R	
3	Inspection Release Note	Approved Drawing & Data Sheet	IRN	H	P	R	
<b>LEGEND:</b>							
R:Review		H-Hold	S : Submission	M-Manufacturer			
P:Performed		CA-Control Authority	W:Witness	RW:Random Witness			
TPIA: Third Party Inspection Agency		Control Authority : Owner/Engineer or their Authorised Inspection Agency					
<b>Note:</b>	1. The Above Testing and acceptance criteria are minimum requirements, however, equipment supplier shall ensure and that the product also comply to the additional requirements as per Technical specifications and data sheets.						
	2. The supplier shall submit their own detailed QAP prepared on the basis of the above for approval of Owner/Owner's representative and TPIA.						
	3. Supplier shall submit Calibration certificates of all Instruments/Equipment to be used for Inspection and Testing to TPIA with relevant procedures and updated standards for TPIA review/Approval.						
	4. TPIA will have Right to Inspect minimum 10% of all manufacturing activities on each day or as specified above.						
	5. TPIA along with Owner/Owner representative shall review/approve all the documents related to QAP/Quality manuals/Drawings etc.submitted by supplier.						
	6. TPIA shall also Review the Test certificates submitted by the manufacturer.						
	7. Contractor shall in coordination with Supplier/Sub vendor shall issue detailed Production and Inspection schedule indicating the dates and the locations to facilitate Owner/Owner's representative and TPIA to organise Inspection.						

 		<b>QUALITY ASSURANCE PLAN ANODE JUNCTION BOX</b>		Doc No: W.00009-G-11000-E009			
				Rev. 00 Date: 08.02.2023			
S.NO.	DESCRIPTION / TYPE OF INSPECTION	REFERENCE DOCUMENT	FORMAT OF RECORD	INSPECTION BY			Remarks
				M	TPIA	CA	
1	Compliance with approved Drawing & Data sheet	Approved Drawing & Data Sheet	Inspection Report	P	W	W	
2	Visual Inspection: 100%	Approved Drawing & Data Sheet	Inspection Report	P	W	W	
3	Dimensional Check: 10%	Approved Drawing & Data Sheet	Inspection Report	P	W	W	
4	Manufacturer Test Certificate (IP 55)	Approved Drawing & Data Sheet	Test Certificate	S	R	R	
5	Document / Marking	Approved Drawing & Data Sheet	IRN	H	P	R	
<b>LEGEND:</b>							
R:Review		H-Hold		M-Manufacturer		RW: Random Witness	
P:Performed		CA - Control Authority		W:Witness		S : Submission	
TPIA: Third Party Inspection Agency		Control Authority : Owner/Engineer or their Authorised Inspection Agency					
<b>Note:</b>	1. The Above Testing and acceptance criteria are minimum requirements, however, equipment supplier shall ensure and that the product also comply to the additional requirements as per Technical specifications and data sheets.						
	2. The supplier shall submit their own detailed QAP prepared on the basis of the above for approval of Owner/Owner's representative and TPIA.						
<b>Note:</b>	3. Supplier shall submit Calibration certificates of all Instruments/Equipment to be used for Inspection and Testing to TPIA with relevant procedures and updated standards for TPIA review/Approval.						
	4. TPIA will have Right to Inspect minimum 10% of all manufacturing activities on each day or as specified above.						
	5. TPIA along with Owner/Owner representative shall review/approve all the documents related to QAP/Quality manuals/Drawings etc.submitted by supplier.						
	6. TPIA shall also Review the Test certificates submitted by the manufacturer.						
	7. Contractor shall in coordination with Supplier/Sub vendor shall issue detailed Production and Inspection schedule indicating the dates and the locations to facilitate Owner/Owner's representative and TPIA to organise Inspection.						





**QUALITY ASSURANCE PLAN  
ER PROBE AND ER PROBE READER**

Doc No: W.00009-G-11000-E010

Rev. 00 Date: 08.02.2023

S.NO.	DESCRIPTION / TYPE OF INSPECTION	REFERENCE DOCUMENT	FORMAT OF RECORD	INSPECTION BY			Remarks
				M	TPIA	CA	
1	Compliance with approved Drawing & Data sheet	Approved Drawing & Data Sheet	Inspection Report	P	RW	RW	
2	Manufacturer Certificates	Approved Drawing & Data Sheet	Test Certificate	S	R	R	
3	MOC of the probe	Approved Drawing & Data Sheet	Test Certificate	S	R	R	
4	Visual check	Approved Drawing & Data Sheet	Test Certificate	P	W	W	
5	Dimensional check	Approved Drawing & Data Sheet	Test Certificate	P	W	W	
6	Calibration certificate of the Reader	----	Manufacturers Certificate	S	R	R	
7	Intrinsic safety certificate of the probe	----	Manufacturers Certificate	S	R	R	
8	IC issuance certificate	----	Manufacturers Certificate	S	R	R	
9	Inspection Release Note	Approved Drawing & Data Sheet	IRN	H	P	R	
<b>LEGEND:</b>							
R:Review		H-Hold		S : Submission		M-Manufacturer	
P:Performed		CA-Control Authority		W:Witness		RW:Random Witness	
TPIA: Third Party Inspection Agency		Control Authority : Owner/Engineer or their Authorised Inspection Agency					
<b>Note:</b>	1. The Above Testing and acceptance criteria are minimum requirements, however, equipment supplier shall ensure and that the product also comply to the additional requirements as per Technical specifications and data sheets. 2. The supplier shall submit their own detailed QAP prepared on the basis of the above for approval of Owner/Owner's representative and TPIA. 3. Supplier shall submit Calibration certificates of all Instruments/Equipment to be used for Inspection and Testing to TPIA with relevant procedures and updated standards for TPIA review/Approval.						



**TRACTEBEL**  
ENGIE

**QUALITY ASSURANCE PLAN  
ER PROBE AND ER PROBE READER**

Doc No: W.00009-G-11000-E010

Rev. 00 Date: 08.02.2023

<b>Note:</b>	4. TPIA will have Right to Inspect minimum 10% of all manufacturing activities on each day or as specified above.
	5. TPIA along with Owner/Owner representative shall review/approve all the documents related to QAP/Quality manuals/Drawings etc.submitted by supplier.
	6. TPIA shall also Review the Test certificates submitted by the manufacturer.
	7. Contractor shall in coordination with Supplier/Sub vendor shall issue detailed Production and Inspection schedule indicating the dates and the locations to facilitate Owner/Owner's representative and TPIA to organise Inspection.



**QUALITY ASSURANCE PLAN  
CATHODE JUNCTION BOX**

Doc No: W.00009-G-11000-E011



Rev. 00 Date: 08.02.2023

S.NO.	DESCRIPTION / TYPE OF INSPECTION	REFERENCE DOCUMENT	FORMAT OF RECORD	INSPECTION BY			Remarks
				M	TPIA	CA	
1	Compliance with approved Drawing & Data sheet	Approved Drawing & Data Sheet	Inspection Report	P	W	W	
2	Visual Inspection: 100%	Approved Drawing & Data Sheet	Inspection Report	P	W	W	
3	Dimensional Check: 10%	Approved Drawing & Data Sheet	Inspection Report	P	W	W	
4	Manufacturer Test Certificate (IP 55)	Approved Drawing & Data Sheet	Test Certificate	S	R	R	
5	Document / Marking	Approved Drawing & Data Sheet	IRN	H	P	R	

**LEGEND:**

R:Review	H:Hold	M:Manufacturer	RW: Random Witness
P:Performed	CA - Control Authority	W:Witness	S : Submission
TPIA: Third Party Inspection Agency	Control Authority : Owner/Engineer or their Authorised Inspection Agency		

<b>Note:</b>	1. The Above Testing and acceptance criteria are minimum requirements, however, equipment supplier shall ensure and that the product also comply to the additional requirements as per Technical specifications and data sheets.
	2. The supplier shall submit their own detailed QAP prepared on the basis of the above for approval of Owner/Owner's representative and TPIA.
	3. Supplier shall submit Calibration certificates of all Instruments/Equipment to be used for Inspection and Testing to TPIA with relevant procedures and updated standards for TPIA review/Approval.
	4. TPIA will have Right to Inspect minimum 10% of all manufacturing activities on each day or as specified above.
	5. TPIA along with Owner/Owner representative shall review/approve all the documents related to QAP/Quality manuals/Drawings etc.submitted by supplier.
	6. TPIA shall also Review the Test certificates submitted by the manufacturer.
	7. Contractor shall in coordination with Supplier/Sub vendor shall issue detailed Production and Inspection schedule indicating the dates and the locations to facilitate Owner/Owner's representative and TPIA to organise Inspection.

 		<b>QUALITY ASSURANCE PLAN POLARISATION COUPON</b>		Doc No: W.00009-G-11000-E012 Rev. 00 Date: 08.02.2023			
S.NO.	DESCRIPTION / TYPE OF INSPECTION	REFERENCE DOCUMENT	FORMAT OF RECORD	INSPECTION BY			Remarks
				M	TPIA	CA	
1	Compliance with approved Drawing & Data sheet.	Approved Drawing & Data Sheet	Inspection Report	P	RW	RW	
2	Visual Inspection: 100%	Approved Drawing & Data Sheet	Inspection Report	P	R	R	
3	Dimensional Check: 100%	Approved Drawing	Inspection Report	P	R	R	
4	Manufacturer Test Certificate	Approved Drawing & Data Sheet	Certificate of Conformance / test certificate	S	R	R	
5	Document / Marking	Approved Drawing & Data Sheet	IRN	H	P	R	
<b>LEGEND:</b>							
R:Review		H-Hold		S : Submission		M-Manufacturer	
P:Performed		CA-Control Authority		W:Witness		RW:Random Witness	
TPIA: Third Party Inspection Agency		Control Authority : Owner/Engineer or their Authorised Inspection Agency					
<b>Note:</b>	1. The Above Testing and acceptance criteria are minimum requirements, however, equipment supplier shall ensure and that the product also comply to the additional requirements as per Technical specifications and data sheets.						
	2. The supplier shall submit their own detailed QAP prepared on the basis of the above for approval of Owner/Owner's representative and TPIA.						
	3. Supplier shall submit Calibration certificates of all Instruments/Equipment to be used for Inspection and Testing to TPIA with relevant procedures and updated standards for TPIA review/Approval.						
	4. TPIA will have Right to Inspect minimum 10% of all manufacturing activities on each day or as specified above.						
	5. TPIA along with Owner/Owner representative shall review/approve all the documents related to QAP/Quality manuals/Drawings etc.submitted by supplier.						
	6. TPIA shall also Review the Test certificates submitted by the manufacturer.						
	7. Contractor shall in coordination with Supplier/Sub vendor shall issue detailed Production and Inspection schedule indicating the dates and the locations to facilitate Owner/Owner's representative and TPIA to organise Inspection.						







**QUALITY ASSURANCE PLAN  
CALCINED PETROLEUM COKE BREEZE**



Doc No: W.00009-G-11000-E013

Rev. 00 Date: 08.02.2023

S.NO.	DESCRIPTION / TYPE OF INSPECTION	REFERENCE DOCUMENT	FORMAT OF RECORD	INSPECTION BY			Remarks
				M	TPIA	CA	
1	Compliance with approved Data sheet & Specification	Approved Data Sheet & Design Specification	Inspection Report	P	RW	RW	
2	Manufacturer Test Certificates	Approved Data Sheet & Design Specification	Test Certificate	S	R	R	
2.1	Make	Approved Vendor list	-----	S	R	R	
2.2	Batch No	Approved Data Sheet	Test certificate	S	R	R	
2.3	Chemical composition (Moisture – on dry basis, fixed carbon),	Approved Data Sheet	Test certificate	S	R	R	
2.4	Bulk density	Approved Data Sheet	Test certificate	S	R	R	
2.5	Particle size	Approved Data Sheet	Test certificate	S	R	R	
2.6	Resistivity (150 psi compaction)	Approved Data Sheet	Test certificate	S	R	R	
3	Inspection Release Note	Approved Drawing & Data Sheet	IRN	H	P	R	
<b>LEGEND:</b>							
R:Review		H:Hold	S : Submission	M-Manufacturer			
P:Performed		CA-Control Authority	W:Witness	RW:Random Witness			
TPIA: Third Party Inspection Agency		Control Authority : Owner/Engineer or their Authorised Inspection Agency					
<b>Note:</b>	1. The Above Testing and acceptance criteria are minimum requirements, however, equipment supplier shall ensure and that the product also comply to the additional requirements as per Technical specifications and data sheets.						
	2. The supplier shall submit their own detailed QAP prepared on the basis of the above for approval of Owner/Owner's representative and TPIA.						
	3. Supplier shall submit Calibration certificates of all Instruments/Equipment to be used for Inspection and Testing to TPIA with relevant procedures and updated standards for TPIA review/Approval.						

		<b>QUALITY ASSURANCE PLAN CALCINED PETROLEUM COKE BREEZE</b>	Doc No: W.00009-G-11000-E013
			Rev. 00 Date: 08.02.2023
<b>Note:</b>	4. TPIA will have Right to Inspect minimum 10% of all manufacturing activities on each day or as specified above.		
	5. TPIA along with Owner/Owner representative shall review/approve all the documents related to QAP/Quality manuals/Drawings etc.submitted by supplier.		
	6. TPIA shall also Review the Test certificates submitted by the manufacturer.		
	7. Contractor shall in coordination with Supplier/Sub vendor shall issue detailed Production and Inspection schedule indicating the dates and the locations to facilitate Owner/Owner's representative and TPIA to organise Inspection.		

 		<b>QUALITY ASSURANCE PLAN BACKFILL MATERIAL</b>		Doc No: W.00009-G-11000-E014 Rev. 00 Date: 08.02.2023			
S.NO.	DESCRIPTION / TYPE OF INSPECTION	REFERENCE DOCUMENT	FORMAT OF RECORD	INSPECTION BY			Remarks
				M	TPIA	CA	
1	Compliance with approved Data sheet & Specification	Approved Data Sheet & Design Specification	Inspection Report	P	RW	RW	
2	<b>Manufacturer Test Certificates</b>	Approved Data Sheet & Design Specification	Test Certificate	S	R	R	
2.1	Make	Approved Vendor list	----	S	R	R	
2.2	Batch No	Approved Data Sheet	Test certificate	S	R	R	
2.3	Chemical composition (Moisture – on dry basis, fixed carbon),	Approved Data Sheet	Test certificate	S	R	R	
2.4	Bulk density	Approved Data Sheet	Test certificate	S	R	R	
2.5	Particle size	Approved Data Sheet	Test certificate	S	R	R	
3	Inspection Release Note	Approved Drawing & Data Sheet	IRN	H	P	R	
<b>LEGEND:</b>							
R:Review		H:Hold	S : Submission	M-Manufacturer			
P:Performed		CA-Control Authority	W:Witness	RW:Random Witness			
TPIA: Third Party Inspection Agency		Control Authority : Owner/Engineer or their Authorised Inspection Agency					
<b>Note:</b>	1. The Above Testing and acceptance criteria are minimum requirements, however, equipment supplier shall ensure and that the product also comply to the additional requirements as per Technical specifications and data sheets. 2. The supplier shall submit their own detailed QAP prepared on the basis of the above for approval of Owner/Owner's representative and TPIA. 3. Supplier shall submit Calibration certificates of all Instruments/Equipment to be used for Inspection and Testing to TPIA with relevant procedures and updated standards for TPIA review/Approval. 4. TPIA will have Right to Inspect minimum 10% of all manufacturing activities on each day or as specified above.						

		<b>QUALITY ASSURANCE PLAN BACKFILL MATERIAL</b>	Doc No: W.00009-G-11000-E014
			Rev. 00 Date: 08.02.2023
<b>Note:</b>	5. TPIA along with Owner/Owner representative shall review/approve all the documents related to QAP/Quality manuals/Drawings etc.submitted by supplier.		
	6. TPIA shall also Review the Test certificates submitted by the manufacturer.		
	7. Contractor shall in coordination with Supplier/Sub vendor shall issue detailed Production and Inspection schedule indicating the dates and the locations to facilitate Owner/Owner's representative and TPIA to organise Inspection.		





QUALITY ASSURANCE PLAN  
TRANSFORMER UNIT ( TRU )

Doc No: W.00009-G-11000-E015

Rev. 00 Date: 08.02.2023

S.NO.	DESCRIPTION / TYPE OF INSPECTION	REFERENCE DOCUMENT	FORMAT OF RECORD	INSPECTION BY			Remarks
				M	TPIA	CA	
1	Compliance with approved Drawing & Data sheet	Approved Data Sheet	Inspection Report	P	RW	RW	
2	<b>BOUGHT OUT ITEMS</b>						
<b>Receiving Inspection for Fabricated Items</b>							
2(a)	1. Physical Check - 100%	Approved Drawing Manufacturer specification	Incoming Test certificate	P	R	R	
	2 Physical damage if any. - 1 in Lot	-----	-----	P	R	R	
	3 Verification with Manufacturer specification	Approved Drawing	-----	P	R	R	
<b>Receiving Inspection of Meters,PCB'S,Semiconductor &amp; Electrical Items</b>							
2(b)	1. Dimensions, Size - Sampling 10%	Approved Drawing Manufacturer specification	Manufacturer Test Report Incoming Test Report	P	R	R	
	2. Electrical Parameters - 1 in Lot	-----	-----	P	W	W	
2(c)	<b>Sub assembly- Transformer, Choke</b> 1. Insulation Test -100% 2. No Load Test -100%	Approved Drawing	Test certificate	P	R	R	
<b>Sub assembly- Timer-Inspection &amp; Test</b>							
2(d)	1. Visual inspection - -100%	Approved Drawing	Test certificate	P	R	R	
	2. Functional Test - -100%	Approved Drawing	Test certificate	P	R	R	
	3. Internal settings- -100%	Approved Drawing	Test certificate	P	R	R	
<b>Assembly Process</b>							
2(e)	1. Electrical wiring and tightness of all connections - 100 %	Approved Drawing	Test report	P	R	R	
	2. Labeling and Marking - 100 %	Approved Drawing	Test report	P	R	R	
2(f)	Auxiliary device check - 100 %	Approved Drawing	Test report	P	R	R	





QUALITY ASSURANCE PLAN  
TRANSFORMER UNIT ( TRU )

Doc No: W.00009-G-11000-E015

Rev. 00 Date: 08.02.2023

S.NO.	DESCRIPTION / TYPE OF INSPECTION	REFERENCE DOCUMENT	FORMAT OF RECORD	INSPECTION BY			Remarks
				M	TPIA	CA	
2(g)	<b>Insulation Test</b> Insulation and High Voltage Test between primary to Earth, Secondary to Earth and/or Primary to secondary	Approved Drawing	Test report	P	R	R	
2(h)	<b>Sub/assembly-control card Inspection &amp; Test</b>						
	1. Visual inspection - 100%	Approved Drawing	Test report	P	R	R	
	2. Functional Test - -100%	Approved Drawing	Test report	P	R	R	
	3. Internal settings- -100%	Approved Drawing	Test report	P	R	R	
2(j)	<b>Heat Run Test</b> Heat run at at rated Load for at least 12/16 Hrs with Temperature measurement on all power devices and Magnetics at the end of test	Approved Drawing Approved Specification	Test report	P	R	R	
3	<b>FINAL TEST</b>						
3(a)	Continuity (ON-OFF) - Electrical Inspection 100%	-----	-----	P	R	R	
3(b)	<b>Functional Test of Unit - 100%</b>						
	1. Visual Inspection	Approved Drawing Approved Specification	Test report	P	W	W	
	2. Insulation Test	Approved Drawing Approved Specification	Test report	P	W	W	
	3. Operation in Manual Mode	Approved Drawing Approved Specification	Test report	P	W	W	
	4. Operation in AVCC & Voltage/current.	Approved Drawing Approved Specification	Test report	P	W	W	
	5. Regulation	Approved Drawing Approved Specification	Test report	P	W	W	
	6. Operation in Auto and PSP regulation	Approved Drawing Approved Specification	Test report	P	W	W	
	7. Ripple content in DC Output	Approved Drawing Approved Specification	Test report	P	W	W	
	8. Indication and alarm	Approved Drawing Approved Specification	Test report	P	W	W	

 		<b>QUALITY ASSURANCE PLAN TRANSFORMER UNIT ( TRU )</b>		Doc No: W.00009-G-11000-E015 Rev. 00 Date: 08.02.2023			
S.NO.	DESCRIPTION / TYPE OF INSPECTION	REFERENCE DOCUMENT	FORMAT OF RECORD	INSPECTION BY			Remarks
				M	TPIA	CA	
3(b)	9. Remote signal and Potential free contacts Converter and Timer(if any)	Approved Drawing Approved Specification	Test report	P	W	W	
	10 Efficiency & power factor	Approved Drawing Approved Specification	Test report	P	W	W	
3(c)	Heat Run Test Heat run at at rated Load for at least 8 Hrs with Temperature measurement on all power devices and Magnetics at the end of test	Approved Drawing & Data Sheet	Test report	P	RW	RW	
<b>LEGEND:</b>							
R:Review		H:Hold	S : Submission	M-Manufacturer			
P:Performed		CA-Control Authority	W:Witness	RW:Random Witness			
TPIA: Third Party Inspection Agency		Control Authority : Owner/Engineer or their Authorised Inspection Agency					
<b>Note:</b>	1. The Above Testing and acceptance criteria are minimum requirements, however, equipment supplier shall ensure and that the product also comply to the additional requirements as per Technical specifications and data sheets.						
	2. The supplier shall submit their own detailed QAP prepared on the basis of the above for approval of Owner/Owner's representative and TPIA.						
	3. Supplier shall submit Calibration certificates of all Instruments/Equipment to be used for Inspection and Testing to TPIA with relevant procedures and updated standards for TPIA review/Approval.						
	4. TPIA will have Right to Inspect minimum 10% of all manufacturing activities on each day or as specified above.						
	5. TPIA along with Owner/Owner representative shall review/approve all the documents related to QAP/Quality manuals/Drawings etc.submitted by supplier.						
	6. TPIA shall also Review the Test certificates submitted by the manufacturer.						
	7. Contractor shall in coordination with Supplier/Sub vendor shall issue detailed Production and Inspection schedule indicating the dates and the locations to facilitate Owner/Owner's representative and TPIA to organise Inspection.						



**TRACTEBEL**  
ENGINEERING

**QUALITY ASSURANCE PLAN  
ZINC GROUNDING CELL**

Doc No: W.00009-G-11000-E016

Rev. 00 Date: 08.02.2023

S.NO.	DESCRIPTION / TYPE OF INSPECTION	REFERENCE DOCUMENT	FORMAT OF RECORD	INSPECTION BY			Remarks
				M	TPIA	CA	
1	Compliance with approved Drawing & Data sheet	Approved Data Sheet	Inspection Report	P	RW	RW	
2	<b>Inspection</b>	Approved Drawing & Data Sheet	Inspection Report	P	RW	RW	
2(a)	Surface 100% Length +/- 2.5% Thickness +/- 5% Weight Tolerance +/- 5%						
2(b)	Visual : Longitudinal cracks of more than 40 mm long and 3 mm deep not acceptable						
3	<b>Radiographic Test</b>  One anode per heat shall be subjected to radiography to evaluate cracks , voids , stack inclusions etc	Approved Drawing & Data Sheet	Test report	P	R	R	
4	<b>Destructive Test</b>  One Anode to be subjected to destructive for slag , inclusions , bond between anode and insert	Approved Drawing & Data Sheet	Test report	P	R	R	
5	Chemical analysis : One anode sample per heat by spectography sample in the beginning for first heat, end of second heat, so on	Approved Drawing & Data Sheet		P	R	R	
6	<b>Electrochemical Test</b>	Approved Drawing & Data Sheet	Test report	P	R	R	
6(a)	Open circuit potential shall be within (+) 10 mv and (-) 50 mv of the guaranteed value						
6(b)	Consumption rate by weight loss method ( consumption rate shall be more than specified value)						
7	All above manufacturer test reports	-----	Test report	S	R	R	



**TRACTEBEL**  
ENGINEERING

**QUALITY ASSURANCE PLAN  
ZINC GROUNDING CELL**

Doc No: W.00009-G-11000-E016



Rev. 00 Date: 08.02.2023



S.NO.	DESCRIPTION / TYPE OF INSPECTION	REFERENCE DOCUMENT	FORMAT OF RECORD	INSPECTION BY			Remarks
				M	TPIA	CA	
8	Document / Marking	Approved Drawing & Data Sheet	IRN	H	P	R	



**LEGEND:**

R:Review	H-Hold	M-Manufacturer	S : Submission
P:Performed	CA-Control Authority	RW:Random Witness	
TPIA: Third Party Inspection Agency	Control Authority : Owner/Engineer or their Authorised Inspection Agency		



<b>Note:</b>	1. The Above Testing and acceptance criteria are minimum requirements, however, equipment supplier shall ensure and that the product also comply to the additional requirements as per Technical specifications and data sheets.
	2. The supplier shall submit their own detailed QAP prepared on the basis of the above for approval of Owner/Owner's representative and TPIA.
	3. Supplier shall submit Calibration certificates of all Instruments/Equipment to be used for Inspection and Testing to TPIA with relevant procedures and updated standards for TPIA review/Approval.
	4. TPIA will have Right to Inspect minimum 10% of all manufacturing activities on each day or as specified above.
	5. TPIA along with Owner/Owner representative shall review/approve all the documents related to QAP/Quality manuals/Drawings etc.submitted by supplier.
	6. TPIA shall also Review the Test certificates submitted by the manufacturer.
	7. Contractor shall in coordination with Supplier/Sub vendor shall issue detailed Production and Inspection schedule indicating the dates and the locations to facilitate Owner/Owner's representative and TPIA to organise Inspection.



 		<b>QUALITY ASSURANCE PLAN SACRIFICIAL MAGNESIUM ANODE</b>		Doc No: W.00009-G-11000-E017 Rev. 00 Date: 08.02.2023			
S.NO.	DESCRIPTION / TYPE OF INSPECTION	REFERENCE DOCUMENT	FORMAT OF RECORD	INSPECTION BY			Remarks
				M	TPIA	CA	
1	Compliance with approved Drawing & Data sheet	Approved Data Sheet	Inspection Report	P	RW	RW	
2	<b>Inspection</b>	Approved Drawing & Data Sheet	Inspection Report	P	RW	RW	
2(a)	Surface 100% Length +/- 2.5% Thickness +/- 5% Weight Tolerance +/- 5%						
2(b)	Visual : Longitudinal cracks of more than 40 mm long and 3 mm deep not acceptable						
3	<b>Radiographic Test</b> One anode per heat shall be subjected to radiography to evaluate cracks , voids , stack inclusions etc	Approved Drawing & Data Sheet	Test report	P	R	R	
4	<b>Destructive Test</b> One Anode to be subjected to destructive for slag , inclusions , bond between anode and insert	Approved Drawing & Data Sheet	Test report	P	R	R	
5	Chemical analysis : One anode sample per heat by spectography sample in the beginning for first heat, end of second heat, so on	Approved Drawing & Data Sheet		P	R	R	
6	<b>Electrochemical Test</b>	Approved Drawing & Data Sheet	Test report	P	R	R	
6(a)	Open circuit potential shall be within (+) 10 mv and (-) 50 mv of the guaranteed value						
6(b)	Consumption rate by weight loss method (consumption rate shall be more than specified value)						
7	All above manufacturer test reports	----	Test report	S	R	R	
8	Document / Marking	Approved Drawing & Data Sheet	IRN	H	P	R	


				<b>QUALITY ASSURANCE PLAN SACRIFICIAL MAGNESIUM ANODE</b>		Doc No: W.00009-G-11000-E017	
						Rev. 00 Date: 08.02.2023	
S.NO.	DESCRIPTION / TYPE OF INSPECTION	REFERENCE DOCUMENT	FORMAT OF RECORD	INSPECTION BY			Remarks
				M	TPIA	CA	
<b>LEGEND:</b>							
R:Review		H-Hold		M-Manufacturer		S : Submission	
P:Performed		CA-Control Authority		RW:Random Witness			
TPIA: Third Party Inspection Agency		Control Authority : Owner/Engineer or their Authorised Inspection Agency					
<b>Note:</b>	1. The Above Testing and acceptance criteria are minimum requirements, however, equipment supplier shall ensure and that the product also comply to the additional requirements as per Technical specifications and data sheets.						
	2. The supplier shall submit their own detailed QAP prepared on the basis of the above for approval of Owner/Owner's representative and TPIA.						
	3. Supplier shall submit Calibration certificates of all Instruments/Equipment to be used for Inspection and Testing to TPIA with relevant procedures and updated standards for TPIA review/Approval.						
	4. TPIA will have Right to Inspect minimum 10% of all manufacturing activities on each day or as specified above.						
	5. TPIA along with Owner/Owner representative shall review/approve all the documents related to QAP/Quality manuals/Drawings etc.submitted by supplier.						
	6. TPIA shall also Review the Test certificates submitted by the manufacturer.						
	7. Contractor shall in coordination with Supplier/Sub vendor shall issue detailed Production and Inspection schedule indicating the dates and the locations to facilitate Owner/Owner's representative and TPIA to organise Inspection.						

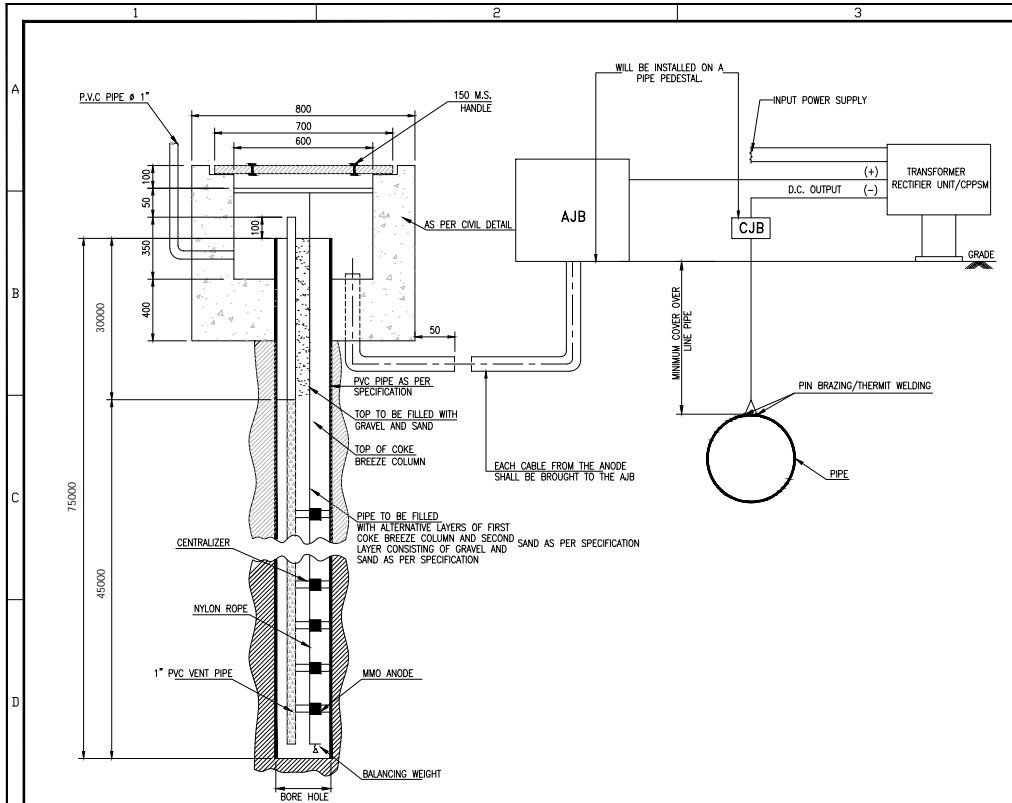
 	<p align="center"><b>LIST OF RECOMMENDED VENDORS FOR PERMANENT CATHODIC PROTECTION SYSTEM &amp; EQUIPMENT</b></p>
<p>Doc. No:</p>	<p>W.00009-G-11040-M001</p>
<p><b>TRANSFORMER- RECTIFIER UNITS &amp; SPARE CARDS / PARTS</b></p>	
1	Raychem RPG Pvt Ltd.(Canara Electric) , Mumbai
2	Kistron Systems Mumbai
3	Cathodic Control Co Pvt. Ltd,
4	Golconda Corrosion Control Pvt. Ltd., India
5	Hind Rectifiers Ltd., India
<p><b>JUNCTION BOXES (CLASSIFIED TYPE)</b></p>	
1	Flame Proof Equipment Pvt. Ltd.(FEPL), Bombay
2	Baliga Lighting, Chennai
3	Ceag Flame Proof Control Gears, Bombay
4	Flexpro Electricals, Navsari, Gujarat
5	Sudhir Switchgear
6	FCG flame proof control gears P. Ltd., Daman
7	Pepperl & Fuchs manufacturing (I) Pvt. Ltd.,Kanchipuram
8	Kaysons Techno equipments Pvt. Ltd., India
9	R Stahl Pvt. Ltd. Kanchipuram
<p><b>JUNCTION BOXES/ Test Stations (NON- CLASSIFIED TYPE)</b></p>	
1	Kistron systems, Mumbai
2	Raychem RPG Pvt Limited
3	Corrtch International Pvt Ltd
4	Sukrit Industries Ahemdabad
5	Silverline Integrity Services
6	UNDTs
7	SARK EPC
<p><b>CABLES</b></p>	
1	Netco Cable
2	KEI
3	Fort Gloster
4	Polycab
5	Universal
6	Cable Corporation of India
7	CMIL
8	Suyog Electricals
9	Victor cables
10	Finolex cables
11	Asian Cables
12	Radiant Cables
13	Icon cables
14	Gemscab
15	Torrent
16	Nicco
17	KEC International
18	Uniflex
19	Havells
20	Crystal Cable Corporation
21	Ravin
<p><b>PORTABLE/ PERMANENT REFERENCE ELECTRODES</b></p>	
1	Permacell/Harco, USA
2	Borin Manufacturer, USA
3	M.C.Miller, USA
4	Tinker & Rasor, USA
5	Ceranoda Technologies, USA



 		<b>LIST OF RECOMMENDED VENDORS FOR PERMANENT CATHODIC PROTECTION SYSTEM &amp; EQUIPMENT</b>
6		Telpro USA
7		Gruppo De nora, Goa
8		Oranzio De nora, Italy
9		Silvion, UK
10		Harco, USA
11		Electrochemical devices, USA
<b>SURGE DIVERTOR – EXD</b>		
1		Dehn (Germany)
2		OBO Betterman (Germany)
<b>AC CORROSION COUPON</b>		
1		MC Miller
2		Farwest Corrosion
<b>THERMIT WELDS</b>		
1		Erico, USA
2		Thermoweld, USA
3		Erico, Europe
4		Bac, UK
<b>PINBRAZING</b>		
1		Safe Track, Sweden
2		Bac, UK
<b>ER PROBE</b>		
1		Rose Corrosion Service, UK
2		Metal Samples, USA
3		Roharbak Cosasco, USA
4		Caproco, UK
5		Korosi Specindo, Indonesia
<b>MMO WIRE ANODE</b>		
1		Titanor Components Ltd., Goa
2		Oranzio De Nora, Italy
3		Eltech System, USA
4		Ceranode Technologies, USA
5		Matcor, USA
6		Covalence, USA
7		Berry Plastics
8		Gruppo De nora, Goa
9		Telpro USA
<b>MMO TUBULAR /STRIP/RIBBON ANODE</b>		
1		Titanor Components Ltd., Goa
2		Oranzio De Nora, Italy
3		Magnetocheme, Holland
4		Actel Ltd., UK
5		Eltech System, USA
6		Ceranode Technologies, USA
7		Matcor, USA
8		Gruppo De nora, Goa
9		Cathodic Control Co Pvt. Ltd, India
10		Electro Protection Services India P Ltd
11		Emirates Techno Casting, UAE
12		Corrosion Matters, Hyderabad
<b>SOLID STATE POLARISATION CELL</b>		
1		Dairyland
2		Metricorr, Denmark

 		<b>LIST OF RECOMMENDED VENDORS FOR PERMANENT CATHODIC PROTECTION SYSTEM &amp; EQUIPMENT</b>
3		Rustrol
4		Dehn, Germany
5		Kristron Systems, Mumbai
6		Corpro system
<b>HEAT SHRINK CAP FOR ANODE TO CABLE JOINT</b>		
1		Raychem, USA
2		Matcor, USA
<b>MAGNESIUM &amp; ZINC ANODE'S</b>		
1		Sargam Metal , Chennai
2		Scientific Metal, Chennai
3		Shakti enterprises, Ahemdabad
4		PSL Holding Pvt. Ltd., Mumbai
5		Cathodic Controls, Bangalore
6		Impalloy International
7		Electro protection services, India
8		Cathodic Control Company Pvt. Ltd., India
9		Nippon Corrosion, Japan
10		AFIC, KSA
11		Platt Bros. and Company, USA
12		Impalloy International, UK
13		Corpro International, Canada
14		Nakabohtec, Japan
15		Metal Founder, Mumbai
16		Corrosion Matters, Hyderabad
<b>ANODE BACKFILL MATERIAL</b>		
1		Goa carbon, Goa
2		India Carbon, Kolkata
3		Petrocarbon & Chemical Company, Kolkata
4		Loresco, USA
<b>INSTRUMENTS, TOOLS AND SPARES</b>		
<b>HAND HELD DATA LOGGER</b>		
1		ECD, Mumbai
2		M C Miller, USA
3		Cath-tech
<b>GSM BASED DIGITAL DATA LOGGER</b>		
1		Raychem, USA
2		M C Miller, USA
3		Kriston, Mumbai
<b>CORROSION VOLTMETER</b>		
1		Rishabh
2		MECO
3		Fluke
4		Yokogawa
<b>MULTI-COMBINATION METER</b>		
1		Rishabh
2		MECO
3		Fluke
<b>CPL SURVEY DATA LOGGER</b>		
1		MC Miller
2		Roger
<b>DCVG SURVEY KIT</b>		
1		DCVG

		<b>LIST OF RECOMMENDED VENDORS FOR PERMANENT CATHODIC PROTECTION SYSTEM &amp; EQUIPMENT</b>
<b>HOLIDAY DETECTOR</b>		
1		Associate Electronics
<b>PIPE LOCATOR</b>		
1		Radio Detection
2		Vivax
<b>ELCOMETER FOR COATING THICKNESS MEASUREMENT</b>		
1		Olympus
<b>4 PIN SOIL RESISTIVITY METER</b>		
1		Tinkor & Rasor
2		Nilsson
3		Fluke
<b>SINCORDER</b>		
1		MC Miller
<b>CP SOFTWARE( FOR REMOTE MONITORING)</b>		
1		Kristron / Equivalent
<b>ELECTRICIAN TOOL BOX WITH TOOL SET</b>		
1		Taparia
2		Stanley
<b>CAT /CAT A FRAME SURVEY EQUIPMENT</b>		
1		Radio Detection
2		Vivax
<b>Note:</b>		
1. Any other vendor(s) apart from as mentioned above may be accepted subject to approval by Owner/Owners representative based onpast track record (PTR). PTR document shall be submitted by the contractor for review. PTR must contain at least 3 nos. past executed purchase order copy.		
2. For the vendors of items not covered in above vendor list, but required for completion of project successfully, supplier shall take approval form Owner/Owners representative for the same during project execution. Bidder shall submit the required certifications, documents, PTR and Performance letters from clients for the same.		



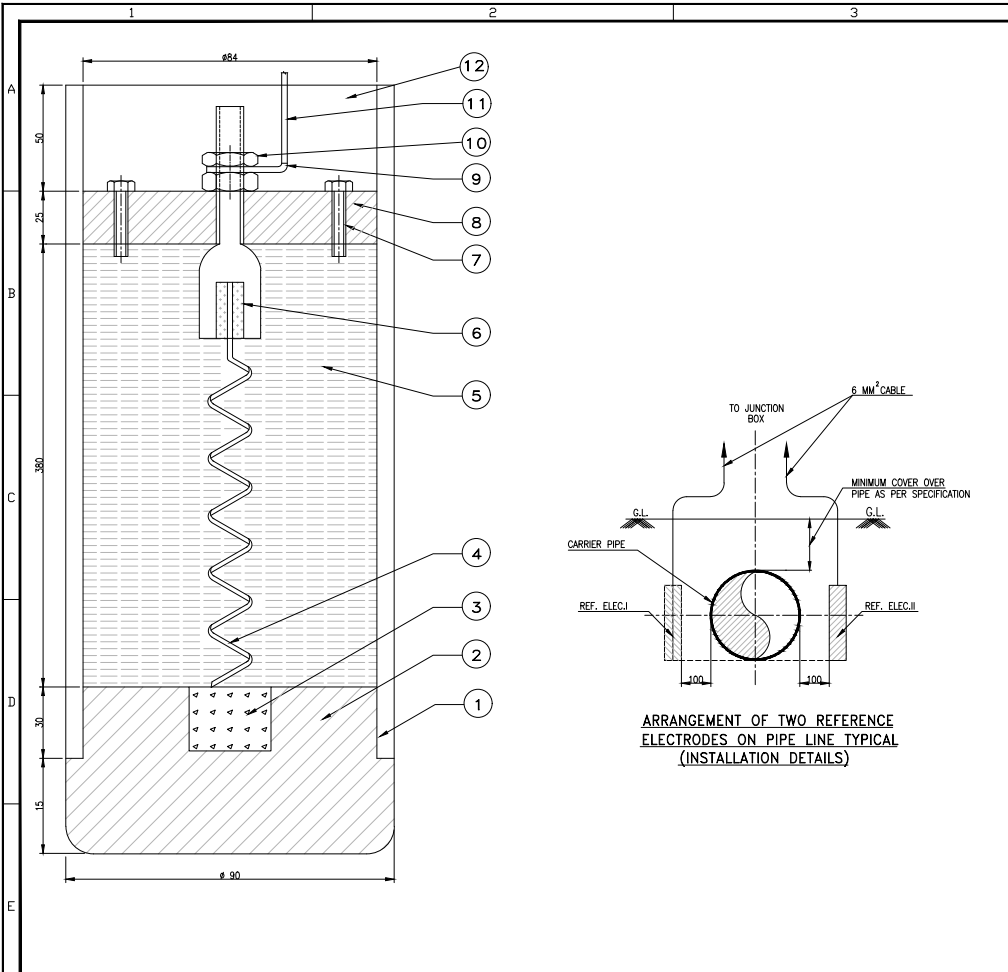
TYPICAL 30 M DEEP ANODE BED  
CONSISTING OF 1 STRING ANODES

NOTES

1. ALL DIMENSIONS ARE IN MM UNLESS OTHERWISE SPECIFIED.
2. THIS DRAWING FOR INFORMATION AND GUIDANCE ONLY. ACTUAL DRAWING AND DOCUMENT TO BE PREPARED BY CONTRACTOR AND APPROVED FROM OWNER/CONSULTANT BEFORE EXECUTION OF SAME.
3. ANODE BED TYPE (DEEP WELL OR HORIZONTAL TYPE) SHALL BE FINALIZED DURING DETAIL ENGINEERING.

0	06.07.2022	ISSUED FOR TENDER PURPOSE ONLY	SS	KRA	MCJ	SMK		
Rev	D	M	Y	Modifications	Drawn	Checked	Approved	Validated
<p>IMPRESSED CURRENT CATHODIC PROTECTION SCHEMATIC</p> <p>TRACTEBEL Engineering pvt. Ltd. Size Scale Sheet Drawing No. NTS 01 of 01 © 2020 01-2-2020 0001 Rev. 0</p>								

This document is the property of TRACTEBEL ENGINEERING PVT. LTD. AND SHALL BE RETURNED TO THE PARTY IN POSSESSION UPON REQUEST.



**NOTES**

1. ALL DIMENSIONS ARE IN MM UNLESS OTHERWISE SPECIFIED.
2. THE PIPE ASSEMBLY SHALL BE HOT DIP GALVANISED AFTER FABRICATION.
3. BRICK WORK SHALL BE DONE AFTER COMPACTING THE SOIL.
4. INSTALLED DETAILS FOR PERMANENT CU-CUSO4 REFERENCE CELLS AS MENTIONED IN DRAWING ARE FOR GUIDANCE ONLY. HOWEVER, INSTALLATION PROCEDURE, DESIGN DRAWING ETC SHALL BE DONE AS PER APPROVAL OF OWNER/CONSULTANT.
5. THIS DRAWING SHALL BE READ IN CONJUNCTION WITH THE TENDER SPECIFICATION OF PERMANENT CATHODIC PROTECTION SYSTEM.

**BILL OF MATERIAL**

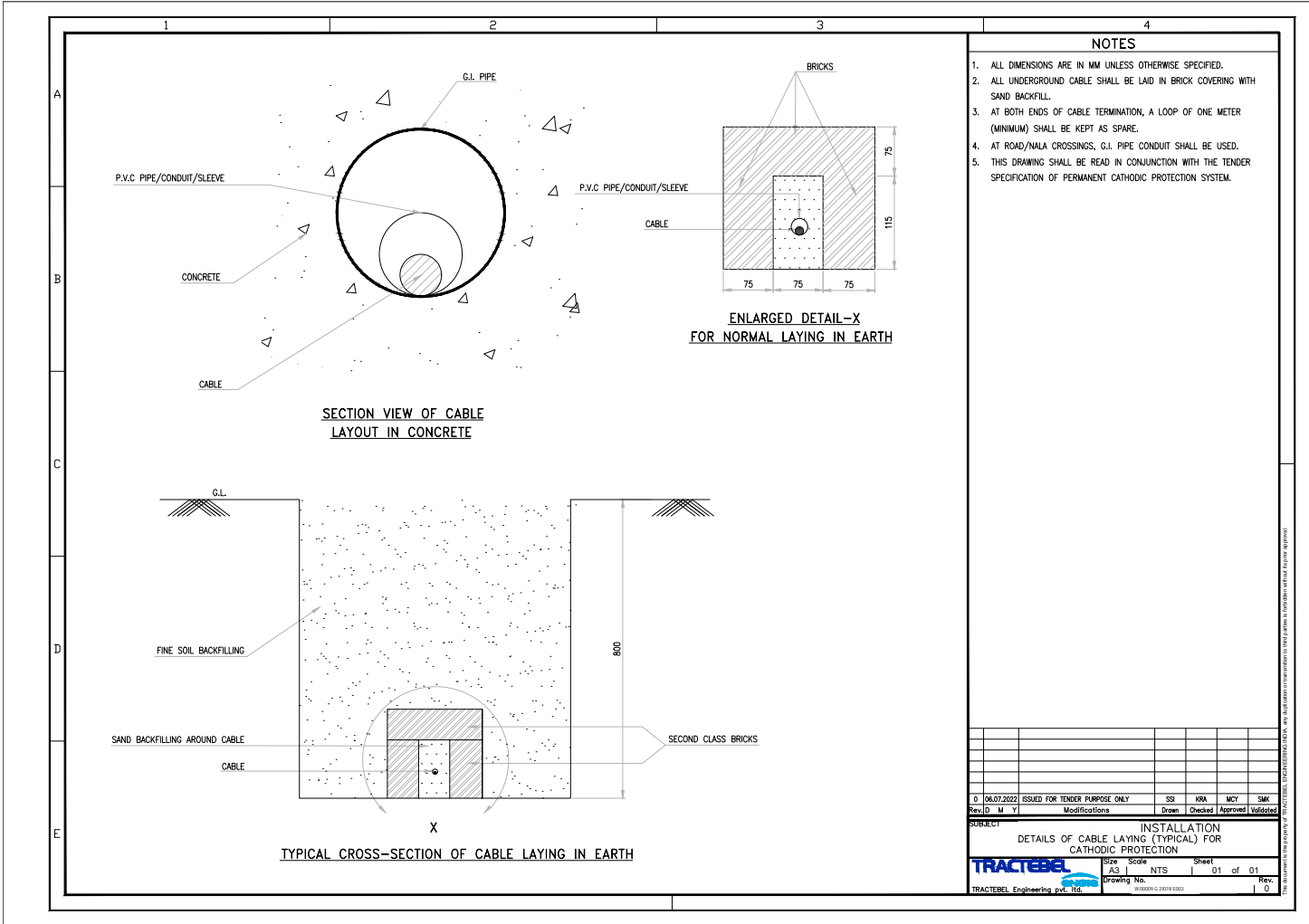
SL. NO.	DESCRIPTION	QTY.
1.	P.V.C PIPE 3 MM THICK	1 No.
2.	SAG WOOD PLUG	1 No.
3.	CUSO <sub>4</sub> CRYSTALS	AS REOD.
4.	ELECTROLYTIC COPPER SPIRAL # 8 MM	1 No.
5.	CUSO <sub>4</sub> SATURATED SOLUTION	AS REOD.
6.	BRAZED COPPER JOINT	1 No.
7.	WATER FILLING BOLTED HOLES # 8 MM	2 Nos.
8.	HYLAM BUSH	1 No.
9.	COPPER LUG	1 No.
10.	BOLTED CABLE CONNECTION	1 No.
11.	CONNECTION CABLE 6 MM <sup>2</sup>	AS REOD.
12.	EPOXY FOR SEALING	AS REOD.

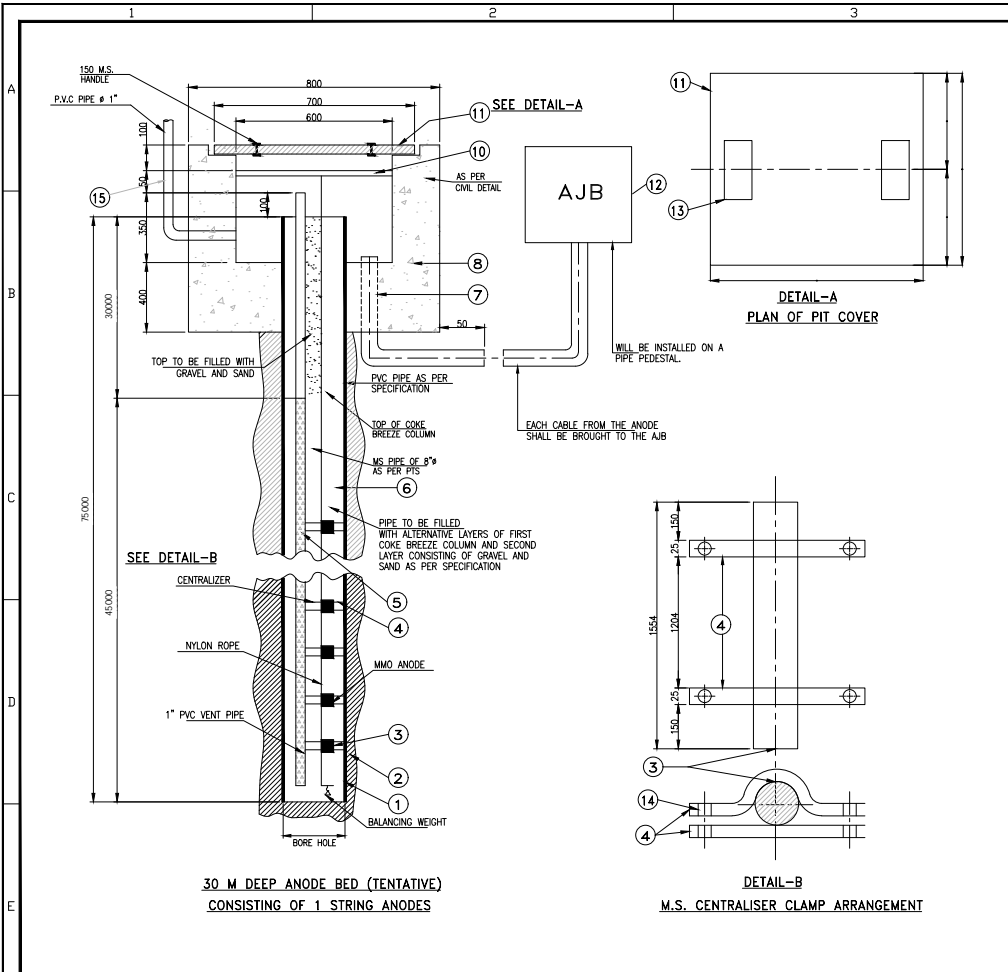
**ARRANGEMENT OF TWO REFERENCE ELECTRODES ON PIPE LINE TYPICAL (INSTALLATION DETAILS)**

0	06.07.2022	ISSUED FOR TENDER PURPOSE ONLY	SSI	KRM	MCY	SMK		
Rev.	D	M	Y	Modifications	Drawn	Checked	Approved	Issue

FABRICATION AND INSTALLATION  
 DETAILS OF CU/CUSO4  
 REFERENCE ELECTRODE

**TRACTEBEL** Size Scale Sheet  
 L A S | N T S | 01 of 01  
 Drawing No. | Rev. | 0  
 TRACTEBEL Engineering pvt. Ltd. | 18/00009 | 2019-0302





**NOTES**

1. ALL DIMENSIONS ARE IN MM UNLESS OTHERWISE SPECIFIED.
2. THE MMO ANODE STRING SHALL BE DUAL FEED TYPE.
3. ALL WORK SHALL BE CARRIED OUT BY EXPERIENCED AND QUALIFIED PERSONNEL WITH APPROVED DESIGN AND DRAWING FROM OWNER/CONSULTANT.

**BILL OF MATERIAL**

SL. NO.	DESCRIPTION	QTY.
1.	PVC CASING PIPE OF 12" DIA.	15 Mtrs.
2.	COKE BREEZE	AS REQD.
3.	ANODE SIZE IS 2.5 MM X 1000 MM, OUTPUT OF 8 Amp.	1 STRING MMO
4.	M.S. CENTRALISER	10 Nos.
5.	P.V.C PERFORATED VENT PIPE 1" #	AS REQD.
6.	CABLE LEADS	AS REQD.
7.	P.V.C PIPE 100 MM #	AS REQD.
8.	CONCRETE WORK FOR TOP OF ANODE BED	AS REQD.
9.	DELETED	
10.	G.I. PIPE 2" # FOR SUPPORTING CABLE	1 No.
11.	M.S. PLATE TOP COVER	1 No.
12.	ANODE LEAD JUNCTION BOX	1 No.
13.	M.S. LIFTING HANDLES	2 Nos.
14.	M.S. NUT & BOLT	AS REQD.
15.	P.V.C PIPE 4" #	AS REQD.

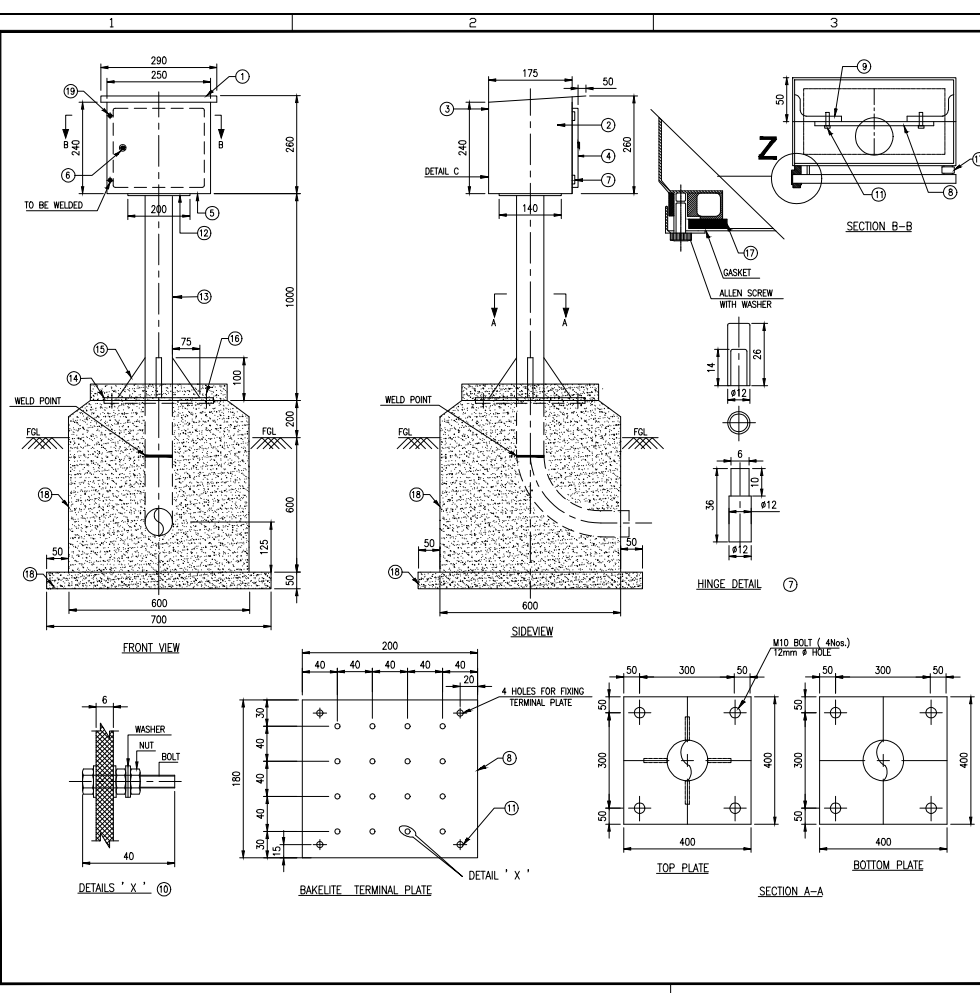
0	06.07.2022	ISSUED FOR TENDER PURPOSE ONLY	SSI	RBA	MCY	SMK
Rev. ID	M	Y	Modifications	Drawn	Checked	Approved

PROJEC11

**INSTALLATION**  
DETAILS OF DEEP ANODE GROUND BED

**TRACTEBEL** Size Scale Sheet  
AS NTS 01 of 01  
Drawing No. Rev. 0

TRACTEBEL Engineering pvt. Ltd. 30-00009-0-2022-0004



- NOTES**
1. ALL DIMENSION ARE IN MM UNLESS OTHERWISE SPECIFIED.
  2. ANODIZED ALUMINUM NAME PLATE SIZE 120 X 120 X 1MM THK. SHALL BE FIXED INNER SIDE OF DOOR.
  3. THE DOOR SHALL BE HINGED TYPE AND SEALED WITH GASKET.
  4. THE DOOR SHALL BE LOCKED WITH LOCK-KEY ( FLASH TYPE )
  5. SURFACE PREPARATION: GRIT/SHOT BLASTED TO SA2 1/2 AS PER SWEDISH STANDARD SIS 055900 PRIMER APPLICATION: ETOH PRIMER WITH 10% DFT BASED PRIMER APPLICATION: ETOH PRIMER WITH 10% DFT BASED ON POLYVINYL BUTYRAL RESIN + 1 COAT OF EPOXY ZINC PHOSPHATE PRIMER @40g DFT/COAT PAINT APPLICATION: 1 COAT OF 2 PACK HIGH EPOXY WITH POLYAMINE HARDNER CURE @100g DFT/COAT FOLLOWED BY 1 TOP COAT OF ACRYLIC POLYURETHANE FINISH PAINT @40g DFT/COAT. COLOUR OF TOP COAT SHALL BE SHADE 431 OF IS ( LIGHTGREY)
  6. SPARE CABLE ENTRY SHALL BE SEALED WITH SEALING COMPOUND AFTER INSTALLATION TO PREVENT WATER ENTRY.
  7. THE HEIGHT OF THE TEST STATION SUPPORT SHALL BE INCREASED SUITABLY WHERE FLOOD LEVEL IS MORE THAN 1 MTR.
  8. THIS DRAWING SHALL BE READ IN CONJUNCTION WITH THE TENDER SPECIFICATION OF PERMANENT CATHODIC PROTECTION SYSTEM.

**BILL OF MATERIAL**

ITEM NO.	DESCRIPTION	QTY.
1	TOP PLATE 290 x 225 x 3 mm THK. M.S.	1
2	SIDE PLATE 175 x 240 x 3 mm THK. M.S.	2
3	REAR PLATE 240 x 250 x 3 mm THK. M.S.	1
4	FRONT DOOR 3 mm THK. M.S.	1
5	BOTTOM PLATE 250 x 175 x 3 mm THK. M.S.	1
6	CENTRE LOCK ( FLUSH TYPE)	1
7	HINGE FOR DOOR	2
8	BAKELITE TERMINAL PLATE 200x 180 x 6 mm THK.	1
9	M.S. ANGLE FOR FIXING TERMINAL PLATE 40x40x3 THK 20 mm LONG	4
10	BRASS NICKEL PLATED BOLT M 6 DIA X 40 mm LONG WITH 2 Nos. NUT & 4 Nos. WASHER WITH EACH TERMINAL	16 SET
11	CROSS HEAD SCREW FOR FIXING TERMINAL PLATE M 6 DIA 20 mm LONG	4
12	M.S. COUPLING PLATE TOP 200 x 140 x 5 THK.	1
13	4"φ HOT DEEP GALVANIZED PIPE ALONG WITH BEND 4.5 MM THK.	1 SET
14	M.S. FOUNDATION PLATE 400 x 400 x 5 mm THK.	1SET
15	M.S. STIFFENER PLATE 6 mm THK.	4
16	M.S. ELEC GALVA BOLT M 12 DIA x 50 mm LONG	4
17	RUBBER GASKET	1
18	PCC (M-15) FOUNDATION	1M <sup>3</sup> .
19	MR ALLEN BOLT	2

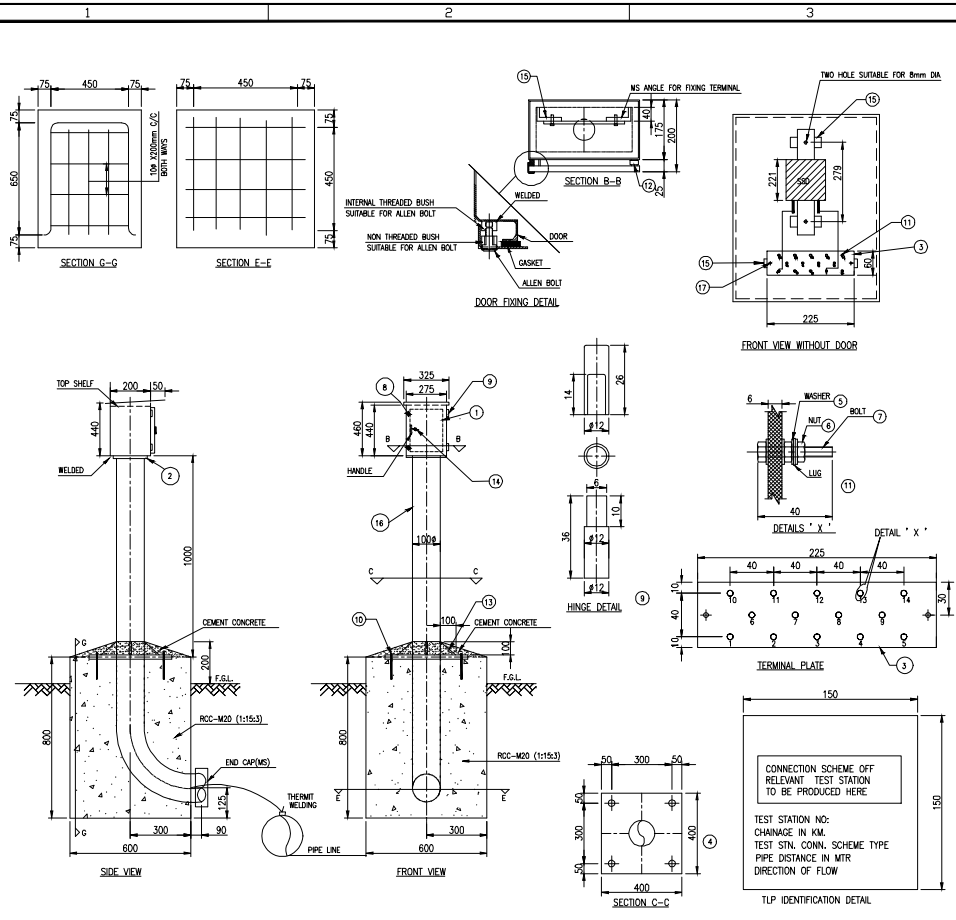
REV.	DATE	BY	CHKD.	APP.

**FABRICATION AND INSTALLATION DETAILS OF TEST STATION BOX**

06.07.2022 ISSUED FOR TENDER PURPOSE ONLY

Size Scale: 1:AS | NTS | Sheet 01 of 01  
 Drawing No. | Rev. 0  
 TRACTEBEL Engineering pvt. Ltd. | 19/00001-0-2018-0006





- NOTES**
1. ALL DIMENSIONS ARE IN MM UNLESS OTHERWISE SPECIFIED.
  2. EACH CABLE COMING TO THE TEST STATION IS TO BE LABELED ON BOTH ENDS WITH NOTIFICATION NUMBER AS PER CONNECTION SCHEME USING PVC FERRULES.
  3. NAME PLATE TO BE FIXED IN INNER SIDE OF THE SHUTTER (150X150X1.5mm)
  4. THE NUMBER OF ALL TEST STATION SHALL BE WRITTEN WITH BLACK PAINT USING 100MM STENCILS ON THE OUTER SIDE OF THE FRONT SHUTTER IN UNIFORM MANNER.
  5. THE TERMINAL PLATE TO BE SCREW PASTED WITH MS ANGLES HAVING INTERNAL THREADS.
  6. THE SHUTTER SHALL BE HINGED TYPED WITH CONCEALED LOCK AND IT SHALL HAVE DOOR GASKET TO MAKE TEST STATION WEATHER PROOF (IP55) TYPE.
  7. THE OUTER SURFACE OF TEST STATION WITH BOND SHALL BE PAINTED WITH TWO COATS OF ZINC RICH EPOXY PRIMER AND 3 COATS OF LIGHT GREY PAINT OR POWDER COATED.
  8. THE INNER SURFACE OF TEST STATION SHALL BE PAINTED WITH LIGHT GRAY PAINT.
  9. HANDLE 25x25x3mm THICK MS.
  10. CONCRETE FOUNDATION M20 GRADE.
  11. A SHELF FOR KEEPING PSP CHART TO BE PROVIDED INSIDE TLP AS PER CL. S.3.8.6 OF TECHNICAL SPECIFICATION.
  12. SIZE OF BOX SHOULD BE SUITABLE FOR MOUNTING OF POLARIZATION CELL.

**BILL OF MATERIAL**

ITEM NO.	DESCRIPTION	QTY.
3	TERMINAL PLATE (GASKETS) 225X225X1.5mm.	1 Nos.
4	FOUNDATION PLATE 400X400X15mm.	1 No.
5	BRASS WASHER 6mm FOR ONE TERMINAL.	AS REQD.
6	BRASS NUT 6mm FOR ONE TERMINAL.	AS REQD.
7	BRASS BOLT 6mm FOR ONE TERMINAL 50 mm LONG.	AS REQD.
8	DOOR LOCK USING ALLEN BOLT (SUITABLE FOR & HEAVY ALLEN BOLT SHOULD BE NON REMOVABLE FROM DOOR OF TLP).	2 Nos.
9	HINGE FOR DOOR SIZE 125 X52 mm.	2 Nos.
10	MS ELECTRO GALVANISED ANCHOR BOLT M10 DIA X 150 MM LONG.	4 SETS
11	BRASS BOLT M 6 DIA X 40 mm LONG WITH 2 Nos. NUT & 4 Nos. WASHER WITH EACH TERMINAL.	14 SETS
12	NEOPRENE (FOR MS) & BALANCE RUBBER 30 X6 mm THICK RECTANGULAR CROSS SECTION GASKET.	AS REQD.
13	FOUNDATION PLATE SUPPORT 5MM THK.	4 NOS.
14	MS/AL CONCEALED LOCK WITH MASTER KEY & SLIDING COVER ON THE KEY HOLE	1 NO.
15	MS ANGLE FOR FIXING TERMINAL PLATE 50 X 50 X 5MM	4 NOS.
16	100 MM DIA. 4.2 mm THICK MS PIPE WITH BOND	1 NO.
17	CROSS HEAD SCREW FOR FIXING TERMINAL PLATE (M 6 DIA 20 mm LONG)	2 NOS.

CONNECTION SCHEME OFF RELEVANT TEST STATION TO BE PRODUCED HERE

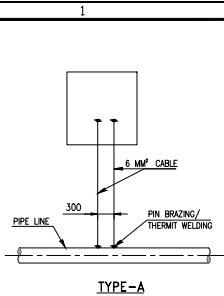
TEST STATION NO:  
CHANNEL IN KM  
TEST STN. CONN. SCHEME TYPE  
PIPE DISTANCE IN MTR  
DIRECTION OF FLOW

TLP IDENTIFICATION DETAIL

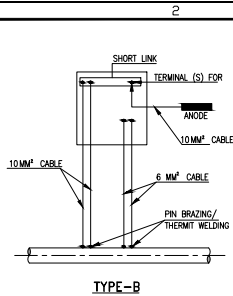
0	06.07.2022	ISSUED FOR TENDER PURPOSE ONLY	SSI	HRA	MCT	SMK
Rev:	0	Modifications:	Drawn	Checked	Approved	Substanced

**TRACTEBEL** CONSTRUCTION & INSTALLATION DETAILS OF TEST STATION BOX FOR HIGH TENSION LINE

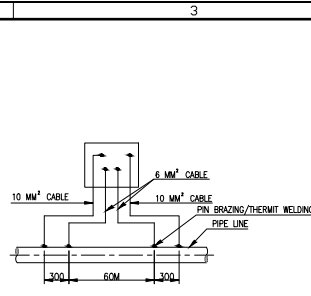
TRACTEBEL Engineering pvt. ltd. Size Scale Sheet: AS NTS 01 of 01. Drawing No. 18-000004-2-0018-0004 Rev. 0



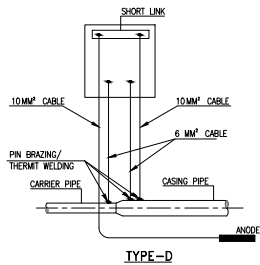
TYPE-A



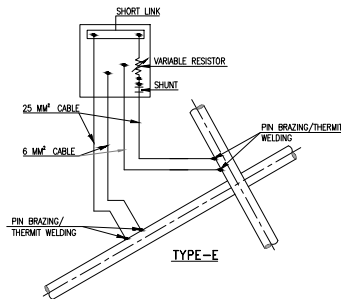
TYPE-B



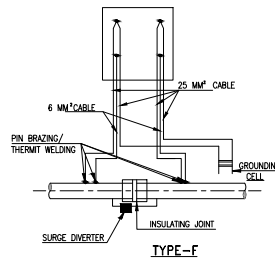
TYPE-A+1



TYPE-D



TYPE-E



TYPE-F

**DETAILS OF CONNECTION SCHEME**

- TYPE A : PSP MONITORING ONLY.
- TYPE A+1 : LINE CURRENT MEASUREMENT.
- TYPE B : ANODE TO PIPE CONNECTION.
- TYPE E : PIPE LINE CROSSING.
- TYPE D : CASSED CROSSING.
- TYPE F : ISOLATION JOINT CONNECTION.
- TYPE H : HIGH TENSION LINE CONNECTION.
- TYPE DMV : MOV LOCATION.

**NOTES**

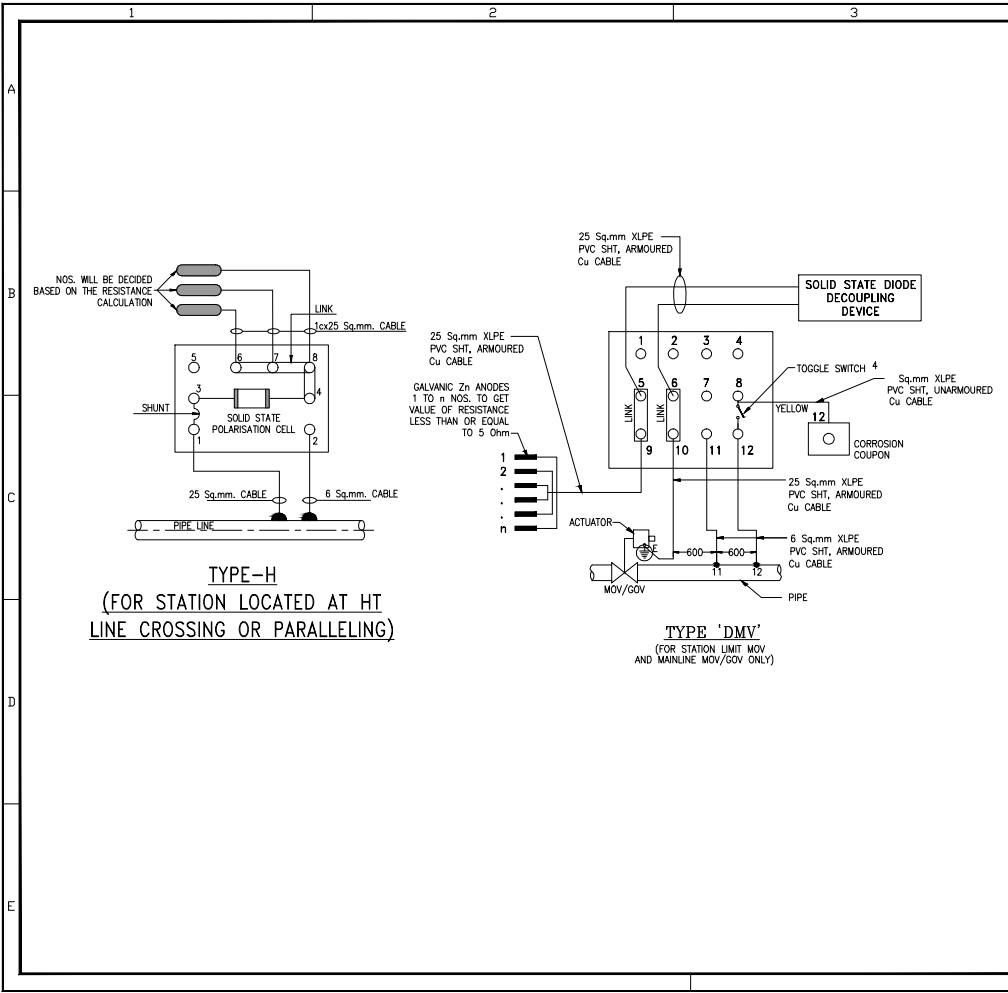
1. ALL DIMENSION ARE IN MM UNLESS OTHERWISE SPECIFIED.
2. THIS DRAWING SHALL BE READ ALONG WITH THE DRAWING FOR FABRICATION & INSTALLATION DETAILS OF TEST STATION.
3. CABLE LENGTH SHALL BE KEPT SUFFICIENT AS SLACK FOR EACH CABLE, ATLEAST 1.0M SHALL BE PROVIDED AT BOTH PIPE AND ITS TERMINAL BOX ENDS.
4. TEST STATION TERMINAL NOS. FOR RESPECTIVE CABLES SHALL BE PROVIDED AT BOTH ENDS USING PLASTIC SLEEVE CABLE TAG (FERRULES)
5. IF MORE THAN ONE CABLE ARE TERMINATED AT ONE TERMINAL, THEN DIFFERENT COLOUR CODES SHALL BE USED FOR EACH CABLE.
6. ALL CABLES TO PIPE JOINTS SHALL BE PIN BRAZING/THERMIT WELDING AS APPROVED BY OWNER.
7. ALL CORROSION COUPON CABLE SHALL BE MARKED BY WHITE TAPE NEAR THE TERMINATION.
8. SUPPLY AND INSTALLATION OF GROUNDING CELL, SURGE DIVERTER, SOLID STATE DIODE DECOUPLING DEVICE SHALL BE DONE BY PERMANENT CATHODIC PROTECTION CONTRACTOR.
9. CORROSION COUPONS TO BE INSTALLED AT SPECIFIED LOCATION AS PER SCOPE OF WORK/ ENGINEERING DESIGN BASIS.
10. CABLES FROM SURGE DIVERTER SHALL BE CONNECTED THROUGH BOLTED CONNECTION AS PER APPROVAL OF EC.
11. GROUNDING CELLS SHALL BE INSTALLED AT PIPE DEPTH BUT IN CASE OF HIGH RESISTIVITY SOILS SPECIAL CARE OF THEIR ENVIRONMENTS SHALL BE TAKEN. GROUNDING RESISTANCE SHOULD LESS THAN OR EQUAL TO 5 Ohms.

0	06.07.2022	ISSUED FOR TENDER PURPOSE ONLY	SSI	KRA	MCY	SMK
Rev. D	M	Y	Modifications	Drawn	Checked	Approved

TRACTEBEL TEST STATION CONNECTION SCHEME TYPICAL DETAILS

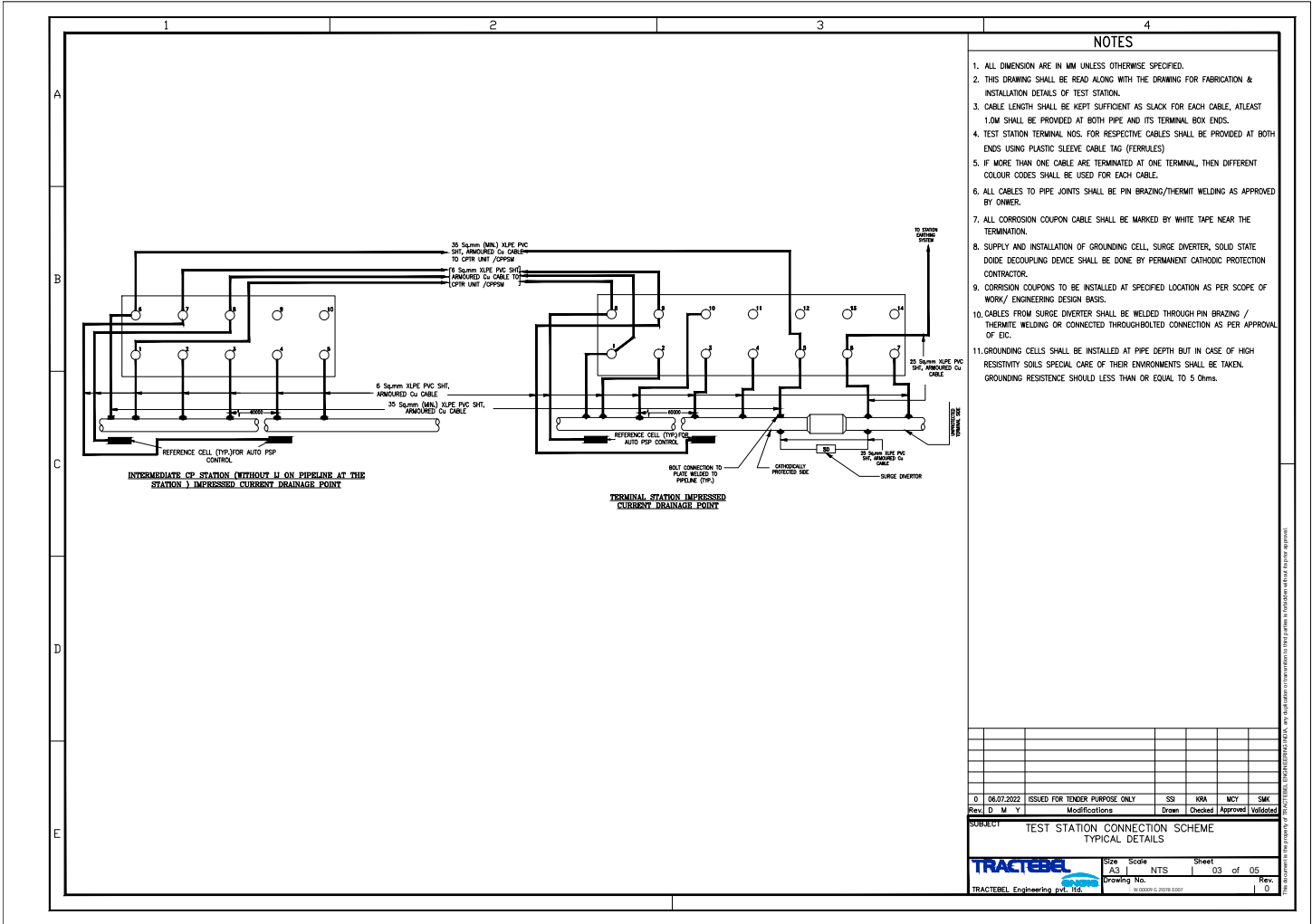
Size Scale Drawing No. Sheet 01 of 05  
 TRACTEBEL Engineering pvt. Ltd. [ 30.000000-2.000000 ] Rev. 0

This document is the property of TRACTEBEL ENGINEERING PVT. LTD. and shall not be used or reproduced in any form without the written permission of TRACTEBEL ENGINEERING PVT. LTD.



- NOTES**
1. ALL DIMENSION ARE IN MM UNLESS OTHERWISE SPECIFIED.
  2. THIS DRAWING SHALL BE READ ALONG WITH THE DRAWING FOR FABRICATION & INSTALLATION DETAILS OF TEST STATION.
  3. CABLE LENGTH SHALL BE KEPT SUFFICIENT AS SLACK FOR EACH CABLE, ATLEAST 1.0M SHALL BE PROVIDED AT BOTH PIPE AND ITS TERMINAL BOX ENDS.
  4. TEST STATION TERMINAL NOS. FOR RESPECTIVE CABLES SHALL BE PROVIDED AT BOTH ENDS USING PLASTIC SLEEVE CABLE TAG (FERRULES)
  5. IF MORE THAN ONE CABLE ARE TERMINATED AT ONE TERMINAL, THEN DIFFERENT COLOUR CODES SHALL BE USED FOR EACH CABLE.
  6. ALL CABLES TO PIPE JOINTS SHALL BE PIN BRAZING/THERMIT WELDING AS APPROVED BY OWNER.
  7. ALL CORROSION COUPON CABLE SHALL BE MARKED BY WHITE TAPE NEAR THE TERMINATION.
  8. SUPPLY AND INSTALLATION OF GROUNDING CELL, SURGE DIVERTER, SOLID STATE DIODE DECOUPLING DEVICE SHALL BE DONE BY PERMANENT CATHODIC PROTECTION CONTRACTOR.
  9. CORROSION COUPONS TO BE INSTALLED AT SPECIFIED LOCATION AS PER SCOPE OF WORK/ENGINEERING DESIGN BASIS.
  10. CABLES FROM SURGE DIVERTER SHALL BE CONNECTED THROUGH BOLTED CONNECTION AS PER APPROVAL OF EIC.
  11. GROUNDING CELLS SHALL BE INSTALLED AT PIPE DEPTH BUT IN CASE OF HIGH RESISTIVITY SOILS SPECIAL CARE OF THEIR ENVIRONMENTS SHALL BE TAKEN. GROUNDING RESISTANCE SHOULD LESS THAN OR EQUAL TO 5 Ohm.

0	06.07.2022	ISSUED FOR TENDER PURPOSE ONLY	SSI	KRA	MCY	SMK
Rev. D	12	Y	Modifications:	Drawn	Checked	Approved
<b>TRACTEBEL</b>						
TEST STATION CONNECTION SCHEME TYPICAL DETAILS						
Size Scale		Sheet				
AS		NTS		02 of 05		
Drawing No.				Rev.		
TRACTEBEL Engineering pvt. Ltd.				0		



**NOTES**

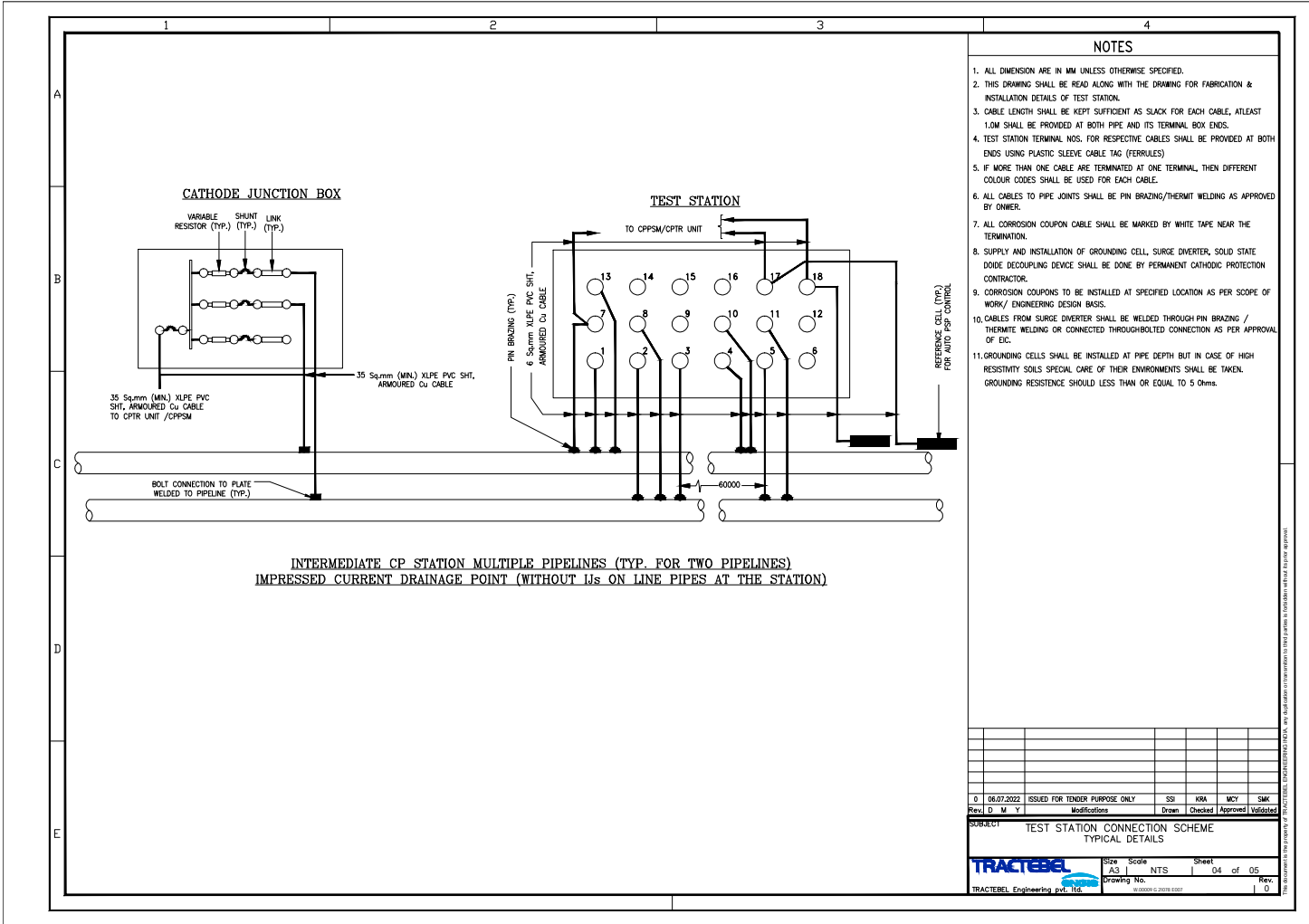
1. ALL DIMENSION ARE IN MM UNLESS OTHERWISE SPECIFIED.
2. THIS DRAWING SHALL BE READ ALONG WITH THE DRAWING FOR FABRICATION & INSTALLATION DETAILS OF TEST STATION.
3. CABLE LENGTH SHALL BE KEPT SUFFICIENT AS SLACK FOR EACH CABLE, ATLEAST 1.0M SHALL BE PROVIDED AT BOTH PIPE AND ITS TERMINAL BOX ENDS.
4. TEST STATION TERMINAL NOS. FOR RESPECTIVE CABLES SHALL BE PROVIDED AT BOTH ENDS USING PLASTIC SLEEVE CABLE TAG (FERRULES)
5. IF MORE THAN ONE CABLE ARE TERMINATED AT ONE TERMINAL, THEN DIFFERENT COLOUR CODES SHALL BE USED FOR EACH CABLE.
6. ALL CABLES TO PIPE JOINTS SHALL BE PIN BRAZING/THERMIT WELDING AS APPROVED BY OWNER.
7. ALL CORROSION COUPON CABLE SHALL BE MARKED BY WHITE TAPE NEAR THE TERMINATION.
8. SUPPLY AND INSTALLATION OF GROUNDING CELL, SURGE DIVERTER, SOLID STATE DIODE DECOUPLING DEVICE SHALL BE DONE BY PERMANENT CATHODIC PROTECTION CONTRACTOR.
9. CORROSION COUPONS TO BE INSTALLED AT SPECIFIED LOCATION AS PER SCOPE OF WORK/ ENGINEERING DESIGN BASIS.
10. CABLES FROM SURGE DIVERTER SHALL BE WELDED THROUGH PIN BRAZING / THERMITE WELDING OR CONNECTED THROUGH BOLTED CONNECTION AS PER APPROVAL OF EIC.
11. GROUNDING CELLS SHALL BE INSTALLED AT PIPE DEPTH BUT IN CASE OF HIGH RESISTIVITY SOILS SPECIAL CARE OF THEIR ENVIRONMENTS SHALL BE TAKEN. GROUNDING RESISTANCE SHOULD LESS THAN OR EQUAL TO 5 Ohms.

0	06.07.2022	ISSUED FOR TENDER PURPOSE ONLY	SSI	HRB	MCY	SMK
Rev. D	M	Y	Modifications	Drawn	Checked	Approved

TRACTEBEL Engineering pvt. Ltd. Sheet 03 of 05

Size: A3 Scope: NTS Drawing No. Rev. 0

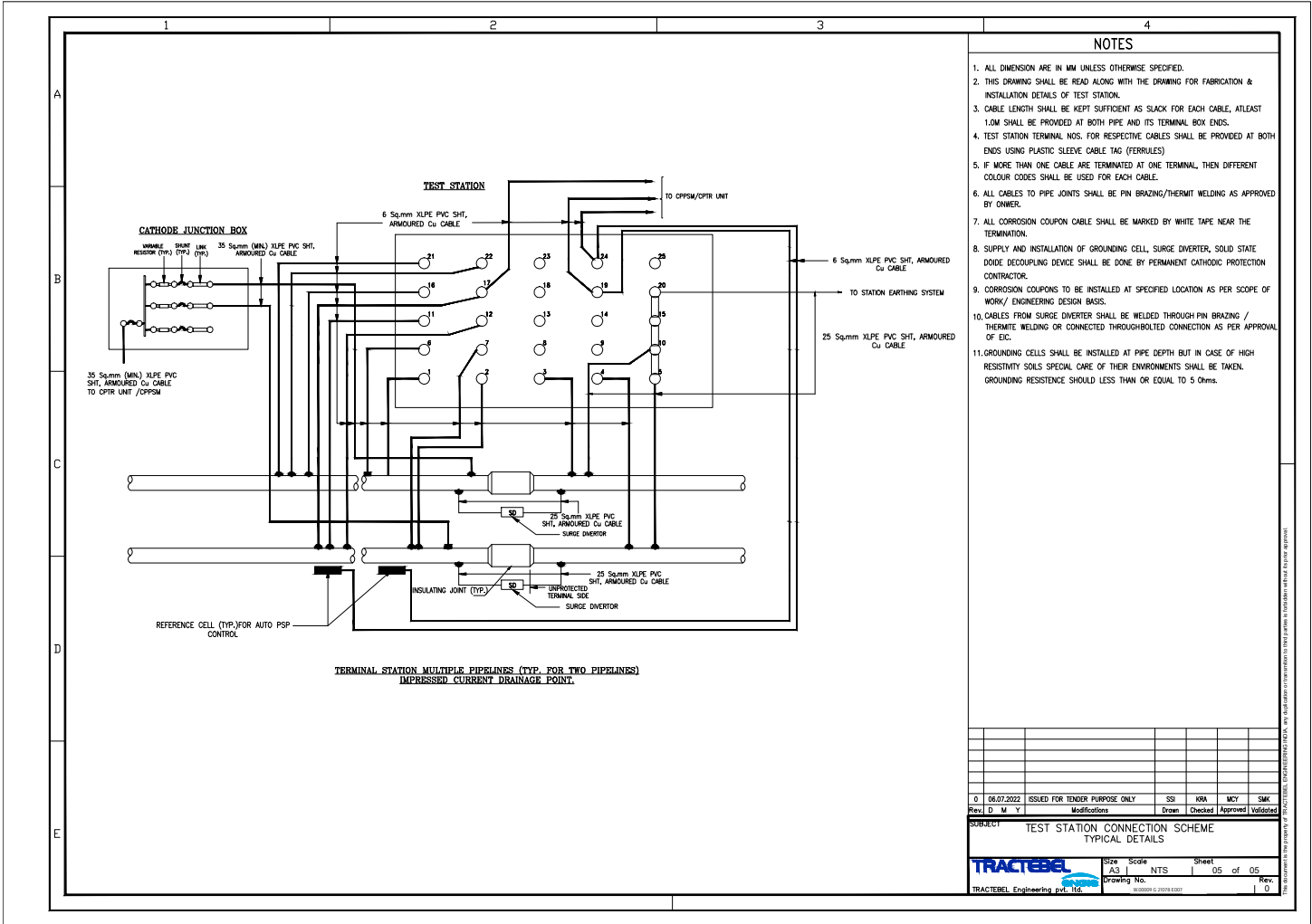
TRACTEBEL Engineering pvt. Ltd. 18-00009-0-2019-0001



**NOTES**

1. ALL DIMENSION ARE IN MM UNLESS OTHERWISE SPECIFIED.
2. THIS DRAWING SHALL BE READ ALONG WITH THE DRAWING FOR FABRICATION & INSTALLATION DETAILS OF TEST STATION.
3. CABLE LENGTH SHALL BE KEPT SUFFICIENT AS SLACK FOR EACH CABLE, ATLEAST 1.0M SHALL BE PROVIDED AT BOTH PIPE AND ITS TERMINAL BOX ENDS.
4. TEST STATION TERMINAL NOS. FOR RESPECTIVE CABLES SHALL BE PROVIDED AT BOTH ENDS USING PLASTIC SLEEVE CABLE TAG (FERRULES)
5. IF MORE THAN ONE CABLE ARE TERMINATED AT ONE TERMINAL, THEN DIFFERENT COLOUR CODES SHALL BE USED FOR EACH CABLE.
6. ALL CABLES TO PIPE JOINTS SHALL BE PIN BRAZING/THERMIT WELDING AS APPROVED BY OWNER.
7. ALL CORROSION COUPON CABLE SHALL BE MARKED BY WHITE TAPE NEAR THE TERMINATION.
8. SUPPLY AND INSTALLATION OF GROUNDING CELL, SURGE DIVERTER, SOLID STATE DIODE DECOUPLING DEVICE SHALL BE DONE BY PERMANENT CATHODIC PROTECTION CONTRACTOR.
9. CORROSION COUPONS TO BE INSTALLED AT SPECIFIED LOCATION AS PER SCOPE OF WORK/ ENGINEERING DESIGN BASIS.
10. CABLES FROM SURGE DIVERTER SHALL BE WELDED THROUGH PIN BRAZING / THERMIT WELDING OR CONNECTED THROUGH BOLTED CONNECTION AS PER APPROVAL OF EIC.
11. GROUNDING CELLS SHALL BE INSTALLED AT PIPE DEPTH BUT IN CASE OF HIGH RESISTIVITY SOILS SPECIAL CARE OF THEIR ENVIRONMENTS SHALL BE TAKEN. GROUNDING RESISTANCE SHOULD LESS THAN OR EQUAL TO 5 Ohms.

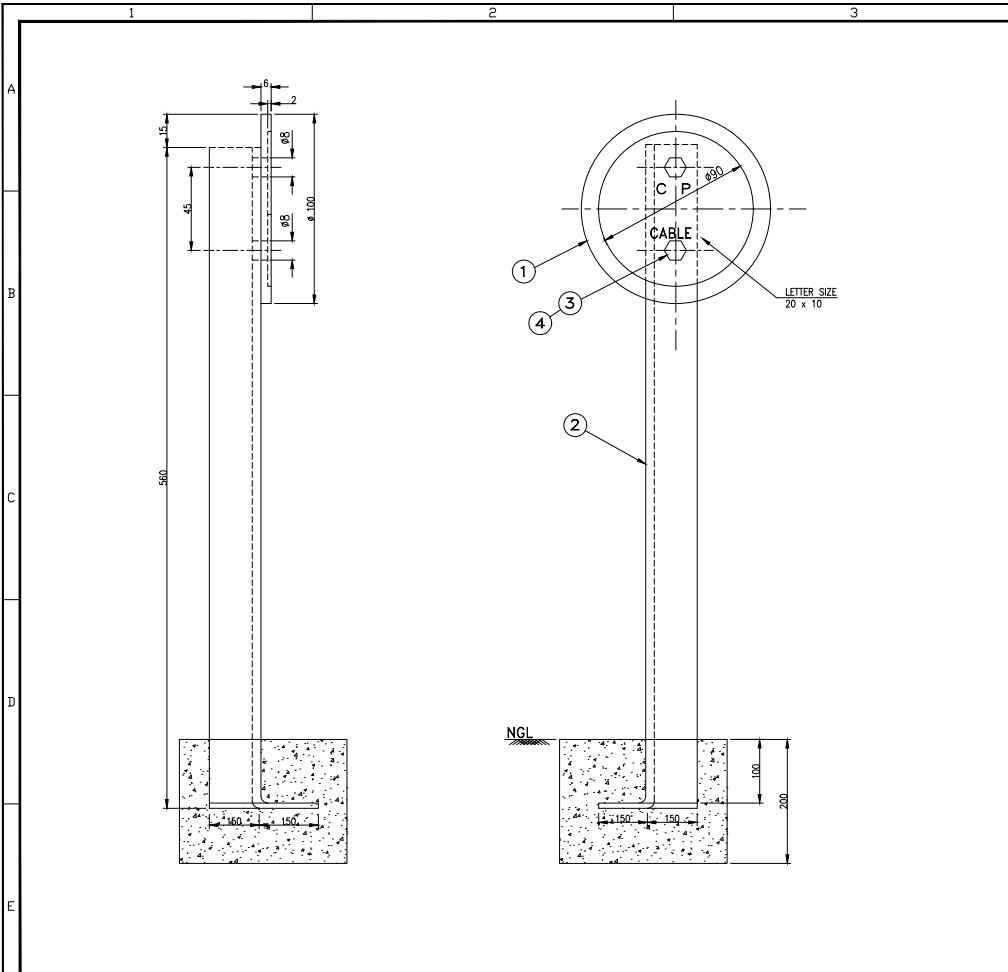
0	06.07.2022	ISSUED FOR TENDER PURPOSE ONLY	SSI	KRA	MCY	SMK
Rev. D	14	Y	Modification:	Drawn	Checked	Approved
<p>PROJECT: TEST STATION CONNECTION SCHEME TYPICAL DETAILS</p> <p><b>TRACTEBEL</b> Engineering pvt. ltd. Size Scale Sheet JAS   NTS   04 of 05 Drawing No. Rev.   0</p> <p>TRACTEBEL Engineering pvt. ltd. 30/00004-0-2019-0001</p>						



**NOTES**

1. ALL DIMENSION ARE IN MM UNLESS OTHERWISE SPECIFIED.
2. THIS DRAWING SHALL BE READ ALONG WITH THE DRAWING FOR FABRICATION & INSTALLATION DETAILS OF TEST STATION.
3. CABLE LENGTH SHALL BE KEPT SUFFICIENT AS SLACK FOR EACH CABLE, ATLEAST 1.0M SHALL BE PROVIDED AT BOTH PIPE AND ITS TERMINAL BOX ENDS.
4. TEST STATION TERMINAL NOS. FOR RESPECTIVE CABLES SHALL BE PROVIDED AT BOTH ENDS USING PLASTIC SLEEVE CABLE TAG (FERRULES)
5. IF MORE THAN ONE CABLE ARE TERMINATED AT ONE TERMINAL THEN DIFFERENT COLOUR CODES SHALL BE USED FOR EACH CABLE.
6. ALL CABLES TO PIPE JOINTS SHALL BE PIN BRAZING/THERMIT WELDING AS APPROVED BY OWNER.
7. ALL CORROSION COUPON CABLE SHALL BE MARKED BY WHITE TAPE NEAR THE TERMINATION.
8. SUPPLY AND INSTALLATION OF GROUNDING CELL, SURGE DIVERTER, SOLID STATE DIODE DECOUPLING DEVICE SHALL BE DONE BY PERMANENT CATHODIC PROTECTION CONTRACTOR.
9. CORROSION COUPONS TO BE INSTALLED AT SPECIFIED LOCATION AS PER SCOPE OF WORK/ ENGINEERING DESIGN BASIS.
10. CABLES FROM SURGE DIVERTER SHALL BE WELDED THROUGH PIN BRAZING / THERMITE WELDING OR CONNECTED THROUGH BOLTED CONNECTION AS PER APPROVAL OF EIC.
11. GROUNDING CELLS SHALL BE INSTALLED AT PIPE DEPTH BUT IN CASE OF HIGH RESISTIVITY SOILS SPECIAL CARE OF THEIR ENVIRONMENTS SHALL BE TAKEN. GROUNDING RESISTANCE SHOULD LESS THAN OR EQUAL TO 5 Ohms.

0	06.07.2022	ISSUED FOR TENDER PURPOSE ONLY	SSI	NRA	MCY	SMK
Rev.	D	Y	Modification	Drawn	Checked	Approved
<p>PROJECT: TEST STATION CONNECTION SCHEME TYPICAL DETAILS</p> <p>Size: A3 Scope: NTS Sheet: 05 of 05 Drawing No. Rev. 0</p> <p>TRACTEBEL Engineering pvt. ltd. 30/00004-1-2019-0001</p>						



**NOTES**

- 1 ALL DIMENSIONS ARE IN MM UNLESS OTHERWISE SPECIFIED.
- 2 IN CASE OF POWER CABLE REPLACE "C.P." WITH "POWER".
- 3 THE CABLE MARKER SHALL BE PAINTED WITH APPROVED GRADE ALUMINUM PAINT.
- 4 ALL THE INSCRIPTION /LETTER/ ARROW PROJECTED TYPE AND PAINTED WITH POST OFFICE RED COLOUR ON M.S. PLATE.
- 5 BEFORE RIVETING, MARKER PLATE IS TO STENCILLED WITH NUMBER /LETTER PUNCH AS PER CABLE TRENCH SECTION NO. GIVEN IN LAYOUT DRAWING.

**BILL OF MATERIAL**

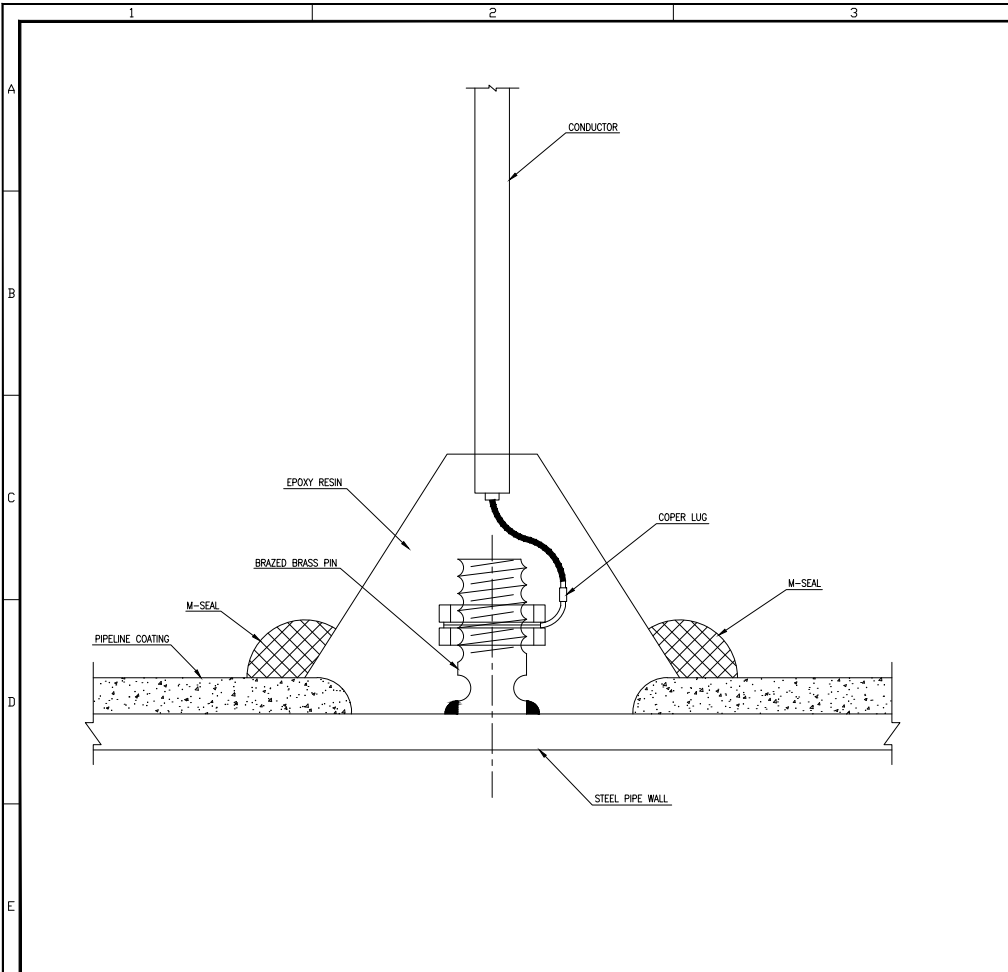
SL. NO.	DESCRIPTION	QTY.
1.	MARKER PLATE (CAST IRON)	1No.
2.	M.S. ANGLE 25x25x560 LONG	1No.
3.	BOLTS M6x20 LONG	2Nos.
4.	NUTS M6	2Nos.

0	06.07.2022	ISSUED FOR TENDER PURPOSE ONLY	SSI	KRA	MCY	SMK		
Rev:	0	M	Y	Modification:	Drawn	Checked	Approved	Validated

PROJECT: FABRICATION AND INSTALLATION  
DETAILS OF CABLE ROUTE MARKER

**TRACTEBEL** Size Scale Sheet  
LAS | NTS | 01 of 01  
Drawing No. Rev. | 0  
TRACTEBEL Engineering pvt. ltd. © 2020-21 2020 E008

This document is the property of TRACTEBEL ENGINEERING PVT. LTD. and shall not be used or reproduced in any form without the prior written approval.

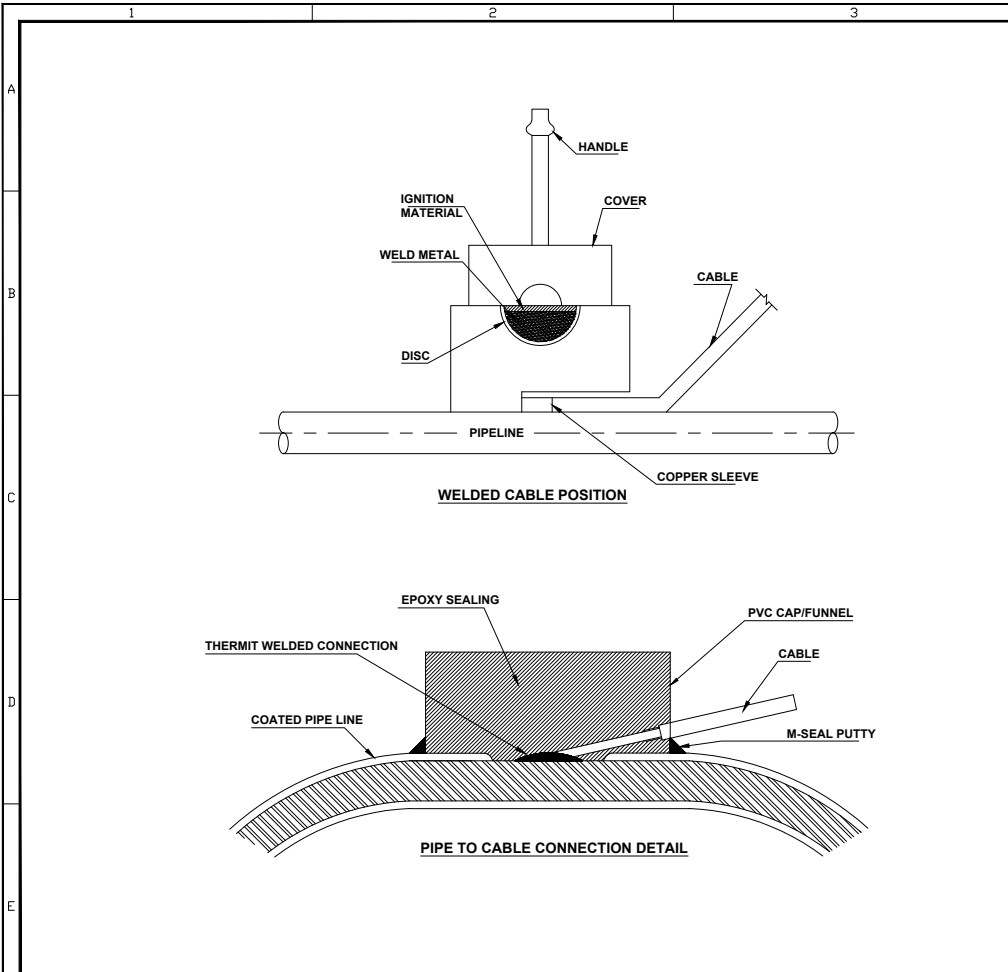


**NOTES**

1. ALL DIMENSIONS ARE IN MM UNLESS OTHERWISE SPECIFIED.
2. THE CABLE WILL BE FIXED TO THE PIPELINE AT AN ANGLE TO FACILITATE LAYING OF THE CABLE ALONG THE PIPELINE.
3. THE PIN BRAZING TO HAVE THE FOLLOWING CHARACTERISTICS:
  - (a) EXTREMELY LOW CONTACT RESISTANCE :  $\leq 0.1 \Omega$ .
  - (b) LOW TRANSITION RESISTANCE : 7.5 TO 14 M $\Omega$  PER BRAZED JOINT
  - (c) HIGH MECHANICAL STRENGTH : BINDING STRENGTH 490 N/MM<sup>2</sup>  
SHEAR STRENGTH 245 N/MM<sup>2</sup>
  - (d) BRAZING TEMPERATURE : 6500 C
  - (e) TIME PER BRAZE : 2 SECONDS
  - (f) WEATHER EFFECT : SUITABLE FOR ALL WEATHER OPERATION
  - (g) LIFE : 35 YEARS
  - (h) FIELD TEST : CABLE CONNECTION THROUGH PIN BRAZING TO BE FIELD TESTED FOR CONTACT RESISTANCE & TEMPERATURE ETC.

0	06.07.2022	ISSUED FOR TENDER PURPOSE ONLY	SSI	KRA	MCY	SMK		
Rev:	D	14	Y	Modification:	Drawn	Checked	Approved	Validated
PROJECT: CABLE TO PIPE CONNECTION BY PIN BRAZING								
		Size: A3 Scale: NTS Drawing No.:	Sheet: 01 of 01	Rev: 0				
TRACTEBEL Engineering pvt. Ltd. 9300004 0 2019 0009								





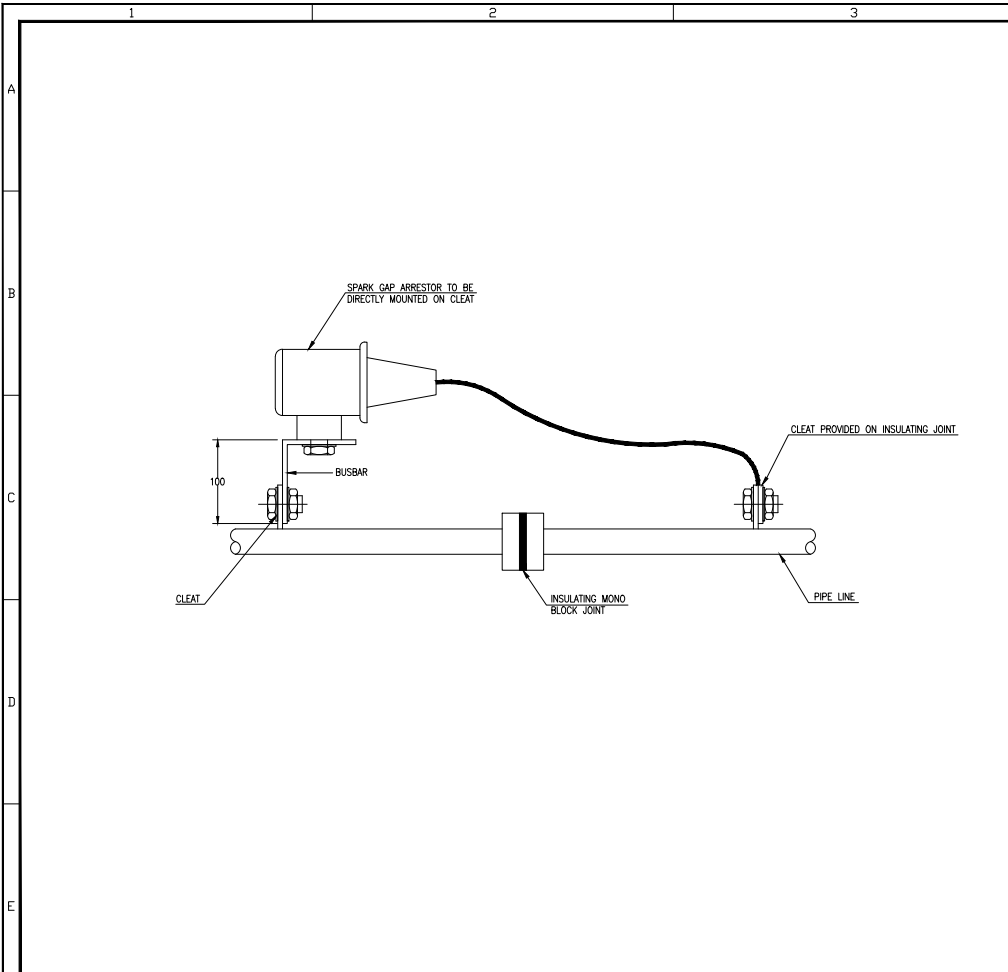
**NOTES**

1. ALL DIMENSIONS ARE IN MM UNLESS OTHERWISE SPECIFIED.
2. THE CABLE WILL BE FIXED TO THE PIPELINE AT AN ANGLE TO FACILITATE LAYING OF THE CABLE ALONG THE PIPELINE.
3. AT LOCATION OF THERMIT WELD CONNECTION REMOVE 50mm x 50mm SQUARE OF THE PIPELINE COATING. EXPOSED AREA OF PIPELINE SHALL BE FILLED TO BRIGHT METAL AND BE FREE OF RUST, PAINT, DIRT, GREASE AND MOISTURE.

0	06.07.2022	ISSUED FOR TENDER PURPOSE ONLY	SSI	HRA	MCY	SMK
Rev. D	14	Y	Modifications	Drawn	Checked	Approved

PROJECT: THERMIT WELDING DETAILS

Size Scale Sheet  
 A3 NTS 01 of 01  
 Drawing No. Rev. 0  
 TRACTEBEL Engineering pvt. Ltd. 30/06/2019 8:00



- NOTES**
1. ALL DIMENSIONS ARE IN MM UNLESS OTHERWISE SPECIFIED.
  2. THIS DRAWING FOR INFORMATION AND GUIDANCE PURPOSE ONLY.
  3. THE SPARK GAP INSULATOR TO BE PROVIDED WITH CABLES SUITABLE TO REACH THE PIPE CLEAT WITHOUT ANY JOINT.

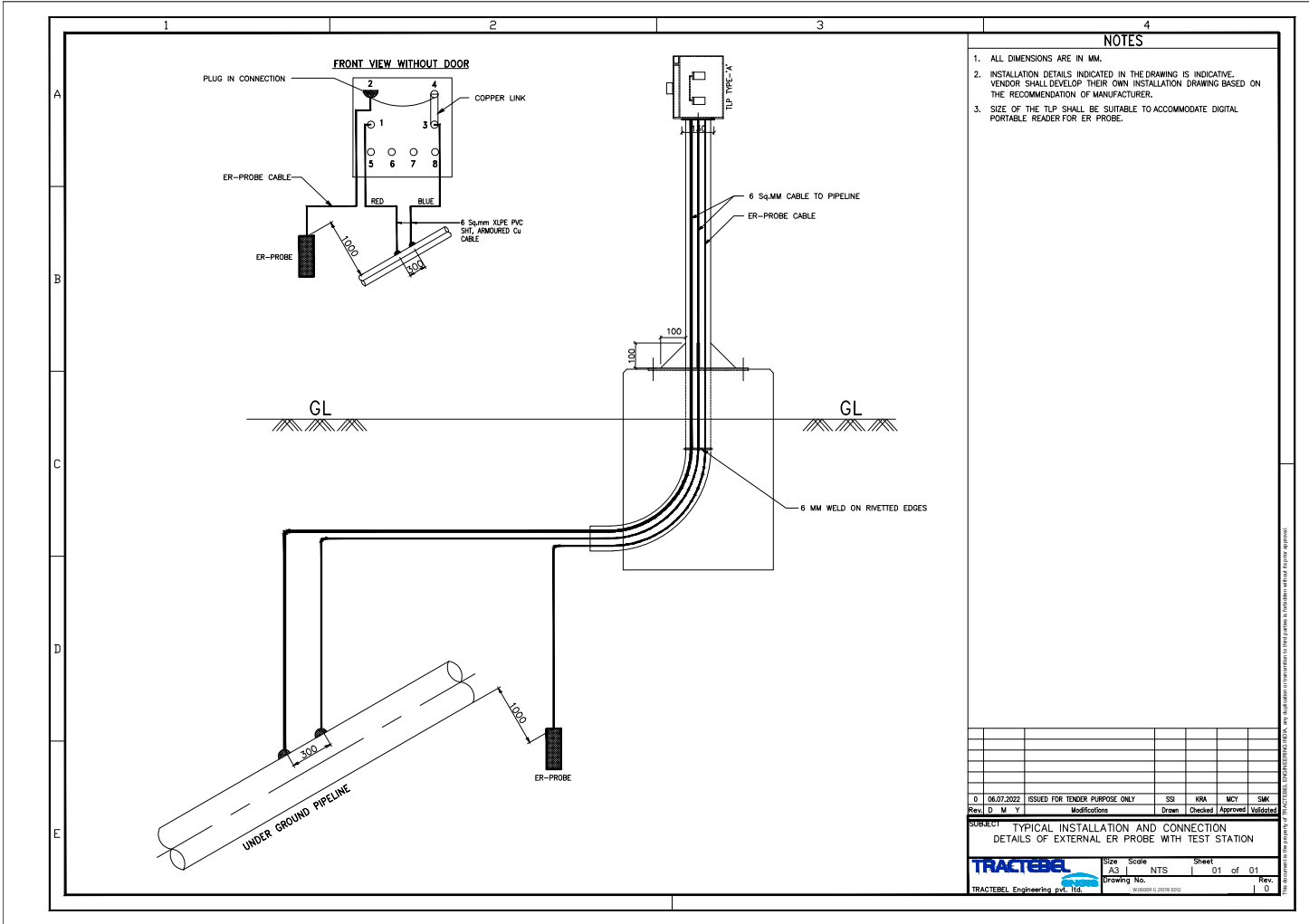
0	06.07.2022	ISSUED FOR TENDER PURPOSE ONLY	SSI	NBA	MCY	SMK
Rev. D	14	Y	Modifications	Drawn	Checked	Approved

SPARK GAP ARRESTOR INSTALLATION

Size	Scale	Sheet
A3	NTS	01 of 01
Drawing No.		Rev.
		0

TRACTEBEL Engineering pvt. Ltd. 30/00004-0-2019-001

This document is the property of TRACTEBEL ENGINEERING PVT. LTD. and shall not be used or copied in any manner without written permission.



- NOTES**
1. ALL DIMENSIONS ARE IN MM.
  2. INSTALLATION DETAILS INDICATED IN THE DRAWING IS INDICATIVE. VENDOR SHALL DEVELOP THEIR OWN INSTALLATION DRAWING BASED ON THE RECOMMENDATION OF MANUFACTURER.
  3. SIZE OF THE TLP SHALL BE SUITABLE TO ACCOMMODATE DIGITAL PORTABLE READER FOR ER PROBE.

Rev. No.	Modification	Drawn	Checked	Approved	Validated	
0	06.07.2022	ISSUED FOR TENDER PURPOSE ONLY	SSI	RMA	MCY	SMK

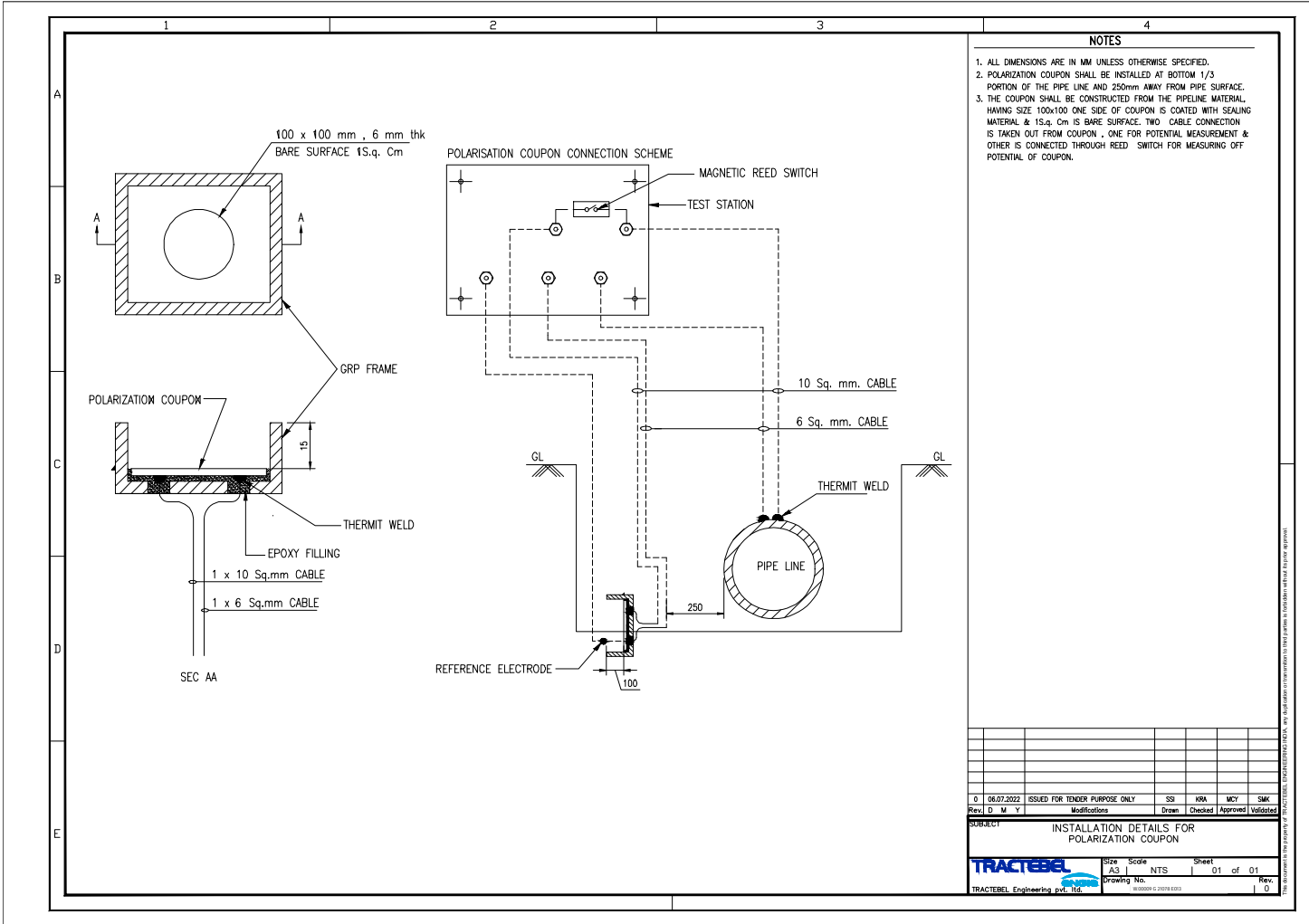
PROJECT: TYPICAL INSTALLATION AND CONNECTION  
 DETAILS OF EXTERNAL ER PROBE WITH TEST STATION

**TRACTEBEL** Engineering pvt. ltd.

Size: A3 | Scale: NTS | Sheet: 01 of 01  
 Drawing No. | Rev. | 0

TRACTEBEL Engineering pvt. ltd. | 9100004-1-2018-000

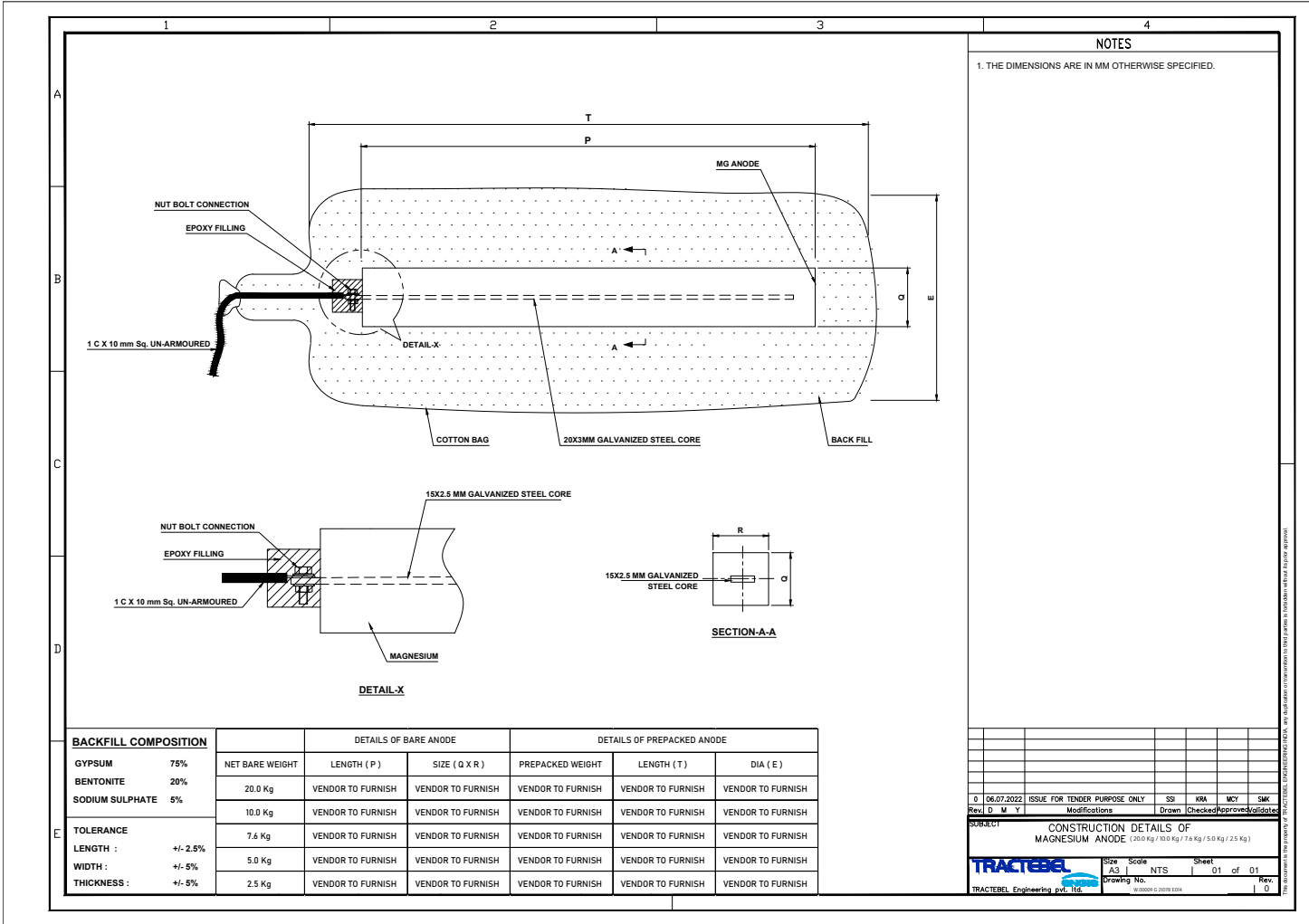
This document is the property of TRACTEBEL ENGINEERING PVT. LTD. and shall not be used or copied without the written permission of TRACTEBEL ENGINEERING PVT. LTD.



**NOTES**

1. ALL DIMENSIONS ARE IN MM UNLESS OTHERWISE SPECIFIED.
2. POLARIZATION COUPON SHALL BE INSTALLED AT BOTTOM 1/3 PORTION OF THE PIPE LINE AND 250mm AWAY FROM PIPE SURFACE.
3. THE COUPON SHALL BE CONSTRUCTED FROM THE PIPELINE MATERIAL, HAVING SIZE 100x100 ONE SIDE OF COUPON IS COATED WITH SEALING MATERIAL & 15sq. Cm IS BARE SURFACE. TWO CABLE CONNECTION IS TAKEN OUT FROM COUPON , ONE FOR POTENTIAL MEASUREMENT & OTHER IS CONNECTED THROUGH REED SWITCH FOR MEASURING OFF POTENTIAL OF COUPON.

0	06.07.2022	ISSUED FOR TENDER PURPOSE ONLY	SSI	NRA	MCY	SMK
Rev:	D	M	Y	Modification:		
			Drawn	Checked	Approved	Validated
PROJECT: INSTALLATION DETAILS FOR POLARIZATION COUPON						
		Size	Scale	Sheet		
		AS	NTS	01 of 01		
		Drawing No.			Rev.	
		TRACTEBEL Engineering pvt. ltd.		10/00000-0-2019-0001		0



**NOTES**

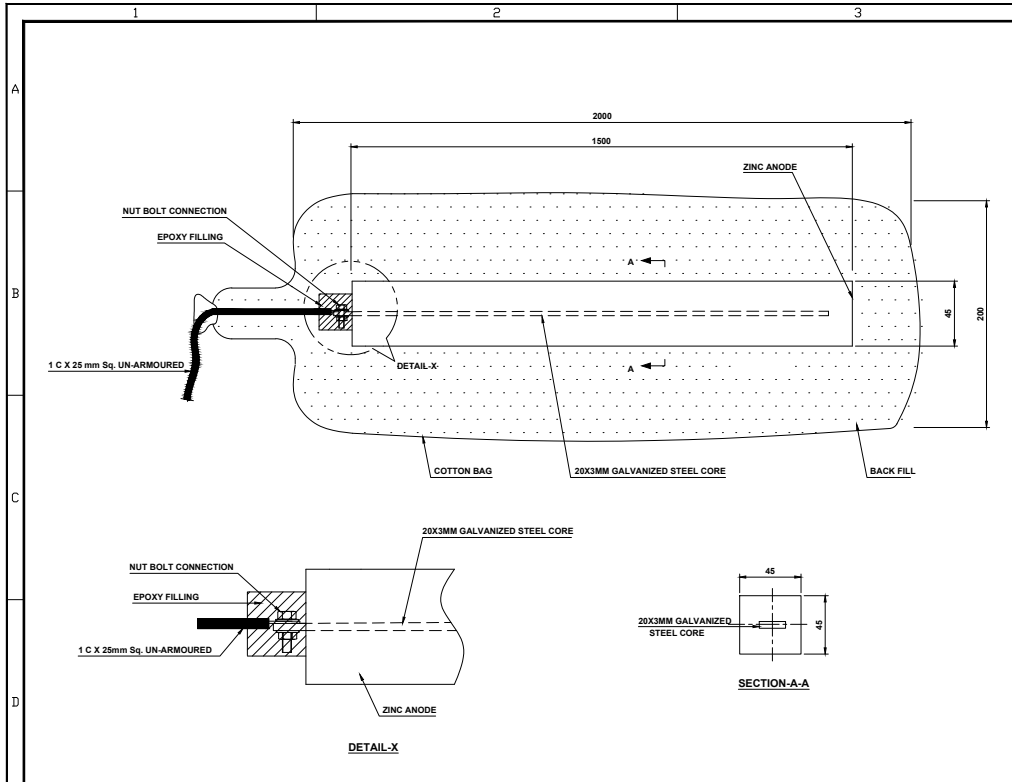
1. THE DIMENSIONS ARE IN MM OTHERWISE SPECIFIED.

BACKFILL COMPOSITION	DETAILS OF BARE ANODE			DETAILS OF PREPACKED ANODE		
	NET BARE WEIGHT	LENGTH ( P )	SIZE ( Q X R )	PREPACKED WEIGHT	LENGTH ( T )	DIA ( E )
GYPSON 75%	20.0 Kg	VENDOR TO FURNISH	VENDOR TO FURNISH	VENDOR TO FURNISH	VENDOR TO FURNISH	VENDOR TO FURNISH
BENTONITE 20%	10.0 Kg	VENDOR TO FURNISH	VENDOR TO FURNISH	VENDOR TO FURNISH	VENDOR TO FURNISH	VENDOR TO FURNISH
SODIUM SULPHATE 5%	7.6 Kg	VENDOR TO FURNISH	VENDOR TO FURNISH	VENDOR TO FURNISH	VENDOR TO FURNISH	VENDOR TO FURNISH
TOLERANCE	5.0 Kg	VENDOR TO FURNISH	VENDOR TO FURNISH	VENDOR TO FURNISH	VENDOR TO FURNISH	VENDOR TO FURNISH
LENGTH :	+/- 2.5%	2.5 Kg	VENDOR TO FURNISH	VENDOR TO FURNISH	VENDOR TO FURNISH	VENDOR TO FURNISH
WIDTH :	+/- 5%					
THICKNESS :	+/- 5%					

0	06.07.2022	ISSUE FOR TENDER PURPOSE ONLY	SSI	KRM	MCY	SMK
Rev. D	12	Modifications	Drawn	Checked	Approved	Issue

CONSTRUCTION DETAILS OF  
MAGNESIUM ANODE (20.0 kg / 10.0 kg / 7.6 kg / 5.0 kg / 2.5 kg)

**TRACTEBEL** Size Scale Sheet  
Drawing No. NTS 01 of 01  
TRACTEBEL Engineering pvt. ltd. 30/06/2019 1.004 Rev. 0



**NOTES**

1. THE DIMENSIONS ARE IN MM UNLESS OTHERWISE SPECIFIED.
2. THESE DIMENSION ARE INDICATIVE ONLY WHICH MAY BE CHANGED BASED ON THE MANUFACTURER'S DETAILS.

**BACKFILL COMPOSITION**

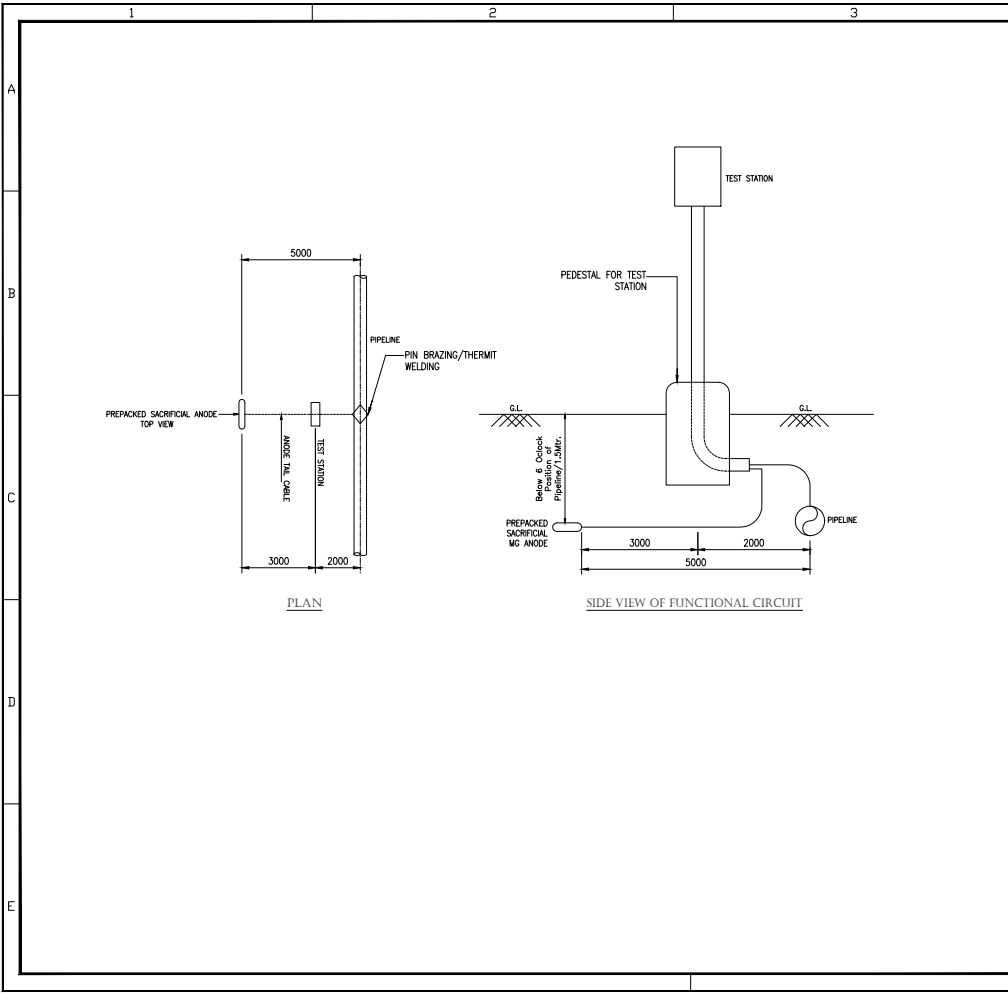
GYPSUM	75%
BENTONITE	20%
SODIUM SULPHATE	5%

TOLERANCE	DETAILS OF BARE ANODE			DETAILS OF PREPACKED ANODE		
	NET BARE WEIGHT	LENGTH	SIZE	PREPACKED WEIGHT	LENGTH	DIA
LENGTH :	+/- 2.5%					
WIDTH :	+/- 5%	VERDOR TO FURNISH	VERDOR TO FURNISH	110 Kg APPROX.	VERDOR TO FURNISH	VERDOR TO FURNISH
THICKNESS :	+/- 5%	20 Kg				

0	06.07.2022	ISSUED FOR TENDER PURPOSE ONLY	SSI	RBA	MCY	SMK
Rev. D	11	Y	Modification	Drawn	Checked	Approved

PROJECT: CONSTRUCTION DETAILS OF ZINC GROUNDING CELL (20KG)

**TRACTEBEL** Size Scale Sheet  
 Drawing No. NTS 01 of 01  
 TRACTEBEL Engineering pvt. ltd. 010000010000000



**NOTES**  
 1. ALL DIMENSIONS ARE IN MM AND ELEVATIONS ARE IN M UNLESS OTHERWISE SPECIFIED.

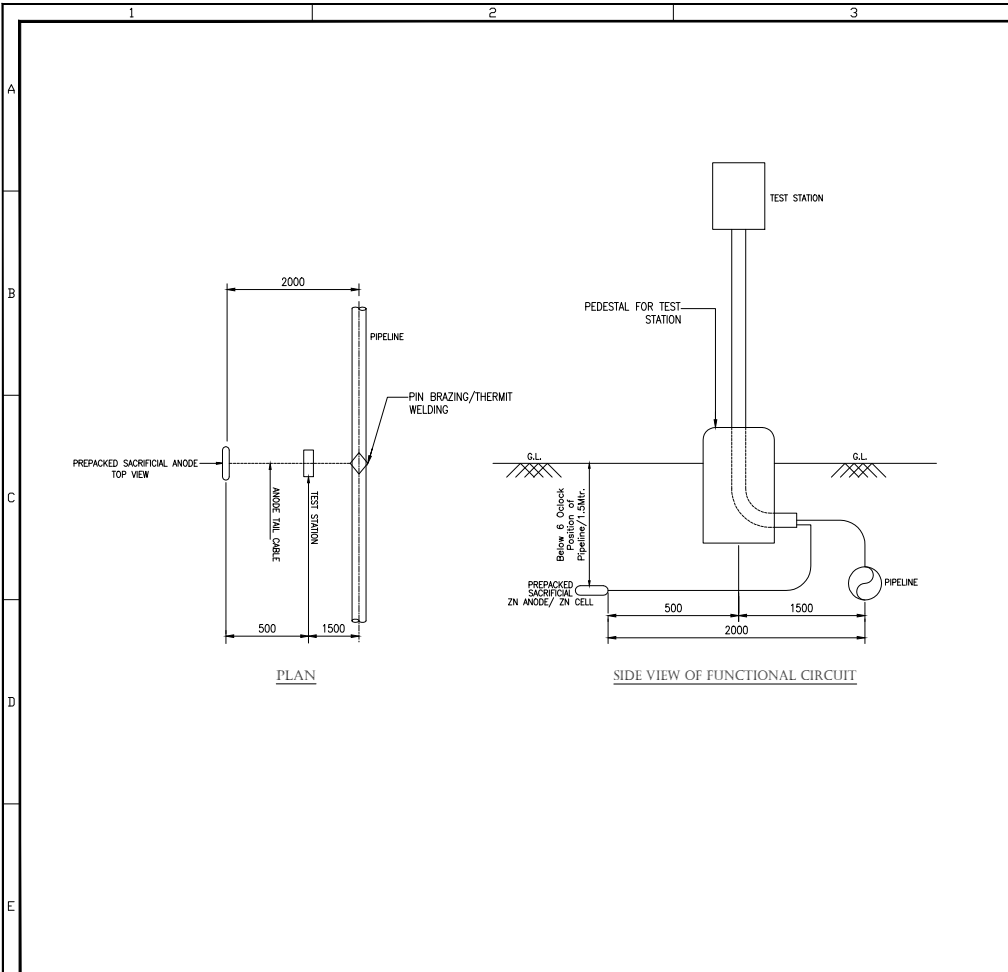

0	06.07.2022	ISSUE FOR TENDER PURPOSE ONLY	SSI	MCY	ARY	SKH
Rev. D	14	Y	Modifications	Drawn	Checked	Approved/Signate

INSTALLATION DETAILS OF MG ANODE

**TRACTEBEL** Size Scale Sheet  
 Drawing No. NTS 01 of 01  
 Rev. 0

TRACTEBEL Engineering pvt. Ltd. © 2020/2021/2022

This document is the property of TRACTEBEL ENGINEERING PVT. LTD. and shall remain the property of TRACTEBEL ENGINEERING PVT. LTD. after the project is completed.



**NOTES**  
 1. ALL DIMENSIONS ARE IN MM AND ELEVATIONS ARE IN M UNLESS OTHERWISE SPECIFIED.


0 06.07.2022 ISSUE FOR TENDER PURPOSE ONLY SSI RRM MCV SMK  
 Rev: D M Y Modifications Drawn Checked/Approved/Issue

PROJECT: **INSTALLATION DETAILS OF ZN ANODE**

**TRACTEBEL** Size Scale Sheet  
 Drawing No. NTS 01 of 01  
 TRACTEBEL Engineering pvt. Ltd. Rev. 0

This document is the property of TRACTEBEL ENGINEERING PVT. LTD. and shall not be used in any form without the written approval of TRACTEBEL ENGINEERING PVT. LTD.



At the helm of the Energy Transition, Tractebel provides a full range of engineering and advisory services throughout the life cycle of its clients' projects, including design and project management. As one of the world's leading engineering and advisory companies and with more than 150 years of experience, it's our mission to actively shape the world of tomorrow. With about 5,000 experts and presence in more than 70 countries, we are able to offer our customers multidisciplinary solutions in energy, water and urban.

**TRACTEBEL ENGINEERING PVT. LTD.**

GURGAON OFFICE  
Intec House, 37  
Institutional Area, Sector 44  
122002 - Gurgaon - INDIA  
[tractebel-engie.com](http://tractebel-engie.com)

Madhab Chowdhury  
tel. +91 124 469 8500  
fax +91 124 469 8586  
[madhab.chowdhury@tractebel.engie.com](mailto:madhab.chowdhury@tractebel.engie.com)

