Material and equipment standard for cathodic protection

First edition

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Foreword

The Iranian Petroleum Standards (IPS) reflect the views of the Iranian Ministry of Petroleum and are intended for use in the oil and gas production facilities, oil refineries, chemical and petrochemical plants, gas handling and processing installations and other such facilities.

IPS is based on internationally acceptable standards and includes selections from the items stipulated in the referenced standards. They are also supplemented by additional requirements and/or modifications based on the experience acquired by the Iranian Petroleum Industry and the local market availability. The options which are not specified in the text of the standards are itemized in data sheet/s, so that, the user can select his appropriate preferences therein

The IPS standards are therefore expected to be sufficiently flexible so that the users can adapt these standards to their requirements. However, they may not cover every requirement of each project. For such cases, an addendum to IPS Standard shall be prepared by the user which elaborates the particular requirements of the user. This addendum together with the relevant IPS shall form the job specification for the specific project or work.

The IPS is reviewed and up-dated approximately every five years. Each standards are subject to amendment or withdrawal, if required, thus the latest edition of IPS shall be applicable

The users of IPS are therefore requested to send their views and comments, including any addendum prepared for particular cases to the following address. These comments and recommendations will be reviewed by the relevant technical committee and in case of approval will be incorporated in the next revision of the standard.

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General definitions

Throughout this Standard the following definitions shall apply.

Company:

Refers to one of the related and/or affiliated companies of the Iranian Ministry of Petroleum such as National Iranian Oil Company, National Iranian Gas Company, National Petrochemical Company and National Iranian Oil Refinery And Distribution Company.

Purchaser:

Means the "Company" where this standard is a part of direct purchaser order by the "Company", and the "Contractor" where this Standard is a part of contract document.

Vendor and supplier:

Refers to firm or person who will supply and/or fabricate the equipment or material.

Contractor:

Refers to the persons, firm or company whose tender has been accepted by the company.

Executor:

Executor is the party which carries out all or part of construction and/or commissioning for the project.

Inspector:

The Inspector referred to in this Standard is a person/persons or a body appointed in writing by the company for the inspection of fabrication and installation work.

Shall:

Is used where a provision is mandatory.

Should:

Is used where a provision is advisory only.

Will:

Is normally used in connection with the action by the "Company" rather than by a contractor, supplier or vendor.

May:

Is used where a provision is completely discretionary.

0 Introduction

This Standard consists of twelve parts, as listed hereunder:

Part 1: Impressed current anodes

Part 2: Carbonaceous backfill for impressed current anodes

Part 3: Galvanic anodes for underground applications (magnesium and zinc)

Part 4: Galvanic anodes for sea water, saline mud and other submerged applications (aluminium, zinc and magnesium)

Part 5: Cathodic protection cables

Part 6: Insulating joint

Part 7: Flange insulation kit

Part 8: Polypropylene rope

Part 9: Splicing kit

Part 10: Split bolt connector (line tap)

Part 11: Splice coating materials

Part 12: Thermit weld (CAD weld) powder

Note: This is a revised version of the standard specification by the relevant technical committee on Feb. 2021, which is issued as revision(1). Revision(0) of the said standard specification is withdrawn.

Part 1

Impressed current anodes

1 Scope

This Part of IPS-M-TP-750 covers the minimum requirements for anodes (Mixed metal oxide, high-silicon-iron, graphite and magnetite) for use in impressed current cathodic protection systems.

It specifies the composition, materials, manufacture, properties, inspection and testing for Mixed Metal Oxide, High-Silicon-Iron, Graphite and Magnetite anodes. The specification covers only general requirements and the specific requirements will be given in pertinent ordering documents by the Purchaser (see appendices A, B, C and D).

2 References

Throughout this Standard the following dated and undated standards/codes are referred to. These referenced documents shall, to the extent specified herein, form a part of this standard. For dated references, the edition cited applies. The applicability of changes in dated references that occur after the cited date shall be mutually agreed upon by the Company and the Vendor. For undated references, the latest edition of the referenced documents (including any supplements and amendments) applies.

2.1 API RP 651, Cathodic protection of above ground petroleum storage tanks

2.2 ASTM A 327/A327M, Standard method of impact testing of cast iron

2.3 ASTM A 518M, Standard specification for corrosion-resistant high-silicon iron casting

2.4 ASTM B 8, Standard specification for concentric-lay-stranded copper conductors, hard, medium-hard, or soft

2.5 ASTM B 193, Standard test method for resistivity of electrical conductor materials

2.6 ASTM B 265, Standard specification for titanium and titanium alloy strip, sheet and plate

2.7 ASTM B 338, Standard specification for seamless and welded titanium and titanium alloy tubes for condensers and heat exchangers

2.8 ASTM B 348, Standard specification for titanium and titanium alloy bars and billets

2.9 ASTM B 863, Standard specification for titanium and titanium alloy wire

2.10 ASTM B 539, Standard test method for measuring resistance of electrical connections (static contacts)

2.11 ASTM D 1047, Standard specification for poly (vinyl chloride) jacket for wire and cable

2.12 ASTM D 1248, Standard specification for polyethylene plastics extrusion materials for wire and cable

2.13 ASTM D 2308, Standard specification for thermoplastic polyethylene jacket for electrical wire and cable

2.14 ASTM D 2655, Standard specification for cross-linked polyethylene insulation for wire and cable rated 0 to 2000 V

2.15 ASTM D 3032, Standard test methods for hookup wire insulation

2.16 ASTM D 3359, Standard test methods for rating adhesion by test tape

2.17 ASTM E 10, Standard test method for brinell hardness of metallic materials

2.18 ASTM E 94, Standard guide for radiographic examination

2.19 ASTM E 802, Standard reference radiographs for gray iron castings up to 114 mm (4½ in.) in thickness

2.20 IEC 60228, Conductors of insulated cables

2.21 ISO 15589-1, Petroleum, petrochemical and natural gas industries - Cathodic protection of pipeline systems

2.22 ISO 2859-1/A1, Sampling procedures for inspection by attributes- Part 1: Sampling schemes indexed by acceptance quality limit (AQL) for lot by-lot inspection

2.23 ISO 9001, Quality management systems - Requirements

2.24 ISO 19097-1, Accelerated life test method of mixed metal oxide anodes for cathodic protection- Part 1: Application in concrete

2.25 ISO 19097-2, Accelerated life test method of mixed metal oxide anodes for cathodic protection- Part 2: Application in soils and natural waters

2.26 NACE SP 0572, Design, installation, operation and maintenance of impressed current deep ground beds

2.27 UFGS-26 42 17 00 10, Cathodic protection system (impressed current system)

3 Definitions and terminology

3.1

accelerated life

Lifetime of mixed metal oxide anode under accelerated testing condition, usually in the specific electrolyte applied with large current density.

3.2

anode

The electrode of an electrochemical cell at which oxidation occurs. Electrons flow away from the anode in the external circuit. Corrosion usually occurs and metal ions enter the solution at the anode. In this standard, the anode is the positive terminal of the impressed electrical system from which current is discharged.

3.3

anode cap

An electrical insulating material placed over the end of anode at the lead wire connection.

3.4

cathodic protection

A technique to reduce the corrosion of a metal surface by making that surface the cathode of an electrochemical cell.

3.5

cell voltage

Voltage between anode and cathode in a single cell.

3.6

current density

The current to or from a unit area of an electrode surface.

3.7

deep ground bed

One or more anodes installed vertically at a nominal depth of 15 m (50 ft) or more below the earth's surface in a drilled hole for the purpose of supplying cathodic protection.

3.8

mixed metal oxide anode

Impressed current anode for cathodic protection consisting of conductive coating of mixed metal oxides formed on titanium substrate. The most common mixture used for cathodic protection is iridium oxide and tantalum oxide. Exact compositions may vary.

4 Units

This Standard is based on International System of Units (SI), as per IPS-E-GN-100 except where otherwise specified.

5 Documentation

5.1 The manufacturer/supplier shall provide sufficient information to identify the anode and shall supply the technical information as a minimum requirement as follows:

a. ISO 9001 certification for design, manufacturing and quality control of the anodes to be used for impressed current cathodic protection installation, issued by an internationally recognized body;
b. Original technical catalogue and data sheet, manufacturing procedure specification, quality control plan, application procedure recommendation and guidelines (installation instructions);
c. Filled, signed and stamped data sheets as shown in Appendices A, B,C and D;
d. All laboratory and shop testing shall be documented. The anodes shall be traceable to the manufacturing batch. Shipping, handling and storage procedures shall ensure that the anodes and lead wire are not damaged;
e. Certificate of current output and anode consumption rates at maximum current density for various application in accordance with reference Tables for each type of anodes;
f. Certificate of analysis according to reference standards for each type of anodes.

Note 1: Manufacturing procedures shall cover all stages of the manufacturing process, from receipt of raw materials to finishing and packing for shipment, including:

a. Chemical analysis;
b. Measurements of weight, dimensions, etc.;
c. Inspection and testing procedures and frequencies;
d. Anode manufacture;
e. Anode connections.

Note 2: The quality control at the anode manufacturing plant shall include control systems on the following:

a. Raw materials, i.e. checking of documentation;
b. Production equipment and process;
c. Testing during and after production;
d. Identification of anodes;
e. Chemical analysis;
f. Weight and dimensional tolerances;
g. Surface condition of produced anodes;
h. Documentation (material certificates).

6 Quality assurance

Manufacturer shall operate an effective, documented quality system based on the relevant part of the ISO 9001 and maintain records identifying the product, date of manufacturing, batch numbers and all results of inspections and testing.

7 Mixed metal oxide anode

7.1 Anode geometry: The MMO anodes should be one of the following types and specifications as per clauses 7.4.1 to 7.4.6.

This standard specification covers all types of MMO anodes. The type of anodes shall be selected by purchaser.

7.2 Anode catalyst: A conductive coating of mixed metal oxide within the combination of iridium oxide and tantalum oxide (IrO_2 and Ta_2O_5) used as the catalyst of the anode.

Suitable to work in an environment where the evaluation of O_2 and Cl_2 or a combination of both would be presented at the anode surface. Exact compositions may vary.

7.3 Anode loading characteristics: The coating mass shall be sufficient for loading characteristics in accordance with this standards reference tables for each type of anode in any arrangement of ground beds.

7.4 Types of mixed metal oxide anodes.

7.4.1 Tubular anode

7.4.1.1 Anode substrate: Seamless titanium tube as per ASTM B 338 grade 1 or 2, in accordance with chemical composition indicated in Table 1.

Table 1- Chemical characteristics, composition, %

Element	Grade 1	Grade 2
Nitrogen, max	0.03	0.03
Carbon, max	0.08	0.08
Hydrogen, max	0.015	0.015
Iron, max	0.2	0.2
Oxygen, max	0.18	0.25
Other elements, max.	0.1	0.1
Other elements, Total	0.4	0.4
Titanium	Balance	Balance

7.4.1.2 Anode properties: The MMO anode should be tubular type with properties & performances as per indicated in table 2 & 3.

Table 2- Dimension and performance of MMO

Item	Environment	Length , mm	Diameter, mm	Anode current output for minimum 20 years life time
1	Coke breeze/fresh water	500	25	4
	Seawater			25
	Mud/brackish water			4
2	Coke breeze/fresh water	1000	25	8
	Seawater			50
	Mud/brackish water			8
3	Coke breeze/fresh water	500	16	2.5
	Seawater			15
	Mud/brackish water			2.5
4	Coke breeze/fresh water	1000	16	5
	Seawater			30
	Mud/brackish water			5
5	Coke breeze/fresh water	500	19	3
	Seawater			19
	Mud/brackish water			3
6	Coke breeze/fresh water	1000	19	6
	Seawater			38
	Mud/brackish water			6

Table 3- Tubular anode loading characteristics

Electrolyte	Current density , A/m^2	Minimum Life Time, Year[1]
Carbonaceous backfill	50	20
Calcined petroleum coke	100	20
Freshwater	100	20
Brackish water	100 - 300	20
Sea water	600	20

Note: Depending on purchaser and manufacture agreement could be prolonged.

7.4.2 Rod anode

7.4.2.1 Anode substrate: Titanium rode as per ASTM B 348 grade 1 or 2, in accordance with chemical composition as indicated in Table 1.

7.4.2.2 Anode properties: The MMO anode should be rod type with properties & performances as per indicated in Table 4 & 5.

Table 4- Rod anode properties

Item	Environment	Length ,mm	Diameter ,mm	Anode current output (A) for minimum 20 years life time
1	Fresh water	500	3.2	0.5
		1000		1
	Brackish water	500		2
		1000		3
	Sea water	500		4
		1000		6
2	Fresh water	500	6.4	0.9
		1000		2
	Brackish water	500		2.5
		1000		6
	Sea water	500		6
		1000		12
3	Fresh water	500	12.7	2
		1000		4
	Brackish water	500		5
		1000		12
	Sea water	500		12
		1000		24
4	Fresh water	500	19	3
		1000		6
	Brackish water	500		8
		1000		17.5
	Sea water	500		17
		1000		35
5	Fresh water	500	25	3.9
		1000		8
	Brackish water	500		10
		1000		23.5
	Sea water	500		23
		1000		47

Table 5- Rod anode loading characteristics

Environment	Current density, A/m^2	Minimum Lifetime, year[1]
Fresh water	100	20
Brackish water	100-300	20
Sea water	600	20

Note: depending on purchaser and manufacture agreement could be prolonged

7.4.3 Ribbon anode

7.4.3.1 Anode substrate: Solid titanium as per ASTM B265 Grade 1 or 2, in accordance with chemical composition as indicated in Table 1.

7.4.3.2 Anode properties: The MMO anode should be ribbon type with performances as per indicated in Table 6.

Table 6- Ribbon anode properties

Item	Environment	Dimension, mm	Coil length, m	Coil weight, kg	Resistance, ohm/m	Current output, A/m
1	Fine sand	6.35(wide)*	100	>=1.6	<= 0.138	0.042
2	Concrete	0.635(thick)				0.015

7.4.3.3 Conductor bar: For connection of Ribbon MMO anode to cathodic protection power system, titanium (ASTM B-265 Gr1) conductor bar shall be used. Other typical details of conductor bar are indicated in Table 7 & 8.

Table 7- Ribbon anode conductor bar details

Item	Element	
1	Material:	Titanium ASTM B-265 Gr1
2	Dimension, mm:	12.7(wide)*0.9(thick)
3	Coil length, m:	100
4	Coil weight, Kg:	5

Table 8- Ribbon anode loading characteristics

Item	Environment	Current Density, A/m^2	Minimum Life Time, year
1	Fine sand	3	50
2	Concrete	0.11	100

7.4.4 Mesh anode

7.4.4.1 Anode substrate: Titanium expanded mesh substrate as per ASTM B265 Grade 1 or 2, in accordance with chemical composition as indicated in Table 1.

7.4.4.2 Anode properties: The MMO anode should be Mesh type with properties & performances as per indicated in Table 9 & 10.

Table 9- Mesh anode properties

Item	Element	Value			
1	Width, mm	10	13	15	20
3	Expanded thickness, mm	1.3			
4	Diamond dimension, mm	2.5*4.6*0.6			
5	Current output, mA/m at 110 mA/m^2	2.8	3.5	3.9	5.3
6	Coil length (m)	100			

Table 10- Mesh anode loading characteristics

Item	Environment	Anode/Concrete Interface Current Density (A/m^2)	Life Time, year
1	Concrete	0.11	75

7.4.5 Disk anode

7.4.5.1 Anode substrate: Titanium substrate (circular or rectangular) as per ASTM B265 Grade 1 or 2, in accordance with chemical composition as indicated in Table1 with 150 mm (6 in) or 300 mm (12 in) in diameter or other size, upon request by purchaser. The performance of anode should be in accordance to Table 11.

Table 11- Disk anode loading characteristics

Item	Environment	Current Density A/m^2	Life Time, year[1]
1	Freshwater	100	20
2	Brackish water	100 - 300	20
3	Sea water	600	20

Note: Depending on purchaser and manufacture agreement could be prolonged

7.4.6 Wire anode

7.4.6.1 Anode substrate: Titanium wire substrate as per ASTM B863 Grade 1 or 2, in accordance with chemical composition as indicated in Table1.

7.4.6.2 Anode properties: The MMO anode should be wire type with properties and performances as per indicated in Table 12 & 13.

Table 12- Wire anode properties

Item	Environment	Current output, Amps	
		1.5 mm dia.	3 mm dia.
1	Soil	0.14	0.28
2	Carbonaceous backfill	0.25	0.5
3	Petroleum coke backfill	0.5	1
4	Fresh water	0.5	1
5	Sea water	3	6
6	Coil length (m)	100	

Table 13- Wire anode loading characteristics

Item	Environment	Current Density (A/m^2)	Minimum Life Time, year[1]
1	Soil	50	20
2	Carbonaceous backfill	100	20
3	Fresh water	100	20
4	Brackish water[2]	100-300	20
5	Sea water	600	20

Note 1: Depending on purchaser and manufacture agreement could be prolonged

Note 2: Current density should be determined in accordance with brackish water resistivity.

8 Anode casting

8.1 Casting of high-silicon-chromium-iron anode

Cast iron containing 14 to 15 percent silicon and one to two percent other alloying elements such as manganese and molybdenum form a protective film of silicon dioxide when current is passed from their surface into the environment. This film is stable in many environments except in chloride rich environments. The formation of this film reduces the deterioration rate of this alloy from approximately 20 pounds per ampere-year for ordinary steel, to one pound per ampere-year for the silicon iron. High silicon iron alloys can be used in electrolytes with high chloride content, if contain appropriate chromium concentrations

8.1.1 Anodes shall be made from High-Silicon-Chromium-Iron casting conforming to the ASTM A518M (Grade 3) and shall have either a solid or "rod type" configuration with the anode lead attached at one end of the anode or a "tubular type" configuration with the anode lead attached at the center of the anode.

8.1.2 The casting may be produced by any process at the option of the manufacturer, capable of meeting the chemical composition and physical properties specified.

8.1.3 Where solid or "rod type" anodes are required; the anode shall be single end with enlarged head. The anode's enlarged head shall be cored to provide cavities for lead wire connection.

8.1.4 Where "tubular type" anodes are required, the anode shall be hollow, straight-walled tubular anode having walls of uniform thickness and having an open cylindrical interior for lead wire connection.

8.1.5 The casting shall be dense and homogeneous ensuring that the anode properties are uniform throughout their length.

8.1.6 The chemical composition of the anode alloy content shall conform to the limits prescribed in Table 14.

8.1.7 In addition the "rod type" High-Silicon-Iron anodes shall conform to the requirements for physical properties prescribed in Table 15.

Table14- Chemical composition limits for high-silicon-iron anode

Element	Composition wt.%	Method of Analysis
Carbon	0.7-1.1	ASTM A 518M
Manganese	1.5 max.	
Silicon	14.2-14.75	
Chromium	3.25-5	
Molybdenum	0.2 max.	
Copper	0.50 max.	
Iron	Remainder	

Note: Determined arithmetically by difference

Table 15- Physical properties of "rod type" high-silicon-iron anodes

Property		Unit	Requirement	Test Method (ASTM)
Density		g/cm3	7-7.05	Approved method
Hardness, Brinell	(min)		500	E10
Compressive strength	(min)	MPa	650	A256
Electrical resistivity	(max)	μΩ.cm	72	B193
Impact resistance	(min)	J	0.1	A327 (Charpy Type)
Uniformity (X-ray Detection)	(min)		Level 3	E186/E446

8.1.8 Dimensions and weights

8.1.8.1 High-Silicon-Iron, anodes are available in a wide variety of standard sizes and shapes. Tables 16 and 17 provide examples of sizes of solid rod and tubular High-Silicon-Iron anodes.

Table 16- Dimensions of high-silicon-iron anodes ("rod type")

Diameter (mm)	Head Diameter (mm)	Length (mm)	Weight (mm)
(Nominal)			
51	76	915	14.5
51	76	1220	19
51	76	1525	22.5
76	102	915	29
76	102	1220	38
76	102	1525	49

Table 17- Dimensions of high-silicon-iron anodes ("tubular type")

Outside Diameter (mm)	Inside Diameter (mm)	Wall Thickness (mm)	Nominal Length (mm)	Nominal Weight (kg)
67	47	10	1067	14
56	36	10	2134	21
67	47	10	2134	29
95	75	10	2134	39
121	100	10	2134	50
121	86	17	2134	79

8.2 Casting of graphite anode

8.2.1 Anodes shall be of the plain graphite type extruded in circular or square shapes. They shall be of the "treated type", having been impregnated with linseed oil by a vacuum-pressure autoclave process.

8.2.2 The graphitizing ovens shall be so designed to ensure that a uniform internal graphite structure is obtained as well as an overall consistency from one anode to another.

Note: If great care is not taken during the manufacturing process, internal cracks and flaws may develop in the graphite. It is therefore necessary that the manufacturer takes the necessary steps to maintain a consistent material free from internal and external flaws.

8.2.3 The aggregate and grain shall be small and shall have similar physical, chemical and electrical properties. The material shall be free of voids and impurities.

8.2.4 The anodes shall be sufficiently resistant to permit firm tamping of backfill around them and immune to chemical attack.

8.2.5 Anodes shall have one end drilled for cable connection.

Table 18 lists typical specifications for commercially available graphite anodes

Table 18- Graphite anode chemical analysis and properties

Impregnate (Linseed Oil)	6.5 wt. % max
Ash	1.5 wt. % max
Moisture & Volatile Matter	0.5 wt. % max
Water Soluble Matter	1.0 wt. % max
Graphite	Remainder
Physical Properties	
Density	99.84 lb./cu ft. max
Resistivity	0.0011 ohm-cm max
Mechanical Requirements	
Lead wire connection strength	325 lbs. minimum

8.2.6 Graphite anodes are available in a wide variety of standard sizes and shapes. Table 19 lists

typical dimensions for commercially available graphite anodes.

Table 19-Dimensions of graphite anodes

Nominal Weight (Kg/Ib)	Nominal Dimensions		
	Diameter (mm/in)	Length (mm/in)	Surface area (mm/in)
5.9 (13)	76.2 (3)	762 (30)	0.18 (2.0)
15.9 (35)	101.6 (4)	1016 (40)	0.32 (3.5)
12.3 (27)	76.2 (3)	1524 (60)	0.36 (3.9)
31.8 (70)	101.6 (4)	2032 (80)	0.65 (7.0)

8.2.7 Table 20 lists current densities of graphite anodes for 20 years' life time.

Table 20-Current density for graphite anodes (amp/m^2)

Seawater	Fresh Water	Soil
40.32	2.69	10.75

8.3 Casting of magnetite anode

8.3.1 Anodes shall be made by casting the magnetite (Fe_3O_4) with the melting point of about 1540°C, plus an addition of small quantities of alloying elements, into a hollow cylinder closed at one end. The whole inside surface of the anode shall be coated with a plated thin copper layer. 100 mm below the anode top a copper tag shall be fixed to the inside copper layer for cable attachment.

The anode body shall be filled with a soft plastic core (e.g., polystyrene or polyurethane) to absorb the differential rates of expansion of the resin and the magnetite.

8.3.2 Casting may be produced by any process at the option of the manufacturer, capable of meeting the requirements specified herein.

8.3.3 The casting shall be dense and homogeneous ensuring that the anode properties are uniform throughout their length.

8.3.4 Table 21 lists typical specifications for commercially available magnetite anodes.

Table 21- Typical specifications of magnetite anode (data sheet of one manufacturer)

Properties	Unit	Quantity
Specific gravity	Kg/dm^3	4.7 – 4.8
Brinell hardness (WB5/187,5/15)	-	344
Bending strength	KN/cm^2	5
Density	g/cm^3	4.71
Melting point	˚C	1500
Coefficient of linear expansion	1/ ˚C (0-100˚C)	6.4*10.6
Consumption rate	Kg/A year	0.02
Current density (depends on environment)	mA/dm^2	0.7
Efficiency	90%	

8.3.5. The typical dimensions and weight of Magnetite anode may be as follows:

Overall length : 800 mm

Effective length : 740 mm

Outside diameter : 60 mm

Inside diameter : 40 mm

Total weight : 6.0 kg

Magnetite weight : 4.7 kg

8.3.6 The actual dimensions shall conform to the following:

8.3.7 Anode mean length shall be ±3% of nominal length or ±25 mm, whichever is smaller.

8.3.8 The diameter of anode shall be ±5% of nominal diameter.

8.3.9 The permissible variation in weight of each finished anode shall be ±5% of the nominal weight.

9 Anode lead wire

9.1 Conductor

The copper conductors shall be single core stranded, compressed, soft annealed, uncoated copper in accordance with ASTM specification B8 Class B or IEC Publication 60228 Class 2.

Unless otherwise specified by the Purchaser, the lead wire size shall be 10 mm^2.

Unless otherwise specified by the Purchaser, the lead wire length shall be 3 meters.

9.2 Anode lead wire insulation

The lead wire insulation shall provide continuous and adequate dielectric properties. The lead wire shall be double insulated and to be protected from both mechanical forces and chemical

attacks and shall be either standard or chlorine resistant type in accordance with following details:

- Standard Type: For surface anode beds installation which the electrolyte is not expected to contain chloride or other halogen ions, high-molecular weight polyethylene (HMWPE) as per NACE SP0572 clause 4.5.4.3 shall be used.

  Chlorine Resistant Type: For surface anode beds installation which the electrolyte is expected to contain chloride or other halogen ions and for deep anode beds installation, anode lead wire shall be sheathed with a chemical resistance insulation material to be resistant to halogen or other corrosive gases and ions, polyvinylidene fluoride (PVDF)*, radiation cross-linked Polyvinylidene fluoride (XLPVDF)*, ethylene chlorotrifluoroethylene (ECTFE)*, and cross-linked ethylene chlorotrifluoroethylene (XLECTFE)* shall be used.

- In addition, the abrasion resistant materials such as high molecular weight polyethylene (HMWPE)* shall be used to jacket sheathed anode lead wires for mechanical protection on thin-wall insulations subject to abrasion or notch propagation

- Anode lead wire insulation shall be tested in accordance with the procedure set forth in clause 5.3.

4.7 (NACE SP0572) Lead Wire to Anode Connection

9.3 Lead wire to anode connection

The lead wire to anode connection (where needed as specified in this standard) shall be of low resistance, provide a positive moisture seal, and have a sufficient mechanical strength to support the anode weight. Anode lead wire connection shall be fabricated by manufacturer and shall be complied with the following details:

9.3.1 For tubular MMO and high- silicon- iron type anodes:

- Anode shall be center connected by means of internal impression of lead/suitable conductive material insert molded to the anode lead wire into the diametrically pre-reduced center of the anode tube.

- Center-connected anodes shall be sealed with 100% filling of a two component sealing material (sealant) inside the anode tube after internally connection of lead wire to anode. The moisture seal shall resist to degradation from oxidizing gases released at the anode. (The specification and data sheet of the sealant materials shall be specified by manufacturer for approval).

- Sufficient anode lead wire centering elements shall be furnished to each end of lead wire extending from the anode tube in order to prevent possible anode lead wire insulation defects during transportation, installation and service life. While minimum of 15 cm of the insulated lead wire extending along the centering elements plugged between the anode tube and lead wire shall be covered by polyolefin based heat shrinkable cap(s).

9.3.2 For Rod MMO and high- silicon- iron and disk MMO type anodes:

- The method of connecting the lead wire to the anode shall either be by leading and

tamping
- (Caulked lead connection), or by the use of a tapered pin connection.

9.3.3 For Graphite anodes: the method of connecting the lead wire to the anode shall either be by a brass soldered, or by the use of a compression connection.

9.3.4 For Magnetite anodes, the method of connecting the lead wire to the anode copper conducting layer shall be by the use of a brazed connection.

9.3.5 Heat shrink anode cap used for sealing the anode lead connection, as will be specified by the purchaser, shall be either standard or chlorine resistant type in accordance with following:

Standard Type:	Heat Shrinkable Polyvinylidene Fluoride
Chlorine Resistant Type:	Heat Shrinkable Polyethylene

Note: End connection and/or externally center crimp connection is not acceptable due to anode end effects and the possible defects on MMO coating during external crimping process.

Surface treatment and cleanliness of the lead wire insulation shall be accomplished in accordance with the manufacturer's recommendations before the anode connection is made.

10 Properties

The finished product shall meet the following requirements:

10.1 Workmanship, Finish, and Appearance.

10.1.1 Anodes shall be free from defects which may impair the performance of the finished component. Anodes shall be free of flaws, slags, cracks, blow holes, and excessive porosity consistent with good commercial practice.

10.1.2 The lead wire insulation shall be continuous having a thickness as uniform as possible and shall be completely free of nicks, scratches, or other discontinuities.

*** Notch propagation:** The tendency of a cut, nick, or scratch in a material to increase in depth and/or length when the material is stressed.

10.2 Mechanical resistance test

When a uniaxial force equivalent to 100 kg, or five times the mass of the anode metal, whichever is the greater, is applied to a cast anode, it shall not result in damage to the cable or its connections.

10.2.1 The Silicone –iron alloy shall meet transverse bend test results (according to test method A518/A518 M and acceptance test criteria)

10.3 Electrical resistance test

The electrical resistance at the connection of a completely assembled anode shall not exceed 0.03 ohms, when tested in accordance with ASTM test method B 539.

Note: Connection resistance is defined as total resistance minus resistance of the anode cable.

10.4 Temperature dependence

Anodes shall not have a tendency of cracking when affected by alternating high and low temperatures.

10.5 Fluoropolymer insulated anode lead wire test

The Fluoropolymer insulation used on anode lead wire must pass the impulse dielectric test** performed in accordance with ASTM D 3032, Section 12, at 600 Volts (peak) per 0.025 mm or a maximum of 18 kilovolts (peak).

If an outer jacket of fluoropolymer or other material is applied, all finished wire must pass the impulse dielectric test at a voltage equal to 600 Volts (peak) per 0.025 mm of primary insulation plus 100 Volts (peak) per 0.025 mm of the jacket thickness or a maximum of 18 kilovolts (peak).

10.6 Radiographic test

The casting anode shall be tested by X-ray method in accordance with ASTM Guide E94. Types and degrees of discontinuities considered shall be judged by reference radiographs ASTM E 186/446.For defects in category A, B and C the severity Level up to 2 as minimum criteria are acceptable and for other categories, no defects are acceptable.

Table 22- Properties, references standards, procedures list and requirements of anodes

Item	Test	Ref. Standard	Procedure	Requirement	Remark
1	Mechanical & Physical properties	ASTM B265,B338,B348, B863,ASTM E10, ASTM A256, ASTM B193, A518M ASTM A327 (Charpy Type) ASTM E186/E446	Test method for Mechanical & Physical testing of metallic material, Ref. Standards	1) Table 7 ASTM B265 2) Tables3,4 and Section9 ASTM B338 3) Table2ASTM B348 4) Section 7.2.2 ASTM B863 5) Table2ASTM A518 6) Table 15	1) MMO Ribbon , Mesh and Disk Anodes 2) MMO Tubular Anode 3) MMO Rod Anode 4) MMO Wire Anode 5) High Silicon Cast Iron
2	Chemical composition	ASTM B265,B338,B348, B863, A518M Electrical TP 16	Chemical analysis	1) Table 2 ASTM B265 2) Table 1 ASTM B338 3) Table 1ASTM B348 4) Table1 ASTM B863 5) Table 14 ASTM A 518M 6) Table 18	1) MMO Ribbon , Mesh and Disk Anodes 2) MMO Tubular Anode 3) MMO Rod Anode 4) MMO Wire Anode 5) High Silicon Cast Iron 6) Graphite Anode

Table 22- Properties, references standards, procedures list and requirements of anodes (continued)

Item	Test	Ref. Standard	Procedure	Requirement	Remark
3	Weight and dimensions	-	Weight measurement with balance and dimensions measurement with meter and caliper	According to purchasing data	All Types of Anode
4	Coating quality	-	Visual inspection	The coating shall be free of flows, cracks, blow holes and excessive porosity	All Types of MMO Anodes
5	Coating type	-	NXRDF spectrometry test	The uniformity shall be minimum 85% and thickness of coating as specified by manufacture	All Types of MMO Anodes
6	Coating adhesion	UFGS-26 42 17 00 10 Sec 2.1.5.1	Pull-Off test	Greater than 50 Mpa	All Types of MMO Anodes
7	Life time	ISO 19097 Part1 & 2	The anode shall survive the accelerated total charge density that is equivalent to the total charge density for the anode design service requirement	According to this standard	All Types of MMO Anodes
8	Moisture seal	ISO 687	The moisture seal shall be tested with helium at 2 atm of pressure	No leakage	Tubular type Anodes
9	Cable to anode connection strength	ASTM D3032	Applying an uniaxial force equivalent to mass of the anode metal	No damage in cable or its connections	All Types of Anodes
10	Electrical resistance	ASTM B539	Anode/cable resistance	1) Less than 0.001 ohms 2) Less than 0.003 ohms	1) For tubular MMO anode 2) For High-Silicon-Iron, Graphite and Magnetite Anodes

11 Sampling

11.1 Lot

Unless otherwise specified by the Purchaser, a lot shall consist of all anodes made from the same production run offered for inspection at one time.

11.2 Sampling for inspection

Sample anodes shall be selected from each lot in accordance with inspection Level II of ISO 2859 (Part 1). The acceptable quality level shall be 4 percent for all visual, dimensional and weight defects combined and 2.5 percent for all other type of defects with reference to this Part of Standard specification. The single sampling plans for normal inspection (Table II A of ISO 2859 Part 1) shall be used.

12 Rejection

Where the numbers of anodes that do not conform to this Part of Standard specification exceed the acceptance numbers specified in 11.2, this shall be cause for rejection of entire lot.

13 Inspection

13.1 The manufacturer and/or supplier shall be responsible for carrying out all the tests and inspections required by this Part of Standard specification, using his own or other reliable facilities, and he shall maintain complete records of all such tests and inspections. Such records shall be available for review by the Purchaser.

13.2 The manufacturer and/or supplier shall afford the purchaser's inspector all reasonable facilities necessary to satisfy him that the material is being produced and furnished in accordance with this Part of Standard specification. Such inspections in no way relieve the manufacturer and/or supplier of his responsibilities under the terms of this Standard specification.

13.3 The Purchaser reserves the right to perform any inspections set forth in this Part of Standard specification where such inspections are deemed necessary to assure that supplies and services conform to the prescribed requirements.

13.4 The Purchaser's inspector shall have access to the material subject to inspection for the purpose of witnessing the selection of the samples, the preparation of the test samples, and the performance of the tests. For such tests, the inspector shall have the right to indicate the pieces from which the samples will be taken in accordance with the provisions of this Part of Standard specification.

14 Certification

14.1 The manufacturer shall provide the Purchaser with a certification stating that the anodes meet the specified requirements of this Part of Standard specification.

14.2 The test report shall contain results of tests required by this Part of Standard specification and other tests specified by the Purchaser.

14.3 Each test report shall be signed by an authorized agent of the seller and/or manufacturer.

14.4 Certified test reports furnished by the manufacturer shall be properly identified with each lot (batch) of products.

15 Packaging and shipment

15.1 Anodes shall be bundled, strapped, placed on pallets or in sturdy crates with supports, pads and binding as necessary to facilitate unloading and minimize damage to anodes during normal handling and transportation.

15.2 Cables shall be carefully coiled and positioned inside the crates or on the pallets so that no cable damage can occur during loading and transportation. Under no circumstances must anodes lay on the cables.

15.3 Cleaning, preservation, and packaging of anodes shall be in accordance with the manufacturer's commercial practice, provided they are such as to ensure acceptance by common or other carriers for safe transportation to the delivery point.

16 Labeling

16.1 Anode identification

Each anode casting shall be stamped with the following:

- Name and/or trademark of the manufacturer;
- Batch number;
- Cast number;
- Alloy type (i.e., High-Silicon-Iron, Graphite, or Magnetite).

16.2 Lead wire identification

The lead wire shall be marked with the following information:

- Manufacturer's name;
- Lead wire size;
- Lead wire insulation;
- Specification.

16.3 Marking of containers

Each container shall be plainly marked with the following information:

Name of anode: (i.e., Mixed Metal Oxide, High-Silicon-Iron, Graphite, or Magnetite) anode

Specification: IPS-M-TP-750: Part 1

Order No.:

M.E.S.C. No.:

Anode type:

Anode Dimensions: Length …... mm, Diameter ..... mm, Weight .....kg.

Batch No.:

Stock No.:

Date of Manufacture:

Quantity:

Inspection date:

Manufacturer's name and address:

Shelf life:

Storage life:

MSDS warning sticker:

Note: Each crate or pallet shall be clearly marked "FRAGILE".

Appendices

Appendix A

Data sheet

(to be submitted by the purchaser) for mixed metal oxide anode

1	Project title:
2	Indent No:
3	Quantity:
4	Date:
5	Purchaser
6	Anode substrate material (ASTM):
7	Anode Coating:
8	Anode Application: ☐ Soil ☐ Fresh water ☐ Sea water
9	Anode Type: ☐ Tubular ☐ Rod ☐ Single type ☐ Ribbon ☐ String type ☐ Mesh ☐ Disk ☐ Wire - Number of anode per string -Spacing between anode per string. From anode center to anode center(mm):
10	Anode Life time (year):
11	Anode Current output (A):
12	Anode dimension (Single): Length…mm Diameter….mm Weight…..kg
13	Anode Cap type(s): ☐ Standard ☐ Chlorine resistance
14	Lead wire insulation type -Standard type: ☐ Double jacket-HMWPE/HMWPE ☐ Double jacket-XLPE/HMWPE - Chlorine resistance type: ☐ Single jacket – PVDF ☐ Double jacket- XLPVDFHMWPE ☐ Double jacket- ECTFE/HMWPE ☐ Double jacket -XLECTFE/HMWPE
15	Lead wire length(m) Single anode: String type anode:
16	Lead wire insulation color:

Appendix B

Data sheet

(to be submitted by the purchaser) for high-silicon-iron anodes

The anodes shall be in accordance with the latest edition of above Iranian Petroleum Standard with following specific requirements:

- Project title: .....
- Indent No.: .....
- Date: ……
- Purchaser: ……...
- M.E.S.C. No.:
- Quantity: .....

- Type of anode: "Rod Type"

"Tubular Type"

- Anode dimensions: .....
- Anode cap type:

Standard

Chlorine resistant

- Lead wire insulation type:

Standard type:

Double Jacket - PVC/PVC (see Note of 8.2.1)

Single Jacket - HMWPE

Double Jacket - HMWPE/PVC

Single Jacket - PVDF

Double Jacket - XLPVDF/HMWPE

Chlorine resistant type:

- Lead wire length:
- Lead wire insulation color:

Appendix C

Data sheet

(to be submitted by the purchaser) for graphite anodes

The anodes shall be in accordance with the latest edition of above Iranian Petroleum Standard with following specific requirements:

- Project title: .....
- Date: ……
- Indent No.: .....
- Purchaser: .....
- M.E.S.C. No.: .....
- Quantity: .....
- Anode dimensions: .....
- Anode cap type: Standard / Chlorine resistant
- Lead wire insulation type:

Standard type: Single Jacket - HMWPE / Double Jacket - HMWPE/PVC / Double Jacket - XLPE/PVC / Single Jacket - PVDF / Double Jacket - XLPVDF/HMWPE

Chlorine resistant type:

- Lead wire length:
- Lead wire insulation color:

Appendix D

Data sheet

(to be submitted by the purchaser) for magnetite anodes

The anodes shall be in accordance with the latest edition of above Iranian Petroleum Standard with the following specific requirements:

- Project title: .....
- Date: ……
- Indent No.: .....
- Purchaser: .....

- M.E.S.C. No.: .....
- Quantity: .....
- Anode dimensions: .....

- Anode cap type:
  - Standard
  - Chlorine resistant

- Lead wire insulation type:

Standard type:

- Single Jacket - HMWPE
- Double Jacket - HMWPE/PVC
- Double Jacket - XLPE/PVC
- Single Jacket - PVDF
- Double Jacket - XLPVDF/HMWPE

Chlorine resistant type:

- Lead wire length:
- Lead wire insulation color:

Part 2
Carbonaceous backfill for impressed current anodes

1 Scope

This Part of IPS-M-TP-750 covers the minimum requirements for the supply of carbonaceous backfill for use in shallow and deep-well type impressed current ground beds.

Notes:

1) The term "carbonaceous backfill" has been used to describe the conductive backfill materials used to surround ground bed anodes to lower the total resistance of the ground bed, to improve current distribution, to prolong anode life, and to provide a permeable medium for migration of gases.

2) In case of local purchase, the specification can be tolerated to some extent.

2 References

Throughout this Standard the following dated and undated standards/codes are referred to. These referenced documents shall, to the extent specified herein, form a part of this standard. For dated references, the edition cited applies. The applicability of changes in dated references that occur after the cited date shall be mutually agreed upon by the Company and the Vendor. For undated references, the latest edition of the referenced documents (including any supplements and amendments) applies.

2.1 ISO 334, Solid mineral fuels-determination of total sulphur-eschka method

2.2 ISO 562, Hard coal and coke-determination of volatile matter

2.3 ISO 567, Coke-determination of the bulk density in a small container

2.4 ISO 609, Solid mineral fuels-determination of carbon and hydrogen-High temperature combustion method

2.5 ISO 625, Solid mineral fuels-determination of carbon and hydrogen-Liebig method

2.6 ISO 687, Solid mineral fuels coke-determination of moisture in the general test sample analysis sample

2.7 ISO 1013, Coke-determination of bulk density in a large container

2.8 ISO 1171, Solid mineral fuels-Determination of ash

2.9 ISO 18283, Hart coal and coke-Manual sampling

2.10 ISO 2325, Coke-size analysis (nominal top size 20 mm or less)

3 Definitions and terminology

3.1

ash

Inorganic residue remaining after ignition of combustible substances, determined by definite prescribed methods.

Note: Ash may not be identical, in composition or quantity, with the inorganic substances present in the material before ignition.

3.2

bulk density

The mass in air per unit volume of bulk material, including the voids within and between particles.

3.3

coke

A carbonaceous solid produced from coal, petroleum, or other materials by thermal decomposition with passage through a plastic state.

3.4

coke breeze

The fine screenings from crushed coke or from coke as taken from the ovens, of a size varied in local practice, but usually passing a 12.5 mm screen opening.

3.5

dry screening

The screening of solid materials of different sizes without the aid of water.

3.6

fixed carbon

In the case of coal, coke, and bituminous materials, the solid residue other than ash, obtained by destructive distillation, determined by definite prescribed methods.

Note: It is made up principally of carbon, but may contain appreciable amounts of sulfur, hydrogen, nitrogen, and oxygen.

3.7

screening

The separation of solid materials of different sizes by causing part to remain on a surface provided with apertures through which the remainder passes.

3.8

sieve analysis

The process or result of the division of a sample into size fractions by the use of test sieves.

3.9

wetting agent

A reagent to reduce the interfacial tension between a solid and a liquid and so to facilitate the spreading of the liquid over the solid surface.

3.10

wet screening

The screening of solid materials of different sizes with the aid of water, normally in the form of a spray.

4 Units

This Standard is based on International System of Units (SI), as per IPS-E-GN-100 except where otherwise specified.

5 Documentation

5.1 The manufacturer/supplier shall provide sufficient information to identify the **coke** and shall supply the technical information as a minimum requirement as follows:

- **a.** ISO 9001 certification for manufacturing and quality control of the coke to be used for impressed current cathodic protection system issued by an international recognized body;
- **b.** Original technical catalogue and data sheet, manufacturing procedure specification, quality control plan[2], application procedure recommendation and guidelines;
- **c.** All laboratory and shop testing shall be documented. The coke shall be traceable to the manufacturing batch. Shipping, handling and storage procedures shall ensure that coke bags are not damaged;
- **d.** Certificate of analysis according to reference standards for each type of coke.

Note 1: Manufacturing procedures shall cover all stages of the manufacturing process, from receipt of raw materials to finishing and packing for shipment, including:

- **a.** Chemical analysis;
- **b.** Particle size;
- **c.** Inspection and testing procedures and frequencies;
- **d.** Coke manufacture;

Note 2: The quality control at the **coke** manufacturing plant shall include control systems on the following:

- **a.** Raw materials, i.e. checking of documentation;
- **b.** Production equipment and process;
- **c.** Testing during and after production;
- **d.** Identification of coke;
- **e.** Chemical analysis;
- **f.** Particle size;

g. Documentation (material certificates).

6 Quality assurance

Manufacturer shall operate an effective, documented quality system based on the relevant part of the ISO 9001 and maintain records identifying the product, date of manufacturing, batch numbers and all results of inspections and testing.

7 Classification

Carbonaceous backfill material, as will be specified by the Purchaser, shall be one of the following types:

Type 1: Coal coke breeze

Type 2: Calcined petroleum coke breeze

Type 3: Special calcined petroleum coke breeze

Note: Types 1 and 2 coke breeze are to be used for shallow (horizontal or vertical) Groundbeds and type 3 coke breeze for deep well Groundbeds.

8 Requirements

8.1 Composition

8.1.1 Type 1 backfill material:

Backfill shall be coal coke breeze of low resistivity and low ash content. The coke breeze may be treated by the addition of 10% (by weight) of commercial grade slaked lime.

The proposed material shall have the properties of Table 1.

Table 1- Type 1 backfill material (coal coke breeze)

Property		Unit	Requirement	Test method
Carbon content	(min.)	wt%	80 (dry)	ISO 609 or ISO 625
Moisture content	(max.)	wt%	10	ISO 687
Ash content	(max.)	wt%	15	ISO 1171
Total Sulphur content	(max.)	wt%	1.5	ISO 334
Volatile matter content	(max.)	wt%	5	ISO 562

8.1.2 Type 2 backfill material

Backfill shall be petroleum coke calcined (heat treated) to remove all other petroleum products, other than carbon, and shall be supplied in granular form. Lime in a proportion of 10% by weight of coke breeze shall be added to the product.

The proposed material shall have the properties of Table 2.

Table 2- Type 2 backfill material (petroleum coke breeze)

Property	Y	Unit	Requirement	Test method
Carbon content	(min.)	wt%	90 (dry)	ISO 609 or ISO 625
Moisture content	(max.)	wt%	10	ISO 687
Ash content	(max.)	wt%	7	ISO 1171
Total Sulphur content	(max.)	wt%	1.2	ISO 334
Volatile matter content	(max.)	wt%	3	ISO 562

8.1.3 Type 3 backfill material

Backfill shall be petroleum coke calcined (heat treated) to remove all other petroleum products, other than carbon, specially formulated to facilitate pumping, settling, and compaction of carbon lubricants. The product shall contain 0.1% wetting agent to enhance setting of the granular particles and water absorption of the backfill. It shall have round, uncrushable shape.

The proposed material shall have the properties of Table 3.

Table 3- Type 3 backfill material (special petroleum coke breeze)

Property		Unit	Requirement	Test method
Carbon content	(min.)	wt%	95 (dry)	ISO 609 or ISO 625
Moisture content	(max.)	wt%	1	ISO 687
Ash content	(max.)	wt%	3	ISO 1171
Total Sulphur content	(max.)	wt%	1	ISO 334
Volatile matter content	(max.)	wt%	1	ISO 562

8.2 Bulk Density

The bulk density of backfill materials on dry packed basis shall conform to the following range:

Table 4- Bulk density

TYPE	BULK DENSITY (kg/m^3)	TEST METHOD
1	650-800	ISO 1013 or ISO 567
2	700 - 1100	
3	1050 - 1200	

8.3 Resistivity

For Types 1 and 2 backfill material the resistivity shall be less than 100 and 50 ohm-cm respectively when dry and lightly tamped and prior to the addition of lime. For Type 3 backfill material the resistivity of the tamped (at 10.55 kg/cm^2) dry backfill shall not exceed 0/1 ohm-cm.

8.4 Particle size

The particle sizes of backfill materials shall conform to the following size distribution as demonstrate in table 5:

Table 5- Particle sizes of backfill materials

Type	Particle size range	%
1	Less than 10 mm	100
	Greater than 1 mm	90
2	Less than 3 mm	100
	Greater than 0.5 mm	90
3	Less than 1.0 mm	100
	Less than 0.6 mm	80
	Greater than 0.4 mm	90
	Greater than 0.15 mm	99

The test method shall be in accordance with ISO 2325

9 Packaging for shipment

The materials purchased according to this Standard specification shall be packaged in suitable containers to ensure acceptance and safe delivery to their destination.

The backfill shall be supplied in 25 kg bags, in 1 tone containers or other suitable containers as specified by the Purchaser.

The method of shipment, as will be specified by the Purchaser, may be either double bagged or bulk in accordance with following:

Double bagged-packaging shall be double packing in bags, the inner bag being woven polypropylene, the outer bag can be hessian but not polyethylene which is subject to U.V deterioration and temperature distortion.

Bulk-method of shipping shall be agreed upon by the Purchaser and supplier.

10 Sampling for inspection

Sampling shall be in accordance with ISO 2309.

The numbers and types of test specimens shall be in accordance with the ISO test method for the specific properties to be determined.

11 Inspection and testing

11.1 All materials supplied under this Standard specification shall be subject to timely inspection by the Purchaser or his authorized representative. The Purchaser shall have the right to reject any material(s) supplied which is (are) found to be defective under this Part of Standard specification. In case of dispute, the arbitration or settlement procedure, established in the procurement documents shall be followed.

11.2 The supplier shall be responsible for the performance and costs for all laboratory test requirements as specified in this Part of Standard specification. The supplier shall set up and maintain such quality assurance and inspection systems as are necessary to ensure that the materials comply in all respects with the requirements of this Part of Standard specification.

11.3 Purchaser's inspector(s) shall have free access to the supplier's work to follow up the progress of the materials covered by this Part of Standard specification and to check the quality of materials. The supplier shall place free of charge at the disposal of the Purchaser's inspector(s) all means necessary for carrying out their inspection results of tests, checking of conformity of materials to this Part of Standard specification, checking of marking and packing and temporary acceptance of materials.

11.4 The supplier shall furnish the Purchaser with a certified copy of results of tests made by the manufacturer covering physical and performance characteristics of each batch of product to be supplied under this Part of Standard specification. The supplier shall furnish, or allow the Purchaser to collect samples of the material representative of each batch of product. Certified test reports and samples furnished by the supplier shall be properly identified with each batch of product.

11.5 Supplier shall submit to the Purchaser a typical analysis, and the test methods used, of a random sample of backfill material giving following information:

- Moisture content.
- Carbon content.
- Ash content.
- Particle size distribution.
- Bulk density.
- Resistivity.

Supplier shall perform screening tests on samples of the backfill to ensure compliance with the particle size requirements.

12 Labeling

Each package or container of backfill material shall be marked with the following information:

Name: .....

Specification: IPS-M-TP-750: Part 2 .....

Order No.: .....

M.E.S.C No.: .....

Type or trade name of backfill: .....

Weight (gross and net): .....

Batch No.: .....

Stock No.: .....

Date of manufacture: .....

Storage conditions: .....

Trademark of the manufacturer: .....

Manufacturer's name and address: .....

Part 3
Galvanic anodes for underground applications
(Magnesium and zinc)

1 Scope

This Part of IPS-M-TP-750 covers the minimum requirements for galvanic (sacrificial) anodes for use in the cathodic protection of buried structures against corrosion. It specifies the compositions, materials, manufacture, properties, inspection and testing for magnesium and zinc anodes. It also includes details of backfill compositions and properties, for magnesium and zinc anodes. This specification covers only the general requirements for the anodes, the specific requirements will be given in pertinent ordering documents by the Purchaser (see Appendices A and B).

2 References

Throughout this Standard the following dated and undated standards/codes are referred to. These referenced documents shall, to the extent specified herein, form a part of this standard. For dated references, the edition cited applies. The applicability of changes in dated references that occur after the cited date shall be mutually agreed upon by the Company and the Vendor. For undated references, the latest edition of the referenced documents (including any supplements and amendments) applies.

2.1 IPS-E-GN-100, Engineering standards for units

2.2 AWS d1.1/D1.1M, Structural welding code-steel

2.3 ASTM A 36, Standard specification for structural steel

2.4 ASTM A 283, Standard specification for low and intermediate tensile strength carbon steel plates

2.5 ASTM B 6, Standard specification for zinc

2.6 ASTM B 843, Standard specification for magnesium alloy anodes for cathodic protection1

2.7 ASTM B 275, Standard practice for codification of certain nonferrous metals and alloys, cast and wrought

2.8 ASTM B 418, Standard specification for cast and wrought galvanic zinc anodes

2.9 ASTM D 1047, Standard specification for poly (vinyl chloride) jacket for wire and cable

2.10 ASTM D 1351, Standard specification for polyethylene insulation for electrical wire and cable

2.11 ASTM D 2219, Standard specification for poly (vinyl chloride) insulation for wire and cable

2.12 ASTM D 2655, Standard specification for cross-linked polyethylene insulation for wire and cable

2.13 ASTM G 97, Laboratory evaluation of magnesium sacrificial anode test specimens for underground applications

2.14 IEC 228, Nominal cross-section areas and composition of conductors of insulated cables

2.15 BSI EN 287-1, Qualification test of welders - fusion welding - Part 1: Steels

2.16 BSI EN 10025, Hot rolled products of structural steels

2.17 BSI EN 287-1, Qualification test of welders. fusion welding steels

2.18 EN 12496, Galvanic anodes for cathodic protection in seawater and saline mud

2.19 ISO 15589-1, Petroleum, petrochemical and natural gas industries - Cathodic protection of pipeline systems - Part 1: On-land pipelines

2.20 ISO 15589-2, Petroleum, petrochemical and natural gas industries - Cathodic protection of pipeline transportation systems - Part 2: Offshore pipelines

2.21 ISO 2859-1, Sampling procedures for inspection by attributes - Part 1: Sampling plans indexed by acceptable quality level (AQL) for lot-by- lot inspection

2.22 ISO 8044, Corrosion of metals and alloys - Basic terms and definitions

2.23 ISO 10474, Steel and steel products - Inspection documents

2.24 ISO 15607, Specification and qualification of welding procedures for metallic materials - General rules

2.25 ISO 15609-1, Specification and qualification of welding procedures for metallic materials - Welding procedure specification - Part 1: Arc welding

2.26 ISO 1461, Hot dip galvanized coatings on fabricated iron and steel articles - Specifications and test methods

2.27 ISO 2081, Metallic and other inorganic coatings - Electroplated coatings of zinc with supplementary treatments on iron or steel

2.28 ISO 8501-1, Preparation of steel substrates before application of paints and related products - Visual assessment of surface cleanliness - Part 1: Rust grades and preparation grades of uncoated steel substrates and of steel substrates after overall removal of previous coatings

2.29 DNVGL-RP-B401, Cathodic protection design

2.30 NACE TM0190, Impressed current laboratory testing of aluminum and zinc alloy anodes

2.31 NACE SP0387, Metallurgical and inspection requirements for cast galvanic anodes for offshore applications

3 Definitions and terminology

For the purpose of this Standard, the definitions below apply:

3.1

anode backfill

Material surrounding and in contact with a buried anode to maintain or improve its performance.

3.2

anode consumption rate

The rate of alloy mass consumption for a given current output over a given period; normally stated in kilograms per ampere year.

3.3

anode core

A metal insert (usually steel) either cast into the anode or extruded with the anode to provide mechanical strength and attachment.

3.4

cast sacrificial anode

The negative (reactive) component of a galvanic cell, designed to oxidize sacrificially and produce direct electrical current to protect a more electropositive (noble) metal operating in the same electrolyte and produced to a desired shape by the solidification of a molten alloy in a mold or die.

3.5

cathodic protection

The prevention or reduction of corrosion of metal by making the metal the cathode in a galvanic or electrolytic cell.

3.6

certificate of conformity

A statement made by the producer's representative (executive) and endorsed by a representative of the Purchaser that the anodes listed comply with the requirements of the order.

3.7

cold lap

Horizontal discontinuity caused by solidification of the meniscus of a partially cast anode as a result of interrupted flow of the casting stream. The solidified meniscus is covered with metal when the flow resumes. Cold laps can occur along the length of an anode.

3.8

cold shut

Horizontal surface discontinuity caused by solidification of a portion of a meniscus during the progressive filling of a mold, which is later covered with more solidifying metal as the molten metal level rises. Cold shuts generally occur at corners remote from the point of pour.

3.9

cracking

Fracture of metal along an irregular path producing a discontinuity similar to a ragged edge. It can occur during the solidification of the anode (hot cracking), during the contraction of the anode after solidification, or under externally applied loads. Hot cracking may be associated with the shrinkage depression can occur in open-topped molds.

3.10

current capacity

The total current flow available from an anode of given mass of alloy; normally expressed as ampere years per kilogram. This is the inverse of the anode consumption rate.

3.11

current density

The average amount of current entering or leaving a given surface area.

3.12

driving potential

The difference between the open circuit potentials of the anode and the structure.

3.13

dulling of zinc

Deterioration in appearance of zinc-coated inserts because of oxidation that produces a white bloom of zinc oxide.

3.14

electrochemical properties

Those properties of potential and current capacity that characterize a sacrificial anode and can be assessed by quantitative tests.

3.15

galvanic anode

An electrode used to protect a structure by galvanic action.

3.16

gas holes

The evidence of bubbles within the metal. The holes can indicate that moisture was on the mold or insert prior to casting, or that the liquid metal contained a high level of hydrogen that had been thrown out of solution to form bubbles during the cooling of the metal.

3.17

gross anode mass

Total mass of an anode, including anode core, and backfill (if a packaged anode).

3.18

heat

Also called a “melt” or “cast”, it is the unit that defines molten metal and identifies the anodes cast from it. A heat is the product that is cast to a planned procedure in one melting operation in one furnace, without significant interruption. If the casting sequence is interrupted, the anodes produced before, between and after the interruptions constitute “batches”.

3.19 net anode mass

Mass of actual anode alloy.

3.20

nonmetallic inclusions

Particles of oxides and other refractory materials entrapped in liquid metal during the melting or casting sequences.

3.21

open circuit potential

The potential of an anode when not connected to a structure; normally measured against a reference electrode in a particular environment.

3.22

packaged anode

Either a magnesium or zinc anode placed, with backfill, in a calico bag or other approved container to provide a uniform low resistivity environment for the anode.

3.23

porosity

Generally distributed fine holes caused by gas bubbles, shrinkage (formed by the starvation of eutectic material within the dendrite arms during "unfed" solidification), or a combination of the two mechanisms when hydrogen in solution diffuses into the lower pressure shrinkage voids.

3.24

protrusion

Extraneous material on the anode surface. It may interfere with the anode-to-structure fit, appear unattractive, and be a safety hazard if there are sharp edges. Protrusions can be formed by careless filling of the mold or the flash from imperfect fitting of mold sections.

3.25

reference electrode

An electrode which has a stable potential in one or more electrolytes, thus enabling it to be used for the measurement of other electrode potentials at a given temperature.

3.26

shrinkage depression

The natural concave surface produced when liquid metal is allowed to solidify in a container without the provision of extra liquid metal to compensate for the reduction in volume that occurs during the liquid-solid transformation. The term also applies to the concave surface produced when liquid metal is solidified in a closed mold in such a manner that the area is not "fed" by the liquid metal provided by the casting's riser.

3.27

test anode

A prepared anode test piece, made from a test specimen by a mechanical operation.

3.28

test sample

A portion of material or a group of items selected from a batch or consignment by a sampling procedure.

3.29

test specimen

A portion of material or a single item taken from the test sample for the purpose of applying a particular test.

3.30

anode utilization factor

The anode utilization factor, u, is the fraction of anode material of an anode with a specific design that may be utilized for calculation of the net anode mass required to sustain protection throughout the design life of a CP system. When an anode is consumed to its utilization factor, the polarizing capacity (as determined by the anode current output) becomes unpredictable due to loss of support of anode material, or rapid increase of anode resistance due to other factors.

3.31

lot

Defined quantity of a thing used as a unit of inventory, output, sale, sampling, or transportation. Items in a lot are of a single class, composition, model, size, type, or version, are produced under essentially the same conditions, and are intended to have uniform quality and characteristics within specified limits. A lot is ordered, sold, released, or delivered in its entirety.

4 Units

This Standard is based on International System of Units (SI), except where otherwise specified.

5 Technical documents

5.1 The manufacturer/supplier shall provide sufficient information to identify the anode and shall supply the technical information as a minimum requirement as follows:

- **a.** ISO 9001 certification for design, manufacturing and quality control of the anodes to be used for sacrificial cathodic protection installation, issued by an internationally recognized body;
- **b.** Original technical catalogue and data sheet, manufacturing procedure specification, quality control plan, application procedure recommendation and guidelines (installation instructions) ;
- **c.** Filled, signed and stamped data sheets as shown in Appendices A, B.C and D
- **d.** All laboratory and shop testing shall be documented. The anodes shall be traceable to the manufacturing batch. Shipping, handling and storage procedures shall ensure that the anodes and lead wire are not damaged.
- **e.** Certificate of current output and anode consumption rates at maximum current density for various application in accordance with reference Tables for each type of anodes.
- **f.** Certificate of analysis according to reference standards for each type of anodes

5.2 Manufacturing procedures shall cover all stages of the manufacturing process, from receipt of raw materials to finishing and packing for shipment, including:

- **a.** Chemical analysis;
- **b.** Measurements of weight, dimensions, etc.;
- **c.** Inspection and testing procedures and frequencies;
- **d.** Anode manufacture;

e. Electrochemical test procedures, including acceptance criteria, description of test apparatus, measurement methods and preparation and cleaning of samples
f. Anode connections.

5.3 The quality control at the anode manufacturing plant shall include control systems on the following:

a. Raw materials, i.e. checking of documentation.
b. Production equipment and process.
c. Testing during and after production.
d. Identification of anodes.
e. Chemical analysis.
f. Weight and dimensional tolerances.
g. Surface condition of produced anodes.
h. Documentation (material certificates).

6 Quality assurance

Manufacturer shall operate an effective, documented quality system based on the relevant part of the ISO 9001 and maintain records identifying the product, date of manufacturing, batch numbers and all results of inspections and testing.

7 Classification

For buried pipeline applications, the two main anode materials used are zinc and magnesium alloys. Aluminum anodes shall not be used in buried conditions in electrolyte except where the chloride content of the electrolyte is high enough. Other alloys may be used providing the reliability of their performance in electrolytes is demonstrated.

The anodes, as will be specified by the Purchaser (see Appendices A and B), shall be one of the following types:

Type I: Cast anodes.

Type II: Extruded rod (or ribbon) anodes.

8 Materials and manufacture

8.1 General

8.1.1 Anodes shall be manufactured by any suitable casting or extruding process. The anode material shall be cast or extruded around a steel insert (core) so designed as to retain the anode material even when it is consumed to its design utilization factor.

8.1.2 Manufacturing of anodes shall be carried out using approved production procedures covering each stage of the process from supply of raw materials to finishing and packing for shipment. The procedures shall be fully referenced in an Inspection and Test plan which shall also refer to requirements of this Standard specification, as applicable. The manufacturer shall ensure that full traceability of all the materials is maintained throughout manufacture and

thereafter.

8.1.3 The supplier shall submit to the Purchaser his quality assurance and control plan. The quality control at the anode manufacturing plant shall include control systems on the following:

- Raw materials, i.e., checking of documentation.
- Production equipment and process.
- Testing during and after production.
- Identification of anodes.
- Chemical analysis.
- Weight and dimensional tolerances.
- Surface condition of produced anodes.
- Documentation (material certificates).

8.1.4 The cast anodes may be supplied bare or packaged in a permeable cloth bag containing a rapid wetting and moisture retaining backfill (see 9), which reduces the electrolyte resistivity adjacent to the anode and improves performance, as will be required by the Purchaser (see Appendices A and B).

8.2 Anode composition

Anodes shall be manufactured from virgin materials as determined by approved spectrographic and analytical procedures due to an approved chemical composition. The anodes should meet the requirements of Table 1 and 2 for chemical analysis depending on the intended application.

Notes:

1) The chemical analysis of the anode samples may be carried out either at the time they are cast, or at the finished or semi-finished product stage.

2) The electrochemical properties are highly dependent on the content of alloying elements and impurity elements. The anode manufacturer shall thus prove his capability of delivering anodes which satisfy this Standard specification.

3) Small deviations from the specification in the alloy composition may significantly reduce the protective properties. Generally, it is of importance that the fabrication procedure ensures that the melt is not polluted by iron or other impurities. Furnaces, pumps, pipes, etc., shall be non-metallic or properly lined.

Table 1- Chemical composition for magnesium anodes given as mass fraction in percent

Element	Alloy M 1[a]	Alloy M 2
	Mass, %	Mass, %
Mn	0.15 to 0.7	0.5 to 1.5
Al	5 to 7	0.05 max
Zn	2 to 4	0.03 max
Fe	0.005 max	0.03 max
Cu	0.08 max	0.02 max
Si	0.3 max	0.05 max
Pb	0.03 max	0.01 max
Ni	0.003 max	0.002 max
Other elements	Total: 0.30 max	Each: 0.05 max
Mg*	Remainder	Remainder

a: Alloy M 1 is normally supplied in accordance with ASTM B843–09.

Table 2- Chemical composition for zinc anodes given as mass fraction in percent

Element	Alloy Z 1[a]	Alloy Z 2[b]	Alloy Z 3
	Mass, %	Mass, %	Mass, %
Al	0.1 to 0.5	0.005 max	0.10 to 0.20
Cd	0.025 to 0.07	0.003 max	0.04 to 0.06
Fe	0.005 max	0.0014 max	0.0014 max
Cu	0.005 max	0.002 max	0.005 max
Pb	0.006 max	0.003 max	0.006 max
Sn	---	---	0.01 max
Mg	---	---	0.5 max
Other elements total	0.10 max	0.005 max	0.01 max
Zn*	99.314 min	99.99 min	Remainder

a: Alloys Z1 is normally supplied in accordance with US. MIL-A-18001-K-93 or to ASTM B418–12, Type I.

b: Alloy Z2 is often termed “high purity zinc” and is normally supplied in accordance with ASTM B418–12, Type II.

8.3 Anode core

8.3.1 The magnesium anode core shall be made from commercial steel conforming to ASTM specification A 283, Grade C or equivalent standard.

8.3.2 The zinc anodes shall have steel cores conforming to ASTM specification A 36.

8.3.3 The position of the anode core shall be such that the maximum possible mass of anode material is available to provide cathodic protection.

8.3.4 Anode core steel for zinc and magnesium anodes shall be blast-cleaned to the minimum standard Sa 2½ in accordance with ISO 8501-1 to ensure that the requirements of 8.5 and 8.6 can be achieved. The degree of cleanliness shall be maintained until casting.

8.4 Production testing

The manufacturer shall carry out the following tests:

A full spectrographic analysis, or an approved alternative, of each cast. The results shall meet the requirements of Table 1 (for magnesium anodes) or Table 2 (for zinc anodes).

An electrochemical performance test for each cast. The test shall be carried out by the manufacturer in accordance with approved procedures designed to demonstrate batch consistency of the as cast electrochemical properties.

9 Requirements

9.1 Performance properties of magnesium anodes

Any anode must be capable of a sufficient driving voltage to provide the necessary design current output. The performance properties of anode alloys shall be in accordance with Table 3.

When installed in soil for pipeline applications, magnesium anodes should be used with anode backfill. Magnesium anode, even with backfill, should not be used if the resistivity of the soil is higher than 100 Ω.m unless the engineering evaluation or field tests confirm that the design requirements can be met

Table 3- Typical electrochemical parameters for magnesium anodes used in soils

Parameter	Alloy M 1 mass %	Alloy M 2 mass %
Open circuit potential (V versus saturated Cu/CuSO4)	-1.57 to -1.60	-1.77 to -1.82
Closed circuit potential (V versus saturated Cu/CuSO4)	-1.52 to -1.57	-1.64 to -1.69
Practical electrochemical capacity (A·hr/kg)	1100	1100
Practical consumption rate (kg/A·yr)	7.5	7.5

9.2 Performance properties of zinc anodes

Any anode must be capable of a sufficient driving voltage to provide the necessary design current output. The performance properties of anode alloys shall be in accordance with Table 4.

When installed in soil for pipeline applications, zinc anodes shall be used with anode backfill, except when soil contains chlorides or sulphates. In environments where carbonates, bicarbonates, or nitrates dominate, the potential of the zinc becomes very noble due to the presence of passivating surface films. This effect can reduce the zinc anode efficiency. This phenomenon doesn’t appear if the electrolyte contains sulphates or chlorides.

Zinc anodes, even with backfill, should not be used if the resistivity of the soil is higher than 50 Ω.m, unless the engineering evaluation or field test confirms that the design requirements can be met.

Zinc anodes should not be used at temperatures exceeding 50°C unless their performance is supported by appropriate test data to the contrary. Inter granular corrosion and/or a reduction in electrochemical capacity is the main problems for zinc anodes at elevated temperatures.

Table 4- Typical electrochemical parameters for Zinc anodes used in soils

Parameter	Properties
Open circuit potential (V versus saturated $Cu/CuSO_4$)	-1.05 to -1.10
Closed circuit potential (V versus saturated $Cu/CuSO_4$)	-1.00 to -1.05
Practical electrochemical capacity (A·hr/kg)	780
Practical consumption rate (kg/A·yr)	11.2

9.3 Workmanship, finish, and appearance

9.3.1 The anodes shall be free of flash burrs, cracks, blow holes, and surface slag consistent with good commercial practice. The cast anodes shall be free of shrinkage cavities exceeding 6 mm (¼ inch) in depth, except that anodes 50 mm (2 inch) thick or more shall be free of shrinkage cavities exceeding 9.5 mm (3.8 inch) in depth, when measured from a straight edge placed diagonally across the opposite edges of the anode.

9.3.2 Metal core extensions from the anodes shall be smooth and free of sharp burrs. The cast-in cores shall have metallurgical bonds specified herein free of air pockets and inclusions consistent with good commercial practice.

9.3.3 The anode lead wire insulation shall be continuous having a thickness as uniform as possible and shall be completely free of nicks, scratches, or other discontinuities.

9.4 Mechanical resistance

When a uniaxial force equivalent to 100 kg, or five times the mass of the anode metal, whichever is the greater, is applied to a cast anode containing a core, no movement of the core or any metal insert shall occur. Where a cable is provided, a uniaxial loading of 100 kg shall not result in damage to the cable or its connections.

9.5 Electrical resistance

When determined in accordance with the test method in Appendix C, the electrical resistance of the anode to core or, if appropriate, of the anode to the end of the cable, shall be not greater than 0.01 for the life of the anode.

9.6 Anode dimensions and weights

The calculation for determining the anode mass shall take into account a utilization factor, u, corresponding to the shape deterioration of the anode with time. Except when otherwise specified, a value of 0.80 should be used for this factor.

9.6.1 Magnesium anodes

9.6.1.1 The cast anode (Type I) dimensions and weights (nominal), as will be specified by the Purchaser (see Appendix A), should be as follows:

Table 5- Magnesium cast anode (Type I) dimensions and weights

Weigh Kg (lbs)	Dimensions (mm) A	B	C	Total packaged Weight (Approx.) Kg
4.1 (9)	90	90	350	10
7.7 (17)	90	90	650	20
14.5 (32)	140	140	540	30
21.8 (48)	140	140	820	45

9.6.1.2 The Type II anodes dimensions and weight (nominal) should be as follows:

Table 6- Magnesium anodes (Type II) dimensions and weight

Magnesium weight:	370 g/m
Cross section:	9.5 × 19 mm
Core diameter:	3.2 mm
Coil length:	300 m (unless otherwise specified by
	Purchaser), (see Appendix A).

9.6.2 Zinc anodes

9.6.2.1 The cast anode (Type I) dimensions and weights (nominal), as will be specified by the Purchaser (see Appendix B), should be as follows:

Table 7- Zinc cast anode (Type I) dimensions and weights

Weigh Kg (lbs)	Dimensions (mm) W	H	L
2.3 (5)	35	35	230
5.5 (12)	35	35	610
8.2 (18)	35	35	915
13.6 (30)	50	50	760
14.5 (32)	35	35	1525
20.5 (45)	50	50	1140
27.3 (60)	50	50	1525

9.6.2.2 The Type II anode dimensions and weights (nominal), as will be specified by the Purchaser (see Appendix B), should be as follows:

Table 8- Zinc cast anode (Type II) dimensions and weights

Weigh kg/m (lb/ft)		Cross Section (mm)	Coil length* (m)
1.8	(1.2)	15.8×22.2	60
0.9	(0.6)	12.7×14.2	150
0.37	0.25)	8.7×11.9	300

* Unless otherwise specified by the Purchaser (see Appendix B.3).

9.6.3 Dimensions and weights tolerances shall conform to the following:

9.6.3.1 Anode mean length shall not deviate more than 3% of nominal length.

9.6.3.2 Anode mean width shall not deviate more than 3% of nominal width.

9.6.3.3 The straightness of the anode shall not deviate more than 2% of the anode nominal length from the longitudinal axis of the anode.

9.6.3.4 The permissible variation in weight of each finished anode will be plus or minus 5% of the nominal weight.

9.6.3.5 The total contract weight shall be no more than 2% above and not below the nominal contract weight.

9.7 Methods of attachment of cable for cast anodes

9.7.1 The cast anodes shall be supplied complete with cables connected to the anode core. One end of the anode should be recessed to provide cavity for attachment of the lead wire to the anode core and subsequent sealing of this connection. The method of connecting the lead wire to anode core shall be either by the use of a brazed connection or silver solder connection or any other approved method. The connection shall be so to bear the weight of the anode. The lead wire to anode core connection shall be sealed to prevent water intrusion by application of a potting compound (e.g. Epoxy resin) or mastic-lined polyethylene heat-shrink sleeve to completely seal the connection and to protect the joint mechanically. For Magnesium anodes, typical methods of attachment are shown in Figs. 1 and 2. For zinc anodes, a typical method of attachment is shown in Fig. 2.

9.7.2 The lead wires shall be 6 sq. mm single core, stranded soft annealed copper conductor conforming to IEC Publication 228, Class 2 or ASTM specification B 8 Class B, and 5 meter in length.

9.7.3 The lead wire insulation, as will be specified by the Purchaser (see Appendices A and B) shall be in accordance with one of the following alternatives:

A single jacket of High Molecular Weight Polyethylene (HMWPE) insulation conforming to ASTM specification D 1351, having a minimum thickness of 1.5 mm.

A single jacket of Cross-Linked Polyethylene (XLPE) insulation conforming to ASTM

specification D 2655, having a minimum thickness of 1 mm.

A double jacket of Polyvinyl Chloride (PVC) primary insulation conforming to ASTM specification D 2219, sheathed with a polyvinyl chloride jacket conforming to ASTM specification D 1047. The average insulation (of insulation and sheath), shall be 2 mm with a 10% tolerance.

9.7.4 Lead wire insulation shall have a minimum of 600 Volt rating.

9.7.5 The color of the insulation of anode cables should be red, unless otherwise specified by the Purchaser.

9.8 Identification of anodes

Each anode shall be clearly marked with the type of material (trade name), the cast number, and a piece serial number. The numbers of any rejected anodes shall not be used again for replacement anodes.

10 Chemical backfill for galvanic anodes

For galvanic anodes, only electrolytic conduction backfills shall be used. They should consist of a mixture of bentonite clay for water retention, gypsum and sodium sulfate to improve the local conductivity around the anodes. The required composition of the anode backfill material shall be included in the anode specification. The composition of backfill shall be determined such that the local resistivity is lowered and the buildup of insulating corrosion products around the anode surface is prevented.

Note: Gypsum helps to minimize the anodic polarization of the anode, mainly for zinc anodes.

When zinc anodes used without backfill, zinc anodes can become covered with non-conductive corrosion products that can reduce their current output. Seawater alloy anodes are specially formulated to reduce this tendency in seawater. When used in soil containing high levels of oxygen, carbonates or phosphates, backfill should be used with zinc anodes in order to reduce the possibility of the buildup of these corrosion products. For magnesium anodes used in soil, the use of backfill is required in most cases and is highly desirable in most instances.

10.1 Backfill composition

When specified by the Purchaser, the cast anodes shall be supplied with backfill. The backfill surrounds, as will be specified by the Purchaser, with reference to Table 9 should be in accordance with the nominal composition.

Table 9- Backfill composition

Gypsum ($CaSO_4$)%	Bentonite Clay %	Sodium Sulfate %	Approx. Resistivity in Ohm-cm
75	20	5	50

10.2 Backfill analysis

The manufacturer shall submit to the Purchaser a typical analysis of a random sample of backfill material giving the following information:

- Moisture content.
- Gypsum content.
- Bentonite content.
- Sodium sulfate content (if any).

The manufacturer shall perform screening tests on samples of the backfill to ensure backfill is in the form of a fine powder.

10.3 Anode packaging

Anodes shall be packed in a calico bag, or in some other type of approved porous container. The diameter of the packaging shall be at least 50 mm greater than the diagonal of the anode. The backfill shall be tightly packed in the bag to prevent movement of the anode and shall achieve the following coverage around the anode:

- A minimum of 25 mm of cover on corners, measured diagonally.
- A minimum of 50 mm of cover on the top, bottom and sides.

The backfill shall be firmly held around the anode, the whole shall be vibrated during filling to ensure compaction.

The container shall be sealed to minimize moisture intrusion during storage and shipment and to ensure against loosening or loss of backfill.

11 Sampling

11.1 Lot

Unless otherwise specified by the Purchaser, a lot shall consist of all anodes made from the same production run offered for inspection at one time.

11.2 Sampling for inspection

Sample anodes shall be selected from each lot in accordance with inspection level II of ISO 2859 (Part 1). The Acceptable Quality Level shall be 4 percent for all visual, dimensional and weight defects combined and 2.5 percent for all other type of defects with reference to this Part of Standard specification. The single sampling plans for normal inspection (Table IIA of ISO 2859 (Part 1) shall be used.

12 Rejection

Where the numbers of anodes that do not conform to this Part of Standard specification exceed the acceptance numbers specified in 10.2, the entire lot shall be rejected.

13 Inspection

13.1 Responsibility for inspection

13.1.1 The manufacturer and/or supplier shall be responsible for carrying out all the tests and inspections (during and after fabrication) required by this Part of Standard specification, using his own or other reliable facilities, and he shall maintain complete records of all such tests and inspections. Such records shall be available for review by the Purchaser.

13.1.2 The manufacturer and/or supplier shall afford the purchaser's inspector all reasonable facilities necessary to satisfy him that the material is being produced and furnished in accordance with this Part of Standard specification. Such inspections in no way relieve the manufacturer and/or supplier of his responsibility under the terms of this Standard specification.

13.1.3 The Purchaser reserves the right to perform any inspections set forth in this Part of Standard specification where such inspections are deemed necessary to assure that supplies and services conform to the prescribed requirements.

13.1.4 The purchaser's inspector shall have access to the material subject to inspection for the purpose of witnessing the selection of the samples, the preparation of the test samples, and the performance of the tests. For such tests, the inspector shall have the right to indicate the pieces from which the samples will be taken in accordance with the provisions of this Part of Standard specification.

13.1.5 Purchaser shall have the right to require anode sample material for verification testing in an independent laboratory, or to present samples for testing by purchaser. Purchaser may further specify that Contractor shall retain sample material for any additional chemical analyses and/or electrochemical testing.

13.2 Inspection

Inspection shall cover the following as a minimum:

- Dimensional checking, identification, weight, and quality of casting on at least 5% of the number of anodes from each cast.
- Quality of steel inserts (cores) before casting on at least 5% of inserts for the batch of anodes from each cast. Any reject inserts shall be isolated and returned to the fabricator or the electroplater for correction.
- Unless otherwise agreed, a minimum of two anodes of each size should be subject to destructive testing to verify absence of internal defects and adequate location of anode inserts. The cutting procedure and acceptance criteria in NACE SP0387 shall apply.
- Quality of insulation of the anode lead wire and each anode lead to anode seal connection to ensure absence of holes or nicks or other faults.
- Compliance of prepackaged anodes with Clause 9.4 particularly with respect to centering of the anode in the backfill.
- Inspection of results of spectro analysis, electrochemical tests, and other tests required by this Part of Standard specification.

14 Packing and shipment

Cast galvanic anodes shall be bundled, strapped, placed on pallets, or individually loaded by an agreed procedure to facilitate unloading and minimize damage to anodes and cores between the manufacturing plant and the installation site each pallet shall be plainly marked with the following information:

- Product name
- Specification
- Order No.
- Anode type and style
- Anode weight
- Anode dimensions
- Batch No.
- Date of manufacture
- Quantity
- Manufacture name and address

Note: Each pallet shall be clearly marked "FRAGILE".

15 Labeling

15.1 Anode identification

Each anode casting shall be stamped with the following:

- Name and/or trademark of the manufacturer.
- Batch number.
- Cast number.
- Alloy type (i.e., Magnesium, Zinc).

15.2 Lead wire identification

The lead wire shall be marked with the following information:

- Manufacturer's name.
- Lead wire size.
- Lead wire insulation.
- Specification.

15.3 Marking of containers

Each container shall be plainly marked with the following information:

Name of anode: (i.e., Magnesium, Zinc) anode

Specification: IPS-M-TP-750: Part 3

Order No.:

M.E.S.C. No.:

Anode type:

Anode Dimensions: Length ..... mm, Diameter ..... mm, Weight ..... kg.

Batch No.:

Stock No.:

Date of Manufacture:

Quantity:

Inspection date:

Manufacturer's name and address: .....

Shelf life:

Storage life:

MSDS warning sticker:

Note: Each crate or pallet shall be clearly marked "FRAGILE".

Appendices

Appendix A

Data sheet

(to be submitted by the purchaser) for magnesium anodes

The anodes shall be in accordance with the latest edition of above Iranian Petroleum Standard with following specific requirements:

- Project title: .....
- Indent No.: .....
- Date:
- Purchaser: ……..
- M.E.S.C. No.:
- Quantity: .....
- Type of anode:
- Anode dimensions: .....
- Anode cap type:

Standard

Chlorine resistant

- Lead wire insulation type:

Standard type:

Chlorine resistant type:

Double Jacket - PVC/PVC

Single Jacket - HMWPE

Double Jacket - HMWPE/PVC

Double Jacket - XLPE/PVC

Single Jacket - PVDF

Double Jacket - XLPVDF/HMWPE

- Lead wire length:
- Lead wire insulation color:

Anode Packaging:

- Packaged with backfill in Calico bag
- Bare anode (No backfill)
- Backfill mixture: .....

Appendix B

Data sheet

(to be submitted by the purchaser) for zinc anodes

The anodes shall be in accordance with the latest edition of above Iranian Petroleum Standard with following specific requirements:

- Project title: .....
- Indent No.: .....
- Date: ……..
- Purchaser: ……...
- M.E.S.C. No.:
- Quantity: .....
- Type of anode:
- Anode dimensions: .....
- Anode cap type:
- Standard
- Chlorine resistant
- Lead wire insulation type:

  Standard type:

  Chlorine resistant type:

Double Jacket - PVC/PVC

Single Jacket - HMWPE

Double Jacket - HMWPE/PVC

Double Jacket - XLPE/PVC

Single Jacket - PVDF

Double Jacket - XLPVDF/HMWPE

- Lead wire length:
- Lead wire insulation color:

Anode Packaging:

- Packaged with backfill in Calico bag
- Bare anode (No backfill)
- Backfill mixture: .....

Part 4

Galvanic anodes for sea water, saline mud and other submerged applications (aluminium, zinc and magnesium)

1 Scope

This Part of IPS-M-TP-750 covers the minimum requirements for supply, identification, inspection and testing of galvanic (sacrificial) anodes made of Aluminum, Zinc or Magnesium for sea water, saline mud and other submerged applications.

2 References

Throughout this Standard the following dated and undated standards/codes are referred to. These referenced documents shall, to the extent specified herein, form a part of this standard. For dated references, the edition cited applies.

The applicability of changes in dated references that occur after the cited date shall be mutually agreed upon by the Company and the Vendor. For undated references, the latest edition of the referenced documents (including any supplements and amendments) applies.

2.1 AWS d1.1/D1.1M, Structural welding code - steel

2.2 ASTM D 1141, Standard practice for the preparation of substitute ocean water

2.3 ASTM B 841-93, Standard specification for magnesium alloy anodes for cathodic protection

2.4 BS EN 12495, Cathodic protection for fixed steel offshore structures

2.5 BS EN 13173, Cathodic protection for steel offshore floating structures

2.6 BS EN 12473, General principles of cathodic protection in sea water

2.7 BS EN 12496, Galvanic anodes for cathodic protection in seawater and saline mud

2.8 BS EN 10025, Hot rolled products of structural steels

2.9 ISO 9606-1, Qualification test of welders - fusion welding - Part 1: Steels

2.10 ISO 15589-2, Petroleum, petrochemical and natural gas industries - Cathodic protection of pipeline transportation systems - Part 2: Offshore pipelines

2.11 ISO 8044, Corrosion of metals and alloys - Basic terms and definitions

2.12 ISO 13174, Cathodic protection of harbor installations

2.13 ISO 20313, Ships and marine technology- Cathodic protection of ships

2.14 EN ISO 15607, Specification and qualification of welding procedures for metallic materials - General rules

2.15 EN ISO 15609-1, Specification and qualification of welding procedures for metallic materials - Welding procedure specification - Part 1: Arc welding

2.16 EN ISO 1461, Hot dip galvanized coatings on fabricated iron and steel articles - Specifications and test methods

2.17 EN ISO 8501-1, Preparation of steel substrates before application of paints and related products - Visual assessment of surface cleanliness - Part 1: Rust grades and preparation grades of uncoated steel substrates and of steel substrates after overall removal of previous coatings

2.18 DNVGL-RP-B401, Cathodic protection design

2.19 DNVGL-RP-F103, Cathodic protection of submarine pipelines

2.20 NACE SP0387, Metallurgical and inspection requirements for cast galvanic anodes for offshore applications

2.21 NACE SP0492, Metallurgical and inspection requirements for offshore pipeline bracelet anodes

3 Definitions and terminology

3.1

anode consumption rate

Mass consumption rate

Amount of anode material consumed for a current output of one ampere during one year.

Note: The anode consumption rate is expressed in kilograms per amp year (kg/A.y).

3.2

batch charge cast

Unit that defines molten metal and identifies the anodes cast from it.

3.3

bracelet anode

Anode shaped as half- or part-rings to be positioned on tubular items

Note: Two or more part-ring anodes will have to fit together to become a bracelet anode.

3.4

closed circuit potential

Potential measured at the anode when a current is flowing in between the anode and the surface being protected.

3.5

cold shut

Horizontal surface discontinuity caused by solidification of a portion of a meniscus during the progressive filling of a mold, which is later covered with more solidifying metals as the molten metal level rises.

Note: Cold shuts generally occur at corners remote from the point of pour.

3.6

current capacity

Total amount of electricity that is produced when one kilogram of anode material is consumed.

Note: The current capacity is expressed in amp-hours per kilogram (A.h/kg).

3.7

driving voltage

Voltage established between the operating potential of a galvanic anode and the protection potential of the structure.

Note: This figure is used in the calculation of anode current output from the anode/electrolyte resistance.

3.8

electrochemical properties

Properties of potential and current capacity that characterize a galvanic anode and can be assessed by quantitative tests.

3.9

flush mounted anode

Anode fitted to a structure with one face in contact with or very close to the structure.

3.10

gas hole

Blow hole, channel or porosity produced by gas evolution during solidification.

Note: Gas holes can indicate contamination of the mold or core prior to casting.

3.11

heat

Product that is cast to a planned procedure in one melting operation in one furnace, without significant interruption.

Note: If the casting sequence is interrupted, the anodes produced before, between, and after the interruptions constitute “batches”.

3.12

insert core

Core form over which the anode is cast and which is used to connect the anode to the structure requiring protection.

3.13

polarization

Change in the potential of an electrode as the result of current flow to or from that electrode.

3.14

stand-off anode

Anode which is offset a certain distance from the object on which it is positioned.

4 Units

This Standard is based on International System of Units (SI), as per IPS-E-GN-100 except where otherwise specified.

5 Technical documents

5.1 The manufacturer/supplier shall provide sufficient information to identify the anode and shall supply the technical information as a minimum requirement as follows:

- **a.** ISO 9001 certification for design, manufacturing and quality control of the anodes to be used for sacrificial cathodic protection installation, issued by an internationally recognized body;
- **b.** Original technical catalogue and data sheet, manufacturing procedure specification, quality control plan, application procedure recommendation and guidelines (installation instructions);
- **c.** Filled, signed and stamped data sheets as shown in Appendices A, B.C and D;
- **d.** All laboratory and shop testing shall be documented. The anodes shall be traceable to the manufacturing batch. Shipping, handling and storage procedures shall ensure that the anodes and lead wire are not damaged;
- **e.** Certificate of current output and anode consumption rates at maximum current density for various application in accordance with reference Tables for each type of anodes;
- **f.** Certificate of analysis according to reference standards for each type of anodes.

Note 1: Manufacturing procedures shall cover all stages of the manufacturing process, from receipt of raw materials to finishing and packing for shipment, including:

- **a.** Chemical analysis;
- **b.** Measurements of weight, dimensions, etc.;
- **c.** Inspection and testing procedures and frequencies;
- **d.** Anode manufacture;
- **e.** Electrochemical test procedures, including acceptance criteria, description of test apparatus, measurement methods and preparation and cleaning of samples;
- **f.** Anode connections.

Note 2: The quality control at the anode manufacturing plant shall include control systems on the following:

- **a.** Raw materials, i.e. checking of documentation;
- **b.** Production equipment and process;
- **c.** Testing during and after production;
- **d.** Identification of anodes;
- **e.** Chemical analysis;
- **f.** Weight and dimensional tolerances;
- **g.** Surface condition of produced anodes;
- **h.** Documentation (material certificates).

6 Quality assurance

Manufacturer shall operate an effective, documented quality system based on the relevant part of the ISO 9001 and maintain records identifying the product, date of manufacturing, batch numbers and all results of inspections and testing.

7 Materials and manufacture

7.1 Manufacturing procedure specification

Unless otherwise agreed, a manufacturing procedure specification (MPS) shall be prepared for purchase orders of 15,000 kg net alloy or more. However, purchaser may also specify an MPS for smaller orders. The MPS shall include as a minimum:

- specification of anode core materials
- receipt, handling and storage of materials
- maximum and/or minimum contents of anode material alloying elements and maximum contents of impurity elements
- detailed anode drawing, with anode inserts, including gross/net weight and dimensional/weight tolerances (see comment below in this paragraph)
- welding procedure specification and reference to qualification test (WPQT) for any welding of anode cores and qualification requirements for welders
- preparation of anode cores prior to casting
- anode casting, including control of temperature and addition of alloying elements
- inspection and testing of anodes
- coating of surfaces facing protection object (not stand-off type anodes)
- handling, storage and shipping of anodes
- marking, traceability and documentation.

Purchaser may specify that detailed procedures for testing/inspection and other information relevant to quality control are also included in the MPS, e.g. detailed procedures for inspection and testing, handling of non-conformances and concession requests. Purchaser may further specify that the MPS shall be submitted for review and acceptance prior to commencement of anode manufacture.

7.2 Pre-production qualification testing

The primary objective of pre-production qualification testing (PQT) is to verify that the MPS is adequate to achieve the specified anode properties. Those aspects that require destructive testing and hence cannot be frequently verified during regular production are of particular interest. The PQT shall use the same specific materials and equipment as for regular production.

Unless otherwise agreed, a PQT shall be prepared for a purchase order of 15,000 kg net alloy or more. However, purchaser may also specify a PQT for smaller orders.

An MPS and an inspection and test plan (ITP) specific for the PQT, together with a detailed schedule for anode casting, inspection and/or testing, and reporting shall be submitted to purchaser in a timely manner (as per the purchase document) prior to start-up of the qualification activities.

Data sheets and calibration certificates for instruments essential to quality control (e.g. temperature sensors) shall be available for purchaser's review during the PQT.

Results from all inspection, testing and calibrations during qualification, recordings of essential operational parameters for casting and material certificates shall be compiled in a PQT report. Unless otherwise agreed, the report shall be accepted by purchaser prior to start of production.

7.3 Production testing

Prior to start-up of regular production (i.e. for purchase orders of 15,000 kg net alloy or more, or for higher/lower quantities as agreed on), Contractor shall submit the following documents to purchaser for acceptance:

- a project specific MPS, updated to reflect the process parameters used during the completed and accepted PQT
- a project specific inspection and testing plan (ITP) updated to reflect the process parameters used during the completed and accepted PQT
- a daily log format
- a description of responsibilities of personnel involved in quality control.

The ITP shall be in tabular form, defining all quality control activities associated with receipt of materials, preparation of anode cores, casting, inspection, testing and marking of anodes. The activities shall be listed in consecutive order, with each activity assigned a unique number and with reference to the applicable codes, standards and contractor's procedures or work instructions, applicable to the specific project. Furthermore, frequency and/or extent of inspection and testing, acceptance criteria and actions in the case of non-conformances shall be defined in the plan. The ITP shall further contain a column for inspection codes, (e.g. inspection, witnessing and hold points) indicating the involvement of contractor, purchaser and any 3rd party. It is good practice to include a reference to the applicable reporting form or document, and to refer to the specific equipment or tools to be used for verification.

The MPS, ITP, and daily log shall be in English.

Purchaser shall have the right to inspect any activity associated with the work throughout production and to carry out audits of contractor's QA / QC system.

7.4 Inspection and test

7.4.1 Chemical analysis

The electrochemical properties are highly dependent on the content of alloying elements and impurity elements. The anode manufacturer shall thus prove his capability of delivering anodes which satisfy this Part of Standard specification.

All samples shall be identified with the cast number. All anodes should be similarly identified with the cast number.

The samples shall be analyzed to prove compliance with the agreed chemical composition limits of the alloy being produced. Additional sample(s) may be taken and stored for future determination of chemical composition.

Two samples from each heat shall be taken for chemical analysis. The samples shall be taken in the beginning and at the end of casting from the pouring stream. For smaller alloying furnaces (max. 500 kg), one sample per heat may be sufficient. The sample shall be taken at

the beginning of the first heat and at the end of the second heat, then in the beginning of the third heat and so on. The samples shall be analyzed to verify the required chemical composition.

Anodes from heats whose chemical composition do not meet the required chemical composition shall be rejected.

7.4.2 Aluminum anodes

Aluminum alloys for use in seawater and saline mud normally contain zinc together with small amounts of indium as an activator; however, there are a wide range of alloy compositions available. Some alloys are non-proprietary; some are proprietary and are covered by national and/or international patents. The different compositions are aimed at modifying the properties of the anodes either to optimize manufacture of specific anode shapes or to optimize specific performance properties.

The Aluminum anodes should meet the requirements of Table 1 for chemical analysis depending on the intended application.

Table 1- Chemical composition for aluminum anodes given as mass fraction in percent

Element	Chemical composition (Mass fraction in percent)							
	Alloy A1		Alloy A2		Alloy A3		Alloy A4	
	min.	max.	min.	max.	min.	max.	min.	max.
Zinc	2.0	6.0	3.0	5.5	4.75	5.75	-	0.15
Indium	0.010	0.030	0.016	0.040	0.016	0.020	-	0.005
Gallium	-	-	-	-	-	-	0.092	0.110
Iron	-	0.12	-	0.09	-	0.06	-	0.08
Silicon	-	0.12	-	0.10	0.08	0.12	-	0.10
Copper	-	0.006	-	0.005	-	0.003	-	0.005
Cadmium	-	0.002	-	0.002	-	0.002	-	-
Other impurities (each)	-	0.02	-	0.02	-	0.02	-	0.02
Other impurities (total)	-	0.1	-	0.1	-	0.05	-	0.05
Aluminum	Remainder		Remainder		Remainder		Remainder	

Note 1:

- Alloy A1 is generally used for marine applications.
- Alloy A2 is normally used for offshore applications.
- Alloy A3 is normally used for deep water and cold water applications.
- Alloy A4 is an alloy used for low driving voltage applications.

Note 2:

- Alloy manufacturers can produce anode alloys within categories A1 to A4 to tighter composition limits than shown in Table 1.
- Alloy A4 is a recently developed alloy designed for low driving voltage applications (e.g. for use with high strength steels) and has not been widely used.
- The indium activated aluminum anode alloy (A1, A2 & A3) have proved to be applicable in marine sediments, i.e. covered with mud.
- Aluminum alloys are only applicable for environments with salinity of greater than 5 g/kg (mass fraction 0.5%), i.e. typically in seawater/brackish water environments with resistivity of less than 2 Ω.m.

Note 3: Other compositions may be used if testing demonstrates that they meet the required anode electrochemical properties.

7.4.3 Zinc anodes

Zinc based anodes are widely used for shipping applications, they are also used for offshore structures but their higher density can lead to weight limitations. Zinc anodes do not require a chloride environment to operate and can be used in brackish and fresh water applications.
Pure zinc can only be used if the iron impurity content is less than 0.0014%; however, with the addition of aluminum this level of acceptable iron impurity can be slightly increased, and further additions of cadmium promote the formation of a soft, non-adherent corrosion product on the anode.
The zinc anodes should meet the requirements of Table 2 for chemical analysis depending on the intended application.

Table 2- Chemical composition for zinc anodes given as mass fraction in percent

Element	Chemical composition (Mass fraction in percent)							
	Alloy Z1		Alloy Z2		Alloy Z3		Alloy Z4	
	min.	max.	min.	max.	min.	max.	min.	max.
Aluminum	0.1	0.5	-	0.005	0.10	0.20	0.10	0.25
Cadmium	0.025	0.07	-	0.003	0.04	0.06	-	0.001
Iron	-	0.005	-	0.001	-	0.001	-	0.002
Copper	-	0.005	-	0.002	-	0.005	-	0.001
Lead	-	0.006	-	0.003	-	0.006	-	0.006
Tin	-	-	-	-	-	0.01	-	-
Magnesiu	-	-	-	-	-	0.5	0.05	0.15
Others	-	0.10	-	0.005	-	0.1	-	0.1
Zinc	99.31	-	99.99	-	Remainder		Remainder	

Note 1: Alloy Z1 is normally supplied in accordance with U.S. MIL-A-18001-K (1993) or to ASTM B418, Type I.
Note 2: Alloy Z2 is of term "high purity zinc" and is normally supplied in accordance with ASTM B418, Type II.
* For alloy Z2 the total impurities shall not exceed 0.01%.
Note 3: Alloy Z4 is a proprietary alloy that has been developed for use at elevated temperatures.
Note 4: Other compositions may be used if testing demonstrates that they meet the required anode electrochemical properties.

7.4.4 Magnesium anodes

Magnesium based anodes are not normally required for use in seawater due to the naturally low seawater resistivity which ensures sufficient current is provided by aluminum or zinc alloys. However, they may be required in brackish or fresh water where their high driving voltage is required to provide practical current output, or in seawater where rapid polarization is desired.

Magnesium based anodes are generally only applicable where frequent replacement is practicable. However, magnesium anodes may be designed for long-term use in seawater, if the anode shape, anode resistance, total circuit resistance and the anode/structure spacing are specifically selected for such applications.

The Magnesium anodes should meet the requirements of Table 3 for chemical analysis depending on the intended application.

Table 3- Chemical composition for magnesium anodes given as mass fraction in percent

Element	Chemical composition (Mass fraction in percent)			
	Alloy M1		Alloy M2	
	min.	max.	min.	max.
Manganese	0.15	0.7	0.5	1.5
Aluminum	5	7	-	0.05
Zinc	2	4	-	0.03
Iron	-	0.005	-	0.03
Copper	-	0.08	-	0.02
Silicon	-	0.3	-	0.05
Lead	-	0.03	-	0.01
Nickel	-	0.003	-	0.002
Other impurities	-	Total 0.3	-	Each 0.05
Magnesium	Remainder	Remainder	Remainder	Remainder

Note 1: Alloy M1 is normally supplied in accordance with ASTM B843-93.
Note 2: In both cases, residual impurities naturally occur in the magnesium need to be controlled to limit polarization and self-corrosion. Manganese is added to sequester iron impurities and make the anode potential more negative.

7.4.5 Casting quality

Over-pouring to fill shrinkage depressions shall be kept to a minimum. All pouring of molten anode alloy shall be finished before the surface of the cast anode solidifies. The surface of the anode may be kept in a liquid state for a while by applying heat, i.e. from gas burners, but once solidified, no re-melting shall be allowed, not even to fill shrinkage depressions.

All cast galvanic anodes of each type shall be inspected visually to conform compliance to the following characteristics:

Shrinkages depressions shall not exceed 10% of the nominal depth of the cast galvanic anode as measured from the uppermost corner to the bottom of the depression.

A shrinkage depression that exposes insert steel shall not be accepted.

Casting surface irregularities shall be fully bonded to the bulk galvanic material.

Not more than 1% of the total surface of the anode casting shall be contaminated with nonmetallic inclusions visible to the naked eye.

Cold shuts shall not exceed a depth of 10 mm and/or extend over a total length of more than 3 times the width of the anode (for stand-off and flush mounting anodes) or more than 150 mm (for bracelet anodes).

All protrusions detrimental to the safety of personnel during handling shall be removed. Except that, peening of cracks or other mechanical treatments to conceal casting defects shall not be accepted.

7.4.6 Cracks in anode material

All anodes shall be inspected visually to confirm compliance with the following requirements.

Even with good foundry practice, particular anode alloy composition (notably aluminum based) may suffer a degree of cracking. Cracks may occur while cooling during the casting of galvanic anodes because of the different coefficients of expansion of the anode and the core.

These cracks are not detrimental, provided they do not converge in a manner to allow loss of anode material. A small amount of warpage is acceptable if it does not adversely affect the anode installation.

No treatment shall be applied to grind, peen, or in any other manner dress cracks before inspection and checks.

Zinc and magnesium anodes shall be free from cracking visible without the aid of magnification.

Small cracks in the anodes can be accepted in aluminum anodes provided the cracks would not cause any mechanical failure during installation, transportation or service of the anode. The combination of cracks and lack of bond to the core is detrimental.

- Visible cracks in the area where the anode material is not internally supported by the core shall not be accepted.
- Cracks penetrating to the steel core or penetrating through the anode are not permitted.

7.4.6.1 Stand-off and flush mounting anodes

The following cracking criteria apply:

- For sections of anode material not fully supported by the anode core, no visible cracks shall be permitted without magnification;
- Cracks within the section of an anode supported by the anode core are not acceptable if the length is > 100 mm and/or the width > 1 mm;
- Cracks penetrating to the steel anode cores or through the anode are not permitted;
- A maximum of 10 cracks per anode with small dense cracks counting as one.
- Longitudinal cracks are not permitted.

7.4.6.2 Bracelet anodes

The following cracking criteria apply:

- for sections of anode material not fully supported by the anode core, no visible cracks shall be permitted without magnification;
- cracks penetrating to the steel anode cores or through the anode are not permitted;
- cracks with a length of > 100 mm or > 50% of the anode diameter (whichever is greater) and/or width > 3 mm are not acceptable.

Provided the above is satisfied, the following cracks are acceptable in transverse direction:

- cracks with a length of ≤ 50 mm or ≤ 20% of the anode diameter, whichever is less, and a width < 3 mm;
- cracks with a length of 50 mm to 200 mm or between 20% and 50% of the anode diameter, whichever is less, and a width < 1 mm;
- cracks with a length of 50 mm to 200 mm are limited to two per half-bracelet or four per anode.
- cracks in the longitudinal direction shall be < 100 mm in length or < 20% of anode length, whichever is less, and/or ≤ 1 mm in width.

7.4.7 Anode weight

- Individual cast anodes of each type and of nominal weights greater than 50 kg shall be within ±3% of the nominal weight or 2.3 kg, whichever is greater. For castings with nominal weight below 50 kg, the tolerances shall be ±5%. All anodes of nominal weight greater than 140 kg shall be weighed. For lighter anodes, a minimum of 10% of randomly selected anodes shall be weighed.
- The total net mass of anode castings shall not be less than the nominal value and should be no more than 2% above.

7.4.8 Anode dimensions and straightness

7.4.8.1 Stand-off and flush mounting anodes

Dimensions shall conform to the following:

- Anode mean length should be ±3% of nominal length or ±25 mm, whichever is smaller.
- Anode mean width should be ±5% of nominal mean width.
- Anode depth should be ±10% of nominal mean depth.
- The diameter of cylindrical anodes should be ±2.5% of nominal diameter.

The straightness of the anode shall not deviate more than 2% of the anode nominal length from the longitudinal axis of the anode.

At least 10% of the total number of anodes shall be checked to confirm compliance with these requirements and also core location is within 10% of the nominal position.

7.4.8.2 Bracelet anodes

Dimensions shall conform to the following:

- The mean length of the anode casting should be ±3% of nominal length or ±25 mm, whichever is smaller.
- The anode internal diameter shall conform to the following dimensional tolerances:
  i) -0 / +4 mm for pipeline diameters ≤ 300 mm;
  ii) -0 / +6 mm for pipeline diameters > 300 mm and ≤ 610 mm;
  iii) -0 / +1% for pipeline diameters > 610 mm.
- The dimensional tolerances on the anode thickness shall be ±3 mm.

At least 10% of the total number of anodes shall be checked to confirm compliance with these requirements and also core location is within 10% of the nominal position.

Anodes shall be free from excessive bowing or twisting. This shall be verified on a completely assembled bracelet by fitting to a full-length former or by any other agreed method. The external diameter should at no point exceed the summation of the tolerances given above.

7.4.9 Internal defects and destructive testing

The number and method of selection of anodes to be destructively tested (sectioned) within each anode type/size shall take into account anode design, and the total number of anodes as

per purchaser and manufacturer agreement.

If the anode does not meet the requirements below, an additional anode shall be subjected to destructive testing. If this does not satisfy specified requirements, the whole anode lot should be rejected or other actions taken as agreed prior to fabrication.

Slender and flush mounting anodes selected for examination shall be sectioned transversely by single cuts at 25%, 50%, and 75% of nominal length, or at other agreed locations for a particular anode design.

Bracelet anodes selected for examination shall be sectioned transversely by single cuts at 25% and 50% of nominal length, or at other agreed locations for a particular anode design.

The cut faces, when examined visually without magnification, shall conform to the following criteria:

- Gas holes and porosities shall be limited to maximum 2% of the total cut surface areas, and maxim 5% of any individual cut surface area; no cavity shall exceed 1 cm^2 for the cross-sectional area in the transverse section.
- Non-metallic inclusions shall be limited to maximum 1% of the total cut surface areas and maximum 2% of any individual cut surface area; no non-metallic inclusion shall exceed 1 cm^2.
- Lack of bond (voids adjacent to the core) shall be limited to maximum 10% of the total anode core perimeter and maximum 20% of the perimeter for any individual cut.
- For non-tubular cores where prevention of voids may be particularly difficult, the limits may be otherwise agreed between the manufacturer and the purchaser.
- The cut faces shall be dimensionally checked to ensure that the core location is within 10% of the nominal position with respect to width and depth.

7.4.10 Heat treatment

For cast galvanic anodes in which post casting heat treatment forms part of the specification for the material manufacture, the heat-treatment history of each batch of cast galvanic anodes, i.e., each heat-treatment furnace charge, shall be recorded.

The temperature of the furnace and of a representative cast galvanic anode in each charge shall be recorded continuously throughout the heat treatment.

7.4.11 Coating

The exposed (external) surfaces of the anode shall not be subject to any coating, except for flush mounted and bracelet anodes where the anode surface facing, immediately adjacent, to the structure surface to be protected may be coated. The coating applied to the anode faces should be an immersion-grade two-component epoxy with a minimum thickness of 100 µm.

When specified, coatings shall be applied only after inspection of casting quality and cracks.

7.4.12 Electrochemical testing

7.4.12.1 Electrochemical quality control testing

The following shall be assessed:

- closed-circuit potential;
- electrochemical capacity;

- corrosion pattern (uneven consumption, intergranular attack, passivity, etc.).

Unless otherwise specified, one set of tests shall be carried out for each 15 t of anodes produced. The electrochemical test data shall be reported.

Testing should be carried out in natural seawater or in artificial seawater in accordance with ASTM D1141.

The test should be conducted using the procedure described in Appendix A or other tests procedure by purchaser and manufacturer agreement. For testing in accordance with Appendix A, test results shall meet the acceptance criteria in Table 4.

Table 4- Recommended acceptance criteria for electrochemical performance (production quality testing)

Anode Type	Minimum electrochemical capacity A·h/kg	Closed-circuit potential V (Ag/AgCl seawater)
Aluminum	2500	-1.050
Zinc	780	-1.00

If the specified requirements are not met, re-tests should be carried out on three specimens from each heat that failed to meet the requirements. Failure of any of these three specimens to meet the specified requirements should lead to rejection or other actions taken as agreed prior to fabrication of all anodes from the heat(s) involved.

The tested anode sample surface shall not show any signs of passivity or intergranular attack.

For magnesium alloys and special aluminum and zinc alloys, test procedure and acceptance criteria shall be agreed between purchaser and manufacturer. Indicative values for normal operation (ambient temperature, normal seawater, anodic current density higher than 1 A/m^2) are given in Appendix B**.**

7.4.12.2 Electrochemical performance testing

Where a new alloy is to be used or where an alloy is to be used in a different environment (e.g. salinity, temperature) where there are no documented historical field performance data or previous laboratory data, then long-term tests (as described in Appendix C) should be used.

7.4.13 Anode core material

Anode cores shall be fabricated from weld able structural steel plate/sections according to a recognized standard such as EN 10025 (all parts) or similar. Anode core materials to be welded to the structure shall be compatible with the steel of the structure or structural elements to which it is attached, and the carbon equivalent (CE) shall not exceed the CE value of the steel on which it will be welded. The CE value shall be calculated using Formula (1):

$$CE = C + Mn/6 + (Cr + Mo + V)/5 + (Ni + Cu)/15 \quad (1)$$

If the full chemical composition is not reported, the alternative CE Formula (2) may be used.

$$CE = C + Mn/6 + 0.04 \quad (2)$$

In all cases, CE shall be no more than 0.45.

The material certificate for the anode cores shall meet at least the requirements of ISO 10474: 1991, 2.1 b).

For all fabrication welding of steel anode cores, welding procedures shall be in accordance with relevant requirements of EN ISO 15607 and EN ISO 15609-1 or any equivalent standard.

Note: AWS D1.1/D1.1M constitutes an acceptable equivalent.

Welds shall be performed by welders qualified according to ISO 9609-1.

Note: AWS D1.1/D1.1M constitutes an acceptable equivalent.

100% visual inspection of the cores shall be carried out prior to casting.

For zinc or magnesium anodes, the steel cores shall be bare steel or hot dip galvanized steel. In this case, hot dip galvanizing shall be in accordance with EN ISO 1461.

Visible surface contamination of the blast cleaned or zinc coated surface shall not be permitted. When bare steel core is used, they shall be blast cleaned to the grade Sa 2½ defined in EN ISO 8501-1.

For aluminum anodes, the steel core shall be blast cleaned at a minimum to the grade Sa 2½ defined in EN ISO 8501-1 before casting. Galvanized or zinc electroplated cores shall not be used.

Note: A zinc coating on the insert would give only a mechanical bond and would be dissolved during casting with possible modification of the alloy chemical composition.

Rust discoloration and/or visible surface contamination of the cores shall not be accepted.

7.4.14 Fit-up test

Fit-up test for verification of bracelet anodes tab location and anode fit-up test on a dummy pipe sample shall be performed for bracelet anodes. The number fit-up tests shall be agreed between manufacturer and purchaser.

7.4.15 Cable connections

Where anodes are to be connected to the structure or pipeline using cables, as opposed to direct welding of the core to the structure, the cable shall be selected to provide a robust connection. The cable shall be multi-stranded with minimum cable size of 10 mm^2 cross section area.

Cable shall be connected to the anode using a suitably sized and fixed cable lug. The cable shall be fixed to the lug by both mechanically crimping and welding or brazing. The cable lug shall be connected to the anode core by either mechanical (i.e. bolted connected) or direct welding. The contact point should be protected using a suitable coating. A suitable coating may be an epoxy or equivalent.

Where connection is by cable, consideration should be given to utilizing multiple cables to provide a degree of redundancy in case of cable damage.

The method of cable attachment to the structure should be selected to provide both a mechanically secure and a low electrical resistance connection, such as pin brazing, thermit welding or by use of “volcano” bolts or serrated washers and use of lock nuts as appropriate.

8 Identification of anodes

As a minimum, each anode shall be marked with manufacturer’s name or symbol, anode material (e.g. A for aluminum, Z for zinc, M for magnesium), heat (cast) number and serial number. Any further requirements for marking shall be specified in the purchase document.

9 Packing and shipment

Cast galvanic anodes shall be bundled, strapped, placed on pallets, or individually loaded by an agreed procedure to facilitate unloading and minimize damage to anodes and cores between the manufacturing plant and the installation site

Each pallet shall be plainly marked with the following information:

- Product name
- Specification
- Order No.
- Anode type and style
- Anode weight
- Anode dimensions
- Batch No.
- Date of manufacture
- Quantity
- Manufacture name and address

Note: Each pallet shall be clearly marked “FRAGILE”.

Appendices

Appendix A

Laboratory testing of galvanic anode materials for quality control

A.1 General

This laboratory test procedure is intended for quality control of Al-base and Zn-base anode materials during manufacture of galvanic anodes.

Note: The results from testing according to this procedure are not applicable to cathodic protection design because electrochemical data from short-term testing, typically using high anodic current densities will tend to be non-conservative with respect to the actual long-term performance in the field.

The testing shall be performed according to a detailed procedure describing all relevant steps. For testing at the premises of contractor, client/purchaser shall have the right to witness the testing.

All requirements of this procedure shall be considered as mandatory, unless deviations have been agreed. Owner/purchaser may, however, choose to specify an alternative test procedure.

A.2 Sampling and preparation of test specimens

Unless otherwise specified, quality control of electrochemical properties (i.e. electrochemical efficiency and closed-circuit anode potential) shall be carried out for each 15,000 kg of anodes produced. Sampling for potential testing (by separate mini-castings) shall, however, be performed for each heat of anode material produced. All samples for testing shall have adequate marking. Client/purchaser shall have the right to select sample for testing, e.g. based on a review of chemical composition of the individual heats.

Note: The individual heats are sometimes much smaller than 15,000 kg and it is then essential that the testing is performed on a heat that is representative for all those produced. Hence, the heat selected should have contents of alloying and/or impurity elements in the lower and upper ranges, respectively.

Cylindrical test specimens with a diameter of 10 mm ±1 mm and a length of 50 mm ±5 mm shall be prepared by machining of samples. A hole of about 2 mm diameter shall be drilled and tapped on one end for connection of a titanium support rod. The specimen shall subsequently be rinsed in tap water followed by ethanol, dried and weighed to an accuracy of ±0.1 mg.

The specimens shall be adequately marked throughout all stages of preparation, storage and testing.

A.3 Equipment and experimental procedure

After mounting of the support rod, the specimen ends and the part of the rod exposed to the test solution shall be coated with a suitable sealing compound such as polychloroprene glue or silicon rubber.

The testing solution shall be natural seawater (of adequate purity and a salinity of minimum 30%) or synthetic seawater according to ASTM D1141.

Note: Seawater constituents other than chloride, sulphate, bicarbonate/carbonate, sodium, calcium and magnesium ions have no effect on the electrochemical performance of galvanic anodes and may be omitted when preparing synthetic seawater. Tap water is acceptable for preparation of the solution.

A minimum of 10 liters per test specimen shall be used. The solution shall be continuously purged with air and shall not be exchanged during the test period. The temperature shall be maintained at 20 ±3°C.

Each specimen shall be suspended in the center of an uncoated cylindrical steel container (e.g. made of a pipe section), the wetted surface area of which shall be minimum 20 times the exposed anode specimen area, i.e. minimum 400 cm^2, approximately. The general arrangement is shown in Figure A-1.

Galvanostatic control shall be carried out by means of a DC constant current source, capable of controlling the current. The specimen and the cathode shall be coupled to the positive and negative rectifier terminals, respectively. Multiple testing cells may be connected in series to one DC source.

A current integrator, e.g. a copper coulometer or an electronic device capable of determining the total discharged current to an accuracy of ±2%, shall be inserted into the circuit containing one or more test cells in circuit.

The current through the cell(s) shall be adjusted to provide anodic current densities, based on the initially exposed surface area, in accordance with the following scheme:

Day 1: 1.5 mA/cm^2

Day 2: 0.4 mA/cm^2

Day 3: 4.0 mA/cm^2

Day 4: 1.5 mA/cm^2

The current density shall be controlled to an accuracy of 0.1 mA/cm^2 and shall be maintained for a period of 24 hours ±1 hour. The total testing time shall be 96 hours ±4 hours.

At the end of each testing period, the anode potential shall be measured at three positions per specimen. A standard reference electrode (silver/silver chloride or calomel) with an electrolyte bridge (e.g. a Luggin capillary) shall be used. The tip of the bridge shall be positioned within 1 mm from the specimen surface, however, without disturbing any corrosion products formed on the anode specimen. Reference electrodes shall be calibrated at intervals not exceeding one week. Potential recordings using a reference electrode other than Ag/AgCl/seawater (e.g. a SCE) shall be converted to this reference.

After completion of the full test period, the support rod and sealing compound shall be removed and the specimen cleaned of corrosion products. Aluminum-based specimens shall be cleaned for 10 min at 80°C in a solution of 20 g chromium trioxide and 30 ml phosphoric acid per liter water. Zinc-based specimens shall be immersed for 2 hours in a saturated

ammonium chloride solution at ambient temperature. Specimens shall subsequently be rinsed in tap water, thereafter in ethanol and weighed to an accuracy of ±0.1 mg.

The electrochemical efficiency, ε (Ah/kg), shall be calculated from

$\varepsilon = (C \cdot 1000)/ \Delta w$

Where C is the total current charge in Ah and Δw is the weight loss in grams.

A.4 Acceptance criteria and re-testing

The acceptance criteria in Table 4 shall apply.

Failures during testing which are obviously due to operational errors may be disregarded and testing repeated on a new specimen of the same sample or a specimen cut from an anode of the same heat.

In the case of failure to meet the specified requirements, re-tests may be carried out on 3 specimens from each heat that failed to meet the requirements. Failure of any of these three specimens to meet the specified requirements shall lead to rejection of all anodes from that heat.

A.5 Documentation

The test report shall contain relevant data for the anode material(s) tested, including heat number, chemical composition and casting date. Specimen preparation, test equipment and testing procedure shall be outlined.

All recorded potentials (i.e. 3 per specimen) shall be presented in tabular form, as-recorded and converted to Ag/AgCl/seawater, if applicable. Specimen weight loss and total current charge shall be given in addition to the calculated electrochemical efficiency. A photograph of the cleaned specimen shall be included in the report.

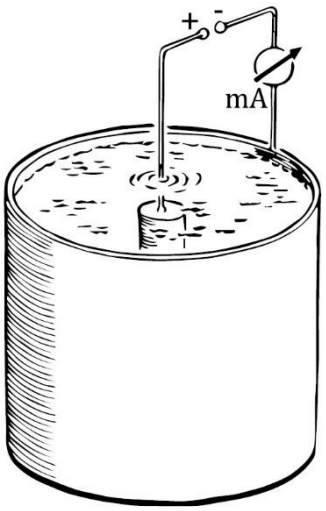


Figure A-1 General arrangement for quality control testing of galvanic anode materials

Appendix B

(Informative)

Performance properties of galvanic anodes

B.1 Aluminum anodes

The electrochemical properties for aluminum based alloys vary depending on the specific alloy composition, operating temperature, operating anodic current density and the operating environment.

The actual properties for an alloy/operational condition should be determined and documented by testing in accordance with Appendix A and C. Indicative values for typical alloy compositions are given in Table B.1 for normal operation (ambient temperature, normal seawater, anodic current density higher than 1 A/m^2).

Table B.1- Typical properties of aluminum anodes in normal operation conditions

Alloy type	Environment	Closed circuit potential Ag/AgCl/seawater reference electrode V	Current capacity A.h/kg	Anode consumption rate kg/A.y
Alloy A1	Seawater	-1.09	2500	3.5
	Marine sediments	-1.05	2000	4.4
Alloy A2	Seawater	-1.09	2500	3.5
	Marine sediments	-1.05	2000	4.4
Alloy A3	Seawater	-1.09	2500	3.5
	Marine sediments	-1.05	2000	4.4
Alloy A4	Seawater	-0.83	1500	5.8

Note 1: The typical closed circuit potential, capacity and anode consumption rate shown are based on normal operating conditions of anode current density, temperature and environment.
Note 2: The current capacity values shown are the practical current capacity values for aluminum alloys and incorporate an allowance for self-corrosion of the alloy. No further efficiency allowance is necessary.
Note 3: There are no reported performance data for Alloy A 4 in marine sediments.

Anode capacity for all aluminum-based alloys will be significantly lower at higher operating temperatures. For example, anode capacity for alloys A1 and A2 will drop essentially linearly from 2500 A.h/kg at 25°C to 500 A.h/kg at 80°C. (Equivalent to a change in anode consumption rate of 3.5 kg/Ay at 25°C to 17.5 kg/Ay at 80°C). In saline mud, at elevated temperatures, the capacity values will be lower than those indicated for seawater (see references [18] and [19]).

Environments such as brines, seawater of varying salinity or marine sediments, with or without hydrogen supplied (H_2S), result in variations in aluminum anode alloy performance properties.

B.2 Zinc alloys

The electrochemical properties for zinc based alloys will vary depending on the specific alloy composition and the operating environment. Generally, zinc alloys are only applicable at temperatures up to 50°C. Above this temperature, zinc alloys Z1 and Z3 can suffer from inter-granular corrosion, especially when buried in saline mud. Some proprietary alloys have been

developed that can operate successfully at higher temperatures up to 85°C. At higher temperatures (>70°C) zinc anodes in low chloride environments can exhibit potential reversal with steel.

Typical values of electrochemical properties for alloy compositions are given in Table B.2.

Table B.2- Typical properties of zinc anodes in normal operation conditions

Alloy type	Environment	Closed circuit potential Ag/AgCl/seawater reference electrode V	Current capacity A.h/kg	Anode consumption rate kg/A.y
Alloy Z1	Seawater	-1.03	780	11.2
	Marine sediments	-0.99	750	11.8
Alloy Z2	Seawater	-1.00	760	11.5
Alloy Z3	Seawater	-1.03	780	11.2
Alloy Z4	Seawater	-1.03	780	11.2
	Marine sediments	-0.98	710	12.3

Note 1: The current capacity values shown are the practical capacity values for zinc alloys and incorporate an allowance for self-corrosion of the alloy. No further efficiency allowance is necessary.

Alloys Z 1 and Z 3 should not be used at temperatures above 50°C in sediments.

Note 2: Alloy Z 4 is a proprietary alloy that has been developed for use at elevated temperatures. It is claimed that at 60°C to 80°C the practical capacity in seawater is 690 A.h/kg, anode consumption rate of 12.7 kg/Ay and the claimed operating potential is -0.97 V vs. Ag/AgCl/seawater.

Note 3: In marine sediment the proprietary alloy Z 4 at 50°C is claimed to have a practical capacity of 710 A.h/kg, anode consumption rate of 12.3 kg/A.y and operating potential of -0.95 V vs. Ag/AgCl/seawater. At 85°C the claimed practical capacity is 430 A.h/kg, anode consumption rate of 20.4 kg/A.y and the claimed operating potential is -0.94 V vs. Ag/AgCl/seawater.

B.3 Magnesium anodes

Magnesium based alloys have a high operating voltage (typically -1.5 or -1.7 V Ag/AgCl/seawater) but have a low current capacity (high consumption rate) due to self-corrosion.

Table B.3- Typical electrochemical properties of magnesium anodes at ambient temperatures (5°C – 25°C)

Alloy type	Environment	Closed circuit potential Ag/AgCl/seawater reference electrode V	Current capacity A.h/kg	Anode consumption rate kg/A.y
Alloy M1	Seawater	-1.50	1200	7.3
Alloy M2	Seawater	-1.70	1200	7.3
Note: The current capacity values shown are the practical current capacity values for magnesium alloys and incorporate the high self-corrosion (corresponding to approx 50%) of the alloy. No further efficiency allowance is necessary.				

The practical capacity may be considerably lower when operating at low current densities or over extended operating periods.

It is reported that magnesium anode electrochemical properties cannot be accurately predicted from composition alone; documented short-term potential and capacity determinations should be considered for each batch or series of batches of anodes having the same minor impurities and microstructure.

Appendix C

Performance testing of galvanic anode materials

C.1 General

This appendix provides a procedure for laboratory testing for determining performance values for galvanic anodes in a given environment.

The performance of galvanic anode materials may also be validated by field experience, either by using data from monitored anodes or by dedicated field-testing of full-size anodes.

This procedure is also applicable to special environments, such as hot seawater or sediments.

Performance testing shall be carried out for new (nominal) anode compositions and/or foundry, and whenever there is a need to verify anode material performance.

C.2 Sampling and preparation of test specimens

Material for testing shall be sampled either from manufactured anodes or from special castings using the same raw materials and melting practice as for normal production.

Two specimens shall be prepared from materials representing a minimum of five heats. The chemical composition of the material test samples shall be representative of normal production, i.e. the content of alloying and impurity elements shall reflect the manufacturers' internal composition limits for the anode material.

Cylindrical specimens with a minimum diameter of 20 mm and a minimum length of 80 mm shall be machined from the sample material.

A hole with a diameter of approximately 2 mm shall be drilled through the test specimen, tapped at one end and connected to a titanium support rod. The support rod shall have an electrically insulating coating on all areas which will be exposed to the test solution.

After mounting on the support rod, the specimen ends shall be coated by a sealing compound such as polychloroprene glue or silicone rubber.

Prior to exposure, the test specimens shall be rinsed in tap water and then dried with ethanol or equivalent. After drying, the specimens shall be weighed to the nearest 0/1 mg.

C.3 Testing equipment and experimental procedure

The testing environment shall be clean natural seawater with a salinity $\geq$ 3.0% mass fraction. The temperature of the testing environment may vary in the range +7°C to +20°C. Temperature and salinity of the test environment shall be recorded at least once per week.

The test cells shall be configured as outlined in Appendix A with a continuous exchange of seawater in the cell at a rate of at least 1 l/min. The seawater shall be continuously purged with air.

Testing shall be performed as a free-running test.

The duration of the test shall be a minimum of 12 months.

The integrated current may be determined by a coulometer or by recording the voltage drop across the precision resistance to be introduced in the circuit. Manual readings of the integrated current shall be taken at least once a week.

Manual recordings of anode potentials (see Appendix A) shall be taken at least once a day for 5 days during the first 2 weeks of testing, and at least once a week thereafter. Continuous recording may be used as an alternative.

The anode and cathode areas shall be connected across a 10 Ω precision resistor in order to limit the anode current density. Higher and lower circuit resistances (e.g. 2 Ω to 20 Ω) may be applied if more extensive data are required. The cathode surface area shall be at least 30 times the exposed anode surface area.

The anode current density shall be calculated from the voltage drop across the 10 Ω circuit resistance using a high-impedance (>107 Ω) voltmeter.

Measurements of current and anode potential shall be made at regular intervals. Steel cathode potentials shall also be recorded at the same time.

The electrochemical capacity shall be calculated as specified in Appendix A.

C.4 Documentation

A test report containing the following shall be prepared:

- **a)** data from melting and casting of the test material, including alloying and impurity elements affecting anode performance;
- **b)** nominal composition and guaranteed compositional limits;
- **c)** specimen preparation, testing equipment and procedures;
- **d)** environmental data, including seawater temperature and salinity;
- **e)** anode potentials presented graphically as a function of time;
- **f)** photographs of anode specimens prior to and after cleaning;
- **g)** electrochemical capacity, in ampere hours per kilogram.

Appendix D

Data sheet

(to be submitted by the purchaser)

for

IPS-M-TP-750**: Part 4 Galvanic anodes**

The anodes shall be in accordance with the latest edition of above standard with the following specific requirements:

- Project title: ..... - Date: .....
- Manufacturer's name and address
- Indent No.: ..... - Purchaser: .....
- M.E.S.C. No.: ..... - No. of Anodes: .....
- Type of Anode: □ Aluminum Anode □ Zinc Anode □ Magnesium anode
- Anode Shape:
- Anode lead wire insulation: □ Single Jacket HMWPE

□ Single Jacket XLPE

□ Double Jacket PVC/PVC

- Anode dimensions:
- Batch No.:

Part 5
Cathodic protection cables

1 Scope

This part of IPS-M-TP-750 covers the minimum requirements for the materials, construction, dimensions, packaging and tests of cables, intended for DC services in cathodic protection installation for pipelines, well casings, storage tanks, ships and other buried or water-submerged metallic structures.

Appendices A, B, C and D are the data sheets which shall be used for ordering purposes.

2 References

Throughout this Standard the following dated and undated standards/codes are referred to. These referenced documents shall, to the extent specified herein, form a part of this standard. For dated references, the edition cited applies. The applicability of changes in dated references that occur after the cited date shall be mutually agreed upon by the Company and the Vendor. For undated references, the latest edition of the referenced documents (including any supplements and amendments) applies.

2.1 B8, Standard specification for concentric-lay-stranded copper conductors, hard, medium hard, or soft

2.2 D 470, Standard test methods for cross- linked insulations and jackets for wire and cable

2.3 D 1047, Standard specification for poly (vinyl chloride) jacket for wire and cable

2.4 D 1248, Standard specification for polyethylene plastics extrusion materials for wire and cable

2.5 D 1351, Standard specification for thermoplastic polyethylene insulation for electrical wire and cable

2.6 D 2219, Standard specification for poly (vinyl chloride) insulation for wire and cable, 60°C operation

2.7 D 2308, Standard specification for thermoplastic polyethylene jacket for electrical wire and cable

2.8 D 2633, Standard test methods for thermoplastic insulations and jackets for wire and cable

2.9 D 2655, Standard specification for cross- linked polyethylene insulation for wire and cable rated 0 to 2000 V 90°C operation

2.10 D 3144, Standard specification for cross- linked poly (vinylidene fluoride) heat-shrinkable tubing for electrical insulation

2.11 IEC 60228, Conductors of insulated cables

2.12 ISO 9001, Quality management systems - requirements

2.13 ISO 15589, Petroleum, petrochemical and natural gas industries cathodic protection systems

2.14 NACE SP0572, Design, installation, operation, and maintenance of impressed current deep anode beds

3 Definitions and terminology

3.1

conductor

A wire or combination of wires not insulated from one another, suitable for carrying an electric current.

3.2

jacket

An integral covering which is applied over the insulation of a cable and whose prime function is to provide mechanical or environmental protection for the component(s) that it covers.

3.3

primary insulation

The first layer of two or more layers of insulating materials over a conductor. Its prime function is to act as an electrical barrier.

3.4

Stranded conductor

A conductor composed of a group of wires, usually twisted, or of any combination of such groups of wires.

3.5

wire

A rod or filament of drawn or rolled metal whose length is great in comparison with the major axis of its cross section.

3.6

lot

A lot is any amount of cable of one type and size presented for acceptance at one time.

3.7

sample

A sample is a quantity of production units (reels) selected at random from the lot for the purpose of determining conformance of the lot to the requirements of this Part of Standard specification.

3.8

sample size

The number of production units taken to make up the sample.

3.9

specimen

A specimen is a length of cable removed for test purposes from any individual production unit of the sample.

4 Units

This Standard is based on International System of Units (SI), as per IPS-E-GN-100 except where otherwise specified.

5 Technical documents

5.1 The manufacturer/supplier shall provide sufficient information to identify the cables and shall supply the technical information as a minimum requirement as follows:

- **a.** ISO 9001 certification for manufacturing and quality control of the cables to be used for cathodic protection system, issued by an internationally recognized body.
- **b.** Original technical catalogue and data sheet, manufacturing procedure specification, quality control plan, application procedure recommendation and guidelines.
- **c.** Filled, signed and stamped data sheets as shown in Appendices
- **d.** All laboratory and shop testing shall be documented. The cables shall be traceable to the manufacturing batch.
- **e.** Shipping, handling and storage procedures shall ensure that the cables are not damaged.
- **f.** Certificate of current output and anode consumption rates at maximum current density for various application in accordance with reference Tables for each type of anodes.
- **g.** Certificate of all quality control tests, physicals and electrical properties according to reference standards for conductor and its coating.

Note 1: Manufacturing procedures shall cover all stages of the manufacturing process, from receipt of raw materials to finishing and packing for shipment, including:

- **a.** Chemical analysis;
- **b.** Measurement of diameter of individual strands, overall conductor diameter, thickness of insulation and jacket.
- **c.** Measurement of DC resistance at 20°C (ohms/km).
- **d.** Inspection and testing procedures and frequencies;

Note 2: The quality control at the anode manufacturing plant shall include control systems on the following:

- **a.** Raw materials, i.e. checking of documentation.
- **b.** Production equipment and process.
- **c.** Testing during and after production.
- **d.** Identification of cables
- **e.** Documentation (material certificates).

6 Quality assurance

Manufacturer shall operate an effective, documented quality system based on the relevant part of the ISO 9001 and maintain records identifying the product, date of manufacturing, batch numbers and all results of inspections and testing.

7 General cable construction requirements

7.1 Conductor

The conductors shall be plain annealed stranded copper. Stranding shall be circular (non-compacted).

The material shall be copper of such quality and purity that the finished product shall have the properties and characteristics prescribed in IEC Publication 60228 Class 2, or ASTM specification B8 Class B. Conductor sizes, as will be specified by the Purchaser, shall be in accordance with one of the designations listed in Table 1 and/or Appendix E to achieve the resistance value required:

Table 1- Conductor sizes

NOMINAL CROSS-SECTIONAL AREA mm^2	MINIMUM NUMBER OF WIRES IN CONDUCTOR	MAXIMUM RESISTANCE OF CONDUCTOR AT 20°C Ω /km
4	7	4.61
6	7	3.08
10	7	1.83
16	7	1.15
25	7	0.727
35	7	0.524
50	19	0.387
70	19	0.268

The size, cross-sectional areas, and direct current resistance of the conductor in the completed cable shall conform the minimum and maximum values allowed by the above referenced standards.

7.2 Insulation

7.2.1 General

Cable insulation shall be made from materials chemically and physically resistant to the environmental effects to be anticipated in buried or submerged service. It shall provide continuous coverage, adequate dielectric properties, and have a high resistance to abrasion, stress cracking and notch propagation.

The insulation shall be one of the types listed in sub clause 7.2.2. The insulation shall be applied tightly to the conductor without adhering to it and shall form a compact and homogeneous body.

The sheath (jacketing) shall be an extruded layer of the types listed in sub clause 7.2.2. The sheath shall be continuous having a thickness as uniform as possible and not less than the values specified. It shall be possible to remove the sheath of the cable without damaging the insulation of the conductor.

Cable insulation (primary insulation and sheath) shall be completely free of cracks, nicks, scratches, or other discontinuities.

Cable insulation shall have a voltage rating of 600/1000 Volts in accordance with National Electrical Code.

7.2.2 Insulating materials

The types of insulation and sheath compound covered by this Part of Standard specification are listed below.

7.2.2.1 Polyvinylchloride (PVC)

Insulation and sheath compound based on polyvinylchloride or copolymer of vinyl chloride and vinyl acetate conforming to ASTM specifications D 2219 (as Insulation) and D 1047 (as Jacketing).

7.2.2.2 High molecular weight polyethylene (HMWPE)

Insulation and sheath compound based on thermoplastic polyethylene conforming to ASTM specifications D 1351 (as Insulation) and D 2308 (as Jacketing).

The polyethylene before application to the conductor (or cable) shall comply with the requirements of ASTM–D 1248 Type 1, Class C-5, Grade J-3, having an average insulation thickness of 2.8 mm (110 mil) with a 10% tolerance (when use single the electrolyte is not expected to contain chloride or other halogen ions).

7.2.2.3 Cross-Linked polyethylene (XLPE)

Insulation compound based on chemically cross-linked polyethylene conforming to ASTM specification D 2655. The base polymer of this insulation consists substantially of polyethylene or a polyethylene copolymer.

7.2.2.4 Polyvinylidene fluoride (PVDF)

Insulation compound based on especially chemical-resistant modified Polyvinylidene fluoride

conforming to ASTM specification D 3144.

7.2.2.5 In addition to above mentioned materials If any halogen or other corrosive gases or ions are expected to exist in the electrolyte, a specialized, chemical-resistant insulation material such as radiation cross-linked Polyvinylidene fluoride (XLPVDF), ethylene chlorotrifluoroethylene (ECTFE), cross-linked ethylene chlorotrifluoroethylene (XLECTFE), or other inert fluorocarbon or halogenated material shall be used.

8 Specific cable requirements

8.1 Positive conductor cable

8.1.1 Cable for use as a positive conductor shall be single core, stranded soft annealed copper as per sub clause 7.1.

8.1.2 Cable insulation, as will be specified by the Purchaser, shall be either standard or chlorine resistant type and shall conform to one of the following alternatives:

8.1.2.1 Standard type cable

8.1.2.1.1 Cable insulation shall be in accordance with one of the following alternatives, as will be specified by the Purchaser (see Appendix A).

- A single jacket of High Molecular Weight Polyethylene (HMWPE), (see 7.2.2.2).
- A double jacket of High Molecular Weight Polyethylene primary insulation/ Polyvinylchloride sheath (see 7.2.2.2 and 7.2.2.1).
- A double jacket of Cross-Linked Polyethylene (XLPE) primary insulation/Polyvinylchloride sheath (see 7.2.2.3 and 7.2.2.1).

8.1.2.1.2 The average thickness of cable insulation shall be minimum 2.8 mm for conductor sizes up to 35 sq. mm and 3 mm for larger sizes. The minimum thickness at any point shall not be less than 90% of the specified average thickness. In case of double jacket the thickness of sheath shall not be less than 1.5 mm.

8.1.2.1.3 Unless otherwise specified by the Purchaser, the color of cable insulation shall be fade-resistant red.

8.1.2.2 Chlorine resistant type cable

(To be used as positive cable in saline water and salty soil ground beds).

8.1.2.2.1 Cable insulation shall be in accordance with one of the following alternatives or other insulation materials as will be specified by the Purchaser (see 7.2.2.5 and Appendix B)

- A single jacket of Polyvinylidene Fluoride (PVDF), single or double extruded with the minimum thickness of 0.75 mm. (see 7.2.2.4).
- A double jacket of a radiation cross-linked Polyvinylidene Fluoride primary insulation/High Molecular Weight Polyethylene sheath (minimum thickness 0.5+1.7=2.2 mm).

8.1.2.2.2 Unless otherwise specified by the Purchaser, the color of cable insulation shall be fade-

resistant red.

8.2 Negative, bond or test conductor cable

8.2.1 All cables for use as negative conductor, bond conductor, or test conductor shall be single core, stranded soft annealed copper as per sub clause 7.1

8.2.2 Cable insulation shall be in accordance with one of the following alternatives or other insulation materials as will be specified by the Purchaser (see 7.2.2.5 and Appendices C & D):

- A single jacket of High Molecular Weight Polyethylene (HMWPE), (see 7.2.2.2).
- A single jacket of Cross-Linked polyethylene (XLPE), (see 7.2.2.3).
- A double jacket of polyvinylchloride primary insulation/polyvinylchloride sheath (see 7.2.2.1).

8.2.3 Minimum thickness of cable insulation shall be 1.0 mm for conductor sizes 6.0 sq. mm or less, 1.5 mm for conductor sizes up to 25 sq. mm and 2 mm for larger sizes.

8.2.4 Unless otherwise specified by the Purchaser, the color of cable insulation shall be fade-resistant black.

Note: Unless otherwise specified by the Purchaser, all type of cables should not have a metal armoring. (ISO 15589)

9 Quality assurance provisions

It is the responsibility of the manufacturer to establish quality assurance by quality control procedures which shall ensure that the product will meet the requirements of this Part of Standard specification.

The quality control at the manufacturing plant shall meet ISO 9001 standards requirements and include control systems on the following:

- Raw materials, i.e. checking of documentation and/or testing for conformity with the specification.
- Production equipment and process.
- Testing during and after production (see 9).
- Identification of cables.
- Dimension tolerances.
- Documentation (material certificates).

10 Tests

10.1 Tests shall be carried out to confirm that the materials comply with this Part of Standard specification and all cables shall satisfactorily pass such tests.

10.2 The factory acceptance tests shall be done on test samples taken from the end of each manufactured length (drum) at a temperature of 20°C and shall cover at least the following:

- Dimensions and construction.

- Dielectric strength of insulation.
- Insulation resistance.
- Electrical resistance of conductor.
- Voltage test.

10.3 All tests shall be carried out in accordance with relevant specifications prescribed in subclasses 7.1 and 7.2.

10.4 Unless otherwise specified in this Part of Standard specification, the methods of sampling and testing shall be in accordance with applicable methods of the International Electro Technical Commission (IEC), British Standards Institution (BSI), and/or Underwriters Laboratories Inc. (UL) latest edition.

11 Inspection

11.1 Responsibility for inspection

11.1.1 The manufacturer is responsible for the performance of all inspection and tests required by this Part of Standard specification using his own or other reliable facilities and he shall maintain complete records of all such tests and inspections. Such records shall be available for review by the Purchaser.

11.1.2 All tests and inspections shall be made at the place of manufacture. The manufacturer shall afford the inspector representing the Purchaser all reasonable facilities to satisfy him that the material is being furnished in accordance with this Part of Standard specification. Such inspections in no way relieve the manufacturer of his responsibilities under the terms of this Part of Standard specification.

11.1.3 Conformance of the cable to the requirements of this Part of Standard specification shall be determined on samples taken from each lot (see 3) of cable presented for acceptance.

11.1.4 The Purchaser reserves the right to perform any inspections set forth in this Part of Standard specification, where such inspections are deemed necessary to assure that supplies and services conform to the prescribed requirements.

11.1.5 The purchaser’s inspector shall have access to the material subject to inspection for the purpose of witnessing the selection of the samples, the preparation of the test samples, and the performance of the test(s). For such tests, the inspector shall have the right to indicate the pieces from which the samples will be taken in accordance with the provisions of this Part of Standard specification.

11.1.6 If any of the samples found not to conform to this Part of Standard specification materials represented by such sample will be rejected.

11.2 General examination

A visual inspection for the conformity of cables with the requirements specified in this Part of Standard specification and with a good manufacturing practice shall be carried out on cable pieces.

11.3 Conductor examination

Compliance with the requirements for conductor construction of IEC Publication 60228 or ASTM specification B8 shall be checked by inspection. The cross-sectional area shall be checked by measuring the electrical resistance. No measurements of wire diameters shall be required in checking the conductors.

11.4 Thickness of insulation and sheath

The thickness of insulation and sheath (if any) shall be checked on a manufacturing length to ensure minimum insulation thickness. The test method shall be in accordance with ASTM methods of testing D 2633 or D 470 complying with the appropriate requirements of Clause 8.

11.5 Insulation resistance test

This test shall be made on a single sample per cable type, in accordance with ASTM methods of testing D 2633 or D 470. For standard type cables test shall be carried out by the submerging the sample in pure water. For chlorine resistant type cables this shall be water with an admixture of salt, 30 grams per liter.

12 Certification

12.1 The manufacturer's and/or supplier's certification shall be furnished to the Purchaser stating that samples representing each lot have been manufactured, tested, and inspected in accordance with this Part of Standard specification and the requirements have been met.

12.2 The test reports shall contain results of tests required by this Part of Standard specification and other tests specified by the Purchaser.

12.3 Each test report shall be signed by an authorized agent of the seller and/or manufacturer.

12.4 Certified test reports furnished by the manufacturer shall be properly identified with each lot (batch) of products.

13 Packaging and shipment

13.1 The cables shall be supplied on non-returnable rigid reels in continuous lengths for the cable size involved, with the inner end of cable brought out through the side of the reel(s).

13.2 The cable shall be placed on the reels so that it will be protected from damage during shipment. Each end of the cable shall be firmly and properly secured to the reel. Care shall be taken to prevent looseness of reeled cable.

13.3 The reels shall be lagged or covered with suitable material to provide physical protection for the cables during transit and during ordinary storage and handling operations

13.4 The manufacturer shall be solely responsible for the adequacy of the preparation for shipping provisions employed with respect to materials and their application to insure that the cable reaches its destination in perfect working condition when handled by commercial carrier systems.

14 Labeling

14.1 Cable Identification

All insulated or jacketed cable shall be durably marked at intervals not exceeding 100 cm with the following minimum information in addition to any standard requirements.

- The maximum working voltage for which the cable was tested or approved.
- The proper designation for the type of cable (positive, negative, chlorine-resistant) and insulation and sheath.
- The manufacturer's name, trademark or other distinctive marking from which the cable manufacturer can be readily identified together with year of manufacture.
- The cross sectional area of the conductor in sq.mm
- The standard to which the conductor conforms (see 7.1).
- Meter marking for the purpose of indicating the length of the cable remaining on partially used Reels (if specified).

14.2 Marking of reels

Each reel and each crate or pallet shall be plainly and durably marked with the following information:

Name: Cathodic Protection Cable .....

Specification: IPS-M-TP-750: Part 5 .....

Order No.: .....

M.E.S.C No.: .....

Type of cable: (i.e. positive, negative, bond or test) .....

Type of insulation: (i.e. standard or chlorine-resistant) .....

Length of cable on reel: ..... (m)

No., size (mm) and type of conductor: .....

Cable configuration: .....

Thickness (mm) and material of insulation: .....

Thickness (mm) and material of sheath: .....

Voltage rating: .....

Batch No.: .....

Stock No.: .....

Date of manufacture: .....

Quantity of reel on each crate or pallet: .....

Name or trademark of the supplier: .....

Manufacturer's name and address: .....

Appendices

Appendix A

Data sheet

(to be submitted by the purchaser)

for

IPS-M-TP-750: Part 5 Cathodic protection cable

Positive cable, standard type, single core, 600/1000 Volts, copper conductor, insulated for use as positive conductor in impressed current cathodic protection systems.

The cable shall be in accordance with the latest edition of above Iranian Petroleum Standard with the following specific requirements:

- Project title: ..... - Date: .....
- Indent No.: ..... - Purchaser: .....
- M.E.S.C No.: .....
- Length of cable required: ..... meters
- Individual drum length: .....
- Conductor size: ..... mm^2
- Type of insulation: ☐ Single jacket- HMWPE
  ☐ Double jacket- HMWPE/PVC
  ☐ Double jacket- XLPE/HMWPE
- Sheath color: .....

Appendix B

Data sheet

(to be submitted by the purchaser)

for

IPS-M-TP-750: Part 5 Cathodic protection cable

Positive cable, chlorine resistant type, single core, 600/1000 Volts, copper conductor, insulated for use as positive conductor in saline water and salty soil ground beds in impressed current cathodic protection systems.

The cable shall be in accordance with the latest edition of above Iranian Petroleum Standard with the following specific requirements:

- Project title: ..... - Date: .....
- Indent No.: ..... - Purchaser: .....
- M.E.S.C No.: .....
- Length of cable required: ..... meters
- Individual drum length: .....
- Conductor size: ..... mm^2
- Type of insulation: ☐ Single jacket PVDF
  ☐ Double jacket PVDF/HMWPE
  ☐ per request
- Sheath color: .....

Appendix C

Data sheet

(to be submitted by the purchaser)

for

IPS-M-TP-750: Part 5 Cathodic protection cable

Negative cable, single core, 600/1000 Volts, copper conductor, insulated for use as negative conductor in cathodic protection systems.

The cable shall be in accordance with the latest edition of above Iranian Petroleum Standard with the following specific requirements:

- Project title: ..... - Date: .....
- Indent No.: ..... - Purchaser: .....
- M.E.S.C No.: .....
- Length of cable required: ..... meters
- Individual drum length: .....
- Conductor size: ..... mm^2
- Type of insulation:
  - ☐ Single jacket- HMWPE
  - ☐ Single jacket - XLPE
  - ☐ Double jacket PVC/PVC
  - ☐ per request
- Sheath color: .....

Appendix D

Data sheet

(to be submitted by the purchaser)

for

IPS-M-TP-750: Part 5 Cathodic protection cable

Cable, single core, 600/1000 Volts, copper conductor, insulated for use as bond conductor or test conductor in cathodic protection systems.

The cable shall be in accordance with the latest edition of above Iranian Petroleum Standard with the following specific requirements:

- Project title: ..... - Date: .....
- Indent No.: ..... - Purchaser: .....
- M.E.S.C No.: .....
- Length of cable required: ..... meters
- Individual drum length: .....
- Conductor size: ..... mm^2
- Type of insulation: ☐ Single jacket - HMWPE
  ☐ Double jacket PVC/PVC
  ☐ per request
- Sheath color: .....

Appendix E

Cable design data

Cooper conductor	Number of strands	Diameter of strands		Cross sectional Area of conductor (calculated)		Signal conduction Weight per km run	Signal conductor Resistance per Meter run at 20˚C	Typical DC Current ratings (conductor temp, Max.70˚C
metric		inch	mm	Sq.in	Sq.mm	kg	microhm	amp
2.5	1		1.78		2.49	22.2	7280	18
	1	0.0808		0.00513	3.31		5315	20
4.0	7		0.85		3.972	36.1	4610	24
	1	0.1019		0.00816	5.26		3340	30
6.0	7		1.04		5.95	54.0	3080	31
	1	0.1285		0.013	8.37		2101	40
10	7		1.35		10.02	90.8	1630	42
	7	0.0612		0.0206	13.3		1345	55
16	7		1.70		15.89	145	1150	56
	7	0.0772		0.033	21.14		350	70
25	7		2.14		25.18	229	727	73
	7	0.0867		0.041	26.66		673	80
	7	0.0974		0.052	33.66		632	95
35	7		1.53		34.93	317	524	90
	19	0.0664		0.066	42.45		423	110
50	19		1.78		47.28	429	387	145
	19	0.0745		0.083	53.43		335	125
	19	0.0837		0.1045	67.45		266	145
70	19		2.14		68.34	620	268	185
	19	0.0040		0.132	85.07		211	165
95	19		2.52		94.75	860	193	230
	19	0.0055		0/166	107.76		167	195
120	37		2.03		119.75	1086	153	260
	37	0.0822		0.196	126.58		141.4	270
150	37		2.25		147.11	1334	124.0	355
	37	0.0900		0.235	151.86		118.1	300
	37	0.0973		0.275	177.50		101.1	325
185	37		2.52		184.54	1673	99.1	405
	37	0.1040		0.314	202.78		88.6	360
240	61		2.25		242.54	2199	75.4	480
	37	0.1162		0.392	253.15		70.9	405
300	61		2.52		304.2	2759	60.1	560
	61	0.0992		0.471	304.2		59.1	455
	61	0.1071		0.550	354.5		50.5	490
	61	0.1109		0.589	380.1		47.2	500
400	61		2.85		389.1	3528	47.0	680
	61	0.1145		0.628	405.2		44.3	515
	61	0.1215		0.709	456.3		39.4	555
500	61		3.20		490.6	4448	36.6	600
	61	0.1280		0.785	506.4		35.4	585
630	127		2.52		633.4	5744	28.3	910

Note: Typical current ratings are given as a guide only- always check manufacturer's rating for the particular site operating conditions, including all relevant dating factors.

Part 6
Insulating joint

1 Scope

This Part of IPS-M-TP-750 covers the minimum requirements for the design, fabrication and inspection of monolithic insulating joints, for electrical isolation of pipelines from plants and/or other pipelines.

Notes:

1) The purpose of insulating joints is to provide electrical isolation between sections of pipelines to prevent detrimental electrochemical interaction between the sections. Insulating joints are used also to ensure effective current distribution for cathodic protection systems.

2) The insulating joint is intended to be installed under/above ground or above water. It is intended to be girth welded between two pipeline sections. The insulating joint should not be buried; this is also the case for other types of electrical isolations (spools). In which case electrical isolation construction is conducted under ground, external corrosion must come to consideration.

2 References

Throughout this Standard the following dated and undated standards/codes are referred to. These referenced documents shall, to the extent specified herein, form a part of this standard. For dated references, the edition cited applies. The applicability of changes in dated references that occur after the cited date shall be mutually agreed upon by the Company and the Vendor. For undated references, the latest edition of the referenced documents (including any supplements and amendments) applies.

2.1 ASME B 16.25, Buttwelding ends

Boiler and pressure vessel code, section VIII,

"Rules for construction of pressure vessels", division 1

Boiler and pressure vessel code, section IX,

"Qualification standard for welding and brazing procedures, welders, brazers, and welding and brazing operators"

Boiler and pressure vessel code, section V,

"Non-destructive examination"

2.2 ASME B 16.5, Pipe flanges and flanged fittings, NPS 1/2 Through NPS 24 metric/inch standard

2.3 ASME B 31.8, Gas transmission and distribution piping systems

2.4 ASTM A 105, Standard specification for "Forgings, carbon steel for piping components"

2.5 ASTM A 370, Standard test methods and definitions for "Mechanical testing of steel products"

2.6 ASTM A 694, Standard specification for

"Carbon and alloy steel forgings, for pipe flanges, fittings, valves and parts for high pressure

transmission service"

2.7 ASTM D 709, Standard specification for

"Laminated thermosetting materials"

2.8 ASTM D 2000, Standard classification system for

"Rubber Products in automotive applications"

2.9 API 1104, Welding of pipelines and related facilities

2.10 API 5L, Line pipe

2.11 ISO 8501-1, Preparation of steel structures before application of paints and related products-Visual assessment of surface cleanliness

2.12 ISO 10474, Steel and steel products inspection documents

2.13 MSS SP-44, Steel pipeline flanges

2.14 MSS SP-75, Specification for high wrought welding fittings

2.15 NACE TM-01-87, Evaluating elastomeric materials in sour gas environments

2.16 ANSI/NACE MR-01-75 /ISO 15156, Material requirements sulfide stress cracking resistance-metallic materials for oilfield equipment

2.17 ANSI/NACE MR 0103/ ISO 17495-1, Petroleum, petrochemical and natural gas industries-Metallic materials resistant to sulfide stress cracking in corrosive petroleum refining environments

3 Units

This Standard is based on International System of Units (SI), as per IPS-E-GN-100 except where otherwise specified.

4 Technical documents

4.1 The technical bid shall include the following:

a. Comprehensive catalogues, technical data, general arrangement drawings showing outline dimensions, proposed test procedure, etc. of the offered insulating joint(s);
b. Detailed drawings showing all parts with material identification and stress/design calculations;
c. Welding procedure specification;
d. Material specifications for the following items:
- Steel forgings
- Insulating rings
- Seal Gaskets
- Epoxy resin filler material
- External coating
- Internal coating

a. Assembly procedure;
b. Records of tests;
c. Declaration of confirmation with this Part of Standard specification and/or clear indication of deviations from this Standard specification;
d. Specification of packing.

4.2 The manufacturer/supplier shall provide sufficient information to identify the insulating joint and shall supply the technical information as a minimum requirement as follows:

a. ISO 9001 certification for design, manufacturing and quality control of the insulating joint to be used for impressed current / sacrificial anode cathodic protection installation, issued by an internationally recognized body;
b. Original technical catalogue and data sheet, manufacturing procedure specification, quality control plan, application procedure recommendation and guidelines (installation instructions).
c. Filled, signed and stamped data sheets as shown in Appendices A.
d. All laboratory and shop testing shall be documented. The insulating joint shall be traceable to the manufacturing batch. Shipping, handling and storage procedures shall ensure that the insulating joints are not damaged.
e. Material certificate and specifications for the following items:
- Steel forgings
- Insulating rings
- Seal Gaskets
- Epoxy resin filler material
- External coating
- Internal coating

Note 1: Manufacturing procedures shall cover all stages of the manufacturing process, from receipt of raw materials to finishing and packing for shipment, including:

a. chemical analysis;
b. inspection and testing procedures and frequencies;

Note 2: The quality control at the insulating joint manufacturing plant shall include control systems on the following:

a. Raw materials, i.e. checking of documentation;
b. Production equipment and process;
c. Testing during and after production;
d. Identification of insulating joint;
e. Chemical analysis;
f. Documentation (material certificates).

4.3 The manufacturer/supplier shall submit following certificates, as a minimum:

a. Test certificates relevant to the chemical and mechanical properties of the materials used for construction as per this Part of Standard specification and relevant standards;
b. Test reports for radiographic and ultrasonic inspection and dye penetration tests;
c. Test certificates for hydrostatic and air tests;
d. Test certificate for electrical tests;

e. Stress relieve and heat treatment certificates;
f. Test certificate for dimensions and sectional drawings;
g. Test certificate for insulation material, sealing and filler material, provided by manufacture;
h. Test certificate for surface preparation;
i. Test certificate for paint system (provided by paint manufacture) ;
j. Test certificate for qualification of applied paint.

In addition to the certified material test reports the manufacturer/supplier shall provide a user manual detailing the requirements for installation and inspection in service.

The certificates shall be considered valid only when signed by Purchaser's inspector.

5 Design

5.1 All insulating joints shall be of monolithic type fabricated by welding and with pups on either side. The insulating joints shall be suitable for pigging operations.

5.2 The design of the insulating joint(s) shall be compatible with the design code adopted for the pipeline in which it is installed, as stated in the data sheet.

Note: ANSI/ASME B 31.4 and B 31.8 are commonly adopted pipeline codes. In some situations, e.g. within plant fences, the pipeline sections connected to the insulating joint may be designed to a plant piping code, e.g. ANSI/ASME B 31.3.

5.3 The insulating joint(s) shall be designed so that it's bending moment along with projection pressure to be able to generate a longitudinal stress equal to 75% of the adjacent pipe pups.

5.4 The insulating joint(s) shall be designed following the methodology described in ASME VIII Division 1 Appendix 2 or equivalent, using the design pressure, design temperature and design factor of the pipeline, and the anticipated external loads acting on the insulating joint. Stress due to internal design pressure shall not exceed 50% of specified minimum yield strength of material.

5.5 The insulating joint(s) must be assembled so that its internal components are tightly fixed in the required position. To this purpose an assembling precompression, adequately calculated, shall be applied.

5.6 The number of weldings must be as restricted as possible. All joints shall be butt welded and have full penetration except for the final closure weld. The final closure weld shall be in accordance with ASME Section VIII Div. 1 ULW 17.6.

5-7 For sour service conditions (when specified), the materials shall comply with the requirements of relevant standards such as ANSI/NACE MR 01 75 / ISO 15156, ANSI/NACE MR 0103/ISO 17495-1 and TM 01 87.

5.8 Sealing system

5.8.1 There are substantially 3 PRIMARY sealing systems adopted by the manufacturers of monolithic isolating joints:

- O-Rings sealing system
- Rectangular shaped sealing system

- U-shape sealing system

5.8.2 Insulating ring material (gasket or spacer) and sealing system shall be so designed that the joint assembly complies with the mechanical and electrical requirements specified in this Standard specification. The sealing system should be made of one rectangular or "U" shaped piece.

5.9 The internal diameter of the joint shall not deviate by more than ±2% from the nominal internal diameter of the pipeline.

5.10 Construction shall not incorporate any flanges, bolts, gaskets, and shall be of rigid and rugged design suitable for field installation without a maintenance pit when installed either on a buried or surface laid pipeline.

5.11 Tension and compression shall be axially transmitted satisfactorily and without appreciable elongation or contraction.

The joint shall indicate no unacceptable deformation when under maximum pressure and temperature.

5.12 The manufacturer shall take into consideration that, during the tie-in to the pipeline, the rings of the rigid insulating material, must not exceed a temperature of 70°C.

5.13 The minimum overall lengths for the joints (as measured between ends) of given size and pressure class shall be as follows:

Table 1- Minimum overall lengths for the joints

PIPE SIZE DN	**ANSI CLASS RATING**					
	150	**300**	**400**	**600**	**900**	**1500**
Up to 350	700 mm	700 mm	1000 mm	1000 mm	1000 mm	1000 mm
400 to 600	1000 mm	1000 mm	1200 mm	1500 mm	1500 mm	1500 mm
650 to 900	1500 mm	1500 mm	1800 mm	2000 mm	2000 mm	2000 mm
950 to 1200	2000 mm	2200 mm	2200 mm	2500 mm	2800 mm	2800 mm
1250 to 1500	2500 mm	2800 mm	3000 mm	3000 mm	3200 mm	3200 mm

Note 1: For pipelines with a wall thickness exceeding 25 mm, the manufacturer/supplier shall confirm that the length of the joint is suitable for post weld heat treatment of the field welds, i.e. the heat generated by the treatment is not detrimental to the isolating and filler materials and the internal coating. If this is not the case, the length of the joint shall be increased accordingly.

5.14 If the product transported by the pipeline is an electrolyte, there is a possibility of cathodic protection current flowing across the isolation causing internal corrosion at the "unprotected" side of the isolation. In this case additional protection system should be considered such as local internal cathodic protection or the protection side of insulating joint has enough length with internal coating.

6 Materials

6.1 Material for the pressure containing parts of the insulating joints shall meet the requirements of data sheet (see Appendix A).

The metallic parts of the insulating joint shall be of forged steel conforming to the requirements of MSS-SP-44.

6.1.1 The ladle analysis of each heat of steel used in the manufacture of insulating joint shall conform to the material degree that is declared to be used with the restrictions foreseen by Para. 6.1.2.

1) Forged, fully killed, normalized or hardened and tempered materials will have to be used according to the schedule here below:

APPROVED STUB MATERIAL	FORGED MATERIAL
API 5L Gr. A	ASTM A 105
API 5L Gr. B	ASTM A 105
API 5L X 42	ASTM A 694 F 42 or F 52
API 5L X 52	ASTM A 694 F 52
API 5L X 60	ASTM A 694 F 60
API 5L X 65	ASTM A 694 F 65

6.1.2 The carbon equivalent calculated with the following formula shall not exceed 0.42%:

C.E. = C + Mn/6

C.E. = Carbon Equivalent

C = Carbon

Mn = Manganese

Materials, quality and size of the pups shall be the same as or better than those of the pipe to be connected (see data sheet).

6.2 Insulation and sealing system material

6.2.1 The Insulating ring material shall be made of an age resisting elastomer of a high dielectric characteristics. It shall resist explosive decompression, and shall be suitable for long-term exposure to the transported fluid at the design pressure and temperature conditions.

6.2.2 The insulating materials and filler materials shall be suitable for the long-term exposure to the transported fluid at the design pressure and temperature conditions.

The insulating material shall be non-hygroscopic and shall be of sustaining high compressive stresses. The material shall have good long-term stability, excellent dielectric strength, and thermic properties without cracking, distorting, or a loss of insulating properties. The material shall be flame resistant, and also resistant to hydrocarbons, sulphides, bacteria and the climatic conditions specified in Appendix A.

6.2.3 Insulating materials shall be made of age resisting laminated epoxy resin reinforced with

glass fiber conforming to ASTM specification D 709 Type IV Group G 10/G 11 or equivalent standard.

6.3 The sealing system shall be made of HNBR/NBR or FKM (Viton) or equivalent according to ASTM D 2000.

Fluorinated elastomers like PTFE and/or Butadiene acrylonitrile copolymers like Nitrile rubber according to ASTM specification D 2000, or equivalent standard.

6.4 Filling materials shall be of adhesive sealant like epoxy resin having a compressive strength greater than 1500 kg/cm².

7 Manufacture

7.1 The manufacturer shall be responsible for the integrity of the manufacturing procedures and adherence to this Part of Standard specification.

7.2 The assembly of insulating joint(s) shall be done in a controlled, clean environment.

7.3 The insulating joint(s) shall be assembled in such a way that its various components are firmly locked in position and the complete joint is capable of withstanding stresses due to designed operating conditions and field hydrostatic testing.

7.4 The surface of the annular space between the pup and the retainer shall be abrasive shot-blasted to SA 2½ grade in accordance with ISO 8501-1. Assembly of the insulating joint shall commence within 2 hours after completion of abrasive shot blasting.

7.5 The annular space between the retainer and the pup shall be filled with filler material; to be approved by the Purchaser's representative.

7.6 Any depressions in the insulating joint shall be filled with adhesive sealant elastomer to prevent the deposition of sediment at this point.

7.7 Insulating joint(s) shall not be of harmful defect specified on para. 14.5.2 of MSS-SP-75 and the other defects in surface shall be removed according to Para. 14.5.3 of MSS-SP-75.

7.8 All butt welds shall be heat treated after all welding has been completed in accordance with the requirements of ASME Boiler and Pressure Vessel Code, Section VIII.

7.8.1 Lamination found at the bevel end parts shall be removed wholly.

7.8.2 The height of internal weld beads shall be less than 2 mm.

7.8.3 Under-cutting on weld seam shall not be permitted.

7.9 The end connections shall be beveled for welding in accordance with MSS-SP-75, unless otherwise specified by the Purchaser, to allow welding to the pipeline with only two circumferential butt welds. Welding bevels shall be dry and free from grease and other contaminants.

7.10 For a distance of 100 mm from the welding ends, the internal diameter shall not deviate by more than ±1.5 mm from the nominal internal diameter of the pipeline.

7.11 Heat-treatment for insulating joint(s) shall be performed according to ASME VIII, Division I and related ASME specification.

In this case, the temperature in furnace shall be recorded and controlled continuously during processing, and record chart shall be submitted to purchaser. When required, before manufacturing, supplier shall submit the heat treatment specification described following items:

- Heat-treatment procedure.
- Standard temperature curve chart.
- Temperature control range.

8 Welding requirements

8.1 Approved welding processes

Any of the following processes may be used:

a. Shielded metal arc welding (SMAW).
b. Gas tungsten-Arc welding (GTAW or TIG).
c. Gas metal-Arc welding (GMAW, or MIG).
d. Submerged arc welding (SAW).
e. Combinations of above processes.

8.2 Procedure qualifications

Welding procedures shall be qualified in accordance with ASME Section IX.

8.3 Welder qualifications

Welders shall be qualified in accordance with the requirements of ASME Section IX.

8.4 Consumable materials

Electrodes, filler wires and fluxes shall conform to AWS specifications A 5.1 through A 5.30 as applicable.

8.5 Weld details

All joints shall be butt-welded and have full penetration welds except for the final closure weld, which shall be welded in accordance with ASME VIII ULW 17.6, Fig. “A”.

9 Coating

After all tests and inspections required have been carried out, insulating joints shall be thoroughly cleaned in order to remove rust or impurities. Surface preparation shall be carried out by blasting to SA 2½ or SA 3 grade in accordance with ISO 8501-1. After visual inspection, all insulating joints shall be externally and internally coated with a phenolic amine cured epoxy paint to a dry film thickness of 500 microns applied in two coats. The application shall be in strict accordance with the coating supplier’s specification. Beveled ends for 50 mm approx. shall be painted with rust preventive paint. Surface roughness shall be considered in accordance to coating supplier’s specification.

For above ground a top coat of two component polyurethane with min thickness (DFT) of 70µm shall be applied.

Coating quality shall be checked by some tests concluding: Pull off test and holiday detection. Coating of inside and outside of insulating joint shall be subjected to holiday detection high voltage spark test with a voltage of 6 volts per micron (6V/M).

Note: Epoxy internal coatings may not be suitable for some chemical products. When other coatings need to be specified, advice from a material specialist should be taken. Metallic pigmented coatings shall not be used.

10 Quality assurance provisions

It is the responsibility of the manufacturer to establish quality assurance by quality control procedures which shall ensure that the product will meet the requirements of this Part of Standard specification.

The quality control at the manufacturing plant shall include control systems on the following:

- Raw materials, i.e. checking of documentation and/or testing for conformity with the specification.
- Production equipment and process.
- Testing during and after fabrication.
- Checking of dimensions.
- Documentation (material certificates).

As alternative to above control system the manufacturer can have quality assurance system in accordance with ISO 9002.

11 Tests

11.1 General

Tests shall be carried out to conform that the materials comply with this Part of Standard specification and all insulating joints shall satisfactorily pass such tests.

11.2 Items of test and inspection

Table 2- Items of test and inspection of insulating joints quality control

TEST ITEM	MANUFACTURER	PURCHASER WITNESS	RECORD
Chemical analysis	0	*	0
Mechanical test	0	*	0
Hydraulic test or air tightness test	0	0	0
Radiographic test	0	*	0
Coating inspection	0	0	0
Dielectric test & megger test	0	0	0
Ultrasonic test & magnetic particle test	0	*	0
Dye penetration test	0	*	0
Visual inspection	0	0	0
Dimension check	0	0	0
Heat treatment	0	*	0

Legend:

0 : Operation & record

* : Document check

11.3 Chemical analysis

Chemical analysis shall be performed by the ladle analysis for each heat of steel used and shall conform to the requirements of the chemical composition for the respective materials as per relevant standard.

11.4 Mechanical test

Tensile test is performed for each lot after heat-treatment.

The same charged, shaped and heat-treated products are considered 1 lot.

a. Forgings

The tensile tests shall be performed according to ASTM A 370 code corresponding to equivalent material and the results shall comply with the mechanical requirements in this Part of Standard specification.

b. Pups

The tensile tests shall be performed according to Section 3, Mechanical Properties and Tests of API 5L. No leakage or pressure drops shall be permitted during the test.

c. Steel parts

The base material and welds shall have maximum hardness of 280 HV 10 hardness test shall be per formed according to ASTM A370.

11.5 Dielectric test and megger test

Upon completion of the assembly and prior to the hydrostatic test, each insulating joint shall be megger tested with 1000 V. DC Minimum resistance shall be 60 Meg ohms.

Each insulating joint shall also be dielectric tested at 5000 V. AC (50 Hz) for 1 minute. There shall be no corona effects or breakdown.

The above stated tests shall be repeated after hydrostatic test. The readings before and after the hydrostatic test shall be accepted.

11.6 Hydrostatic test

The insulating joint shall be hydrostatically tested, in an unrestrained condition, using water with a low surface tension, at 1.5 times the rating (permissible working pressure).

In the test, the insulating joint shall be subjected to the full axial load deriving from the hydrostatic pressure unless it has been verified in a type test that the insulating joint is able to resist the full axial load in service.

Unless otherwise specified by the Purchaser the maximum test pressure shall be maintained for at least three hours. No leaks or unacceptable deformation shall occur during the test.

11.7 Low pressure leakage test (air test)

After hydrostatic test, a low pressure leakage test shall be carried out on each insulating joint. The joint shall be filled with air and will be pressurized to 0.5 MPa and held at that pressure for 10 minutes. No leakage or pressure drops shall be permitted during the test.

11.8 Prototype tests

Prototype tests shall be required if the manufacturer cannot provide data of similar tests to the satisfaction of the Purchaser.

Prototype joints, representative of production, selected for test shall be identified as to material, grade, and lot, including heat treatment, hydrostatic cyclic pressure tests, hydrostatic pressure plus bending test, and vacuum test where appropriate.

11.9 Radiographic test

All butt welds shall be 100% radiographed by X-ray or ɣ ray in accordance with Section V of the ASME Boiler and Pressure Vessel Code Non-destructive Examination.

11.10 Magnetic particle and ultrasonic test

11.10.1 The final closure weld shall be inspected by ultrasonic or magnetic particle methods in accordance with ASME Section VIII.

11.10.2 All finished bevel ends shall be 100% ultrasonically tested for lamination type defects

for a distance of 50 mm from the ends. Lamination shall not be acceptable.

Notes:

1) The ultrasonic examination method shall be applied before preparing weld edges, especially for areas of 25 mm width around the edge.

2) The magnetic particle examination shall be made only after completion of weld edge preparation.

11.10.3 Acceptance criteria shall be as per ASME Sec. VIII Div. I, Appendix 12.

11.11 Dye penetrant test

Dye penetrant test shall be performed on the machined surface according to ASME Section VIII, DIV. I, Appendix 8.

11.12 Visual inspection and dimensional check

11.12.1 Visual inspection of all parts prior to assembly and after finishing of the insulating joint shall be carried out by the manufacturer. General appearance shall show good workmanship.

11.12.2 Dimensions of the insulating joint(s) shall be checked against the specifications, purchase order description and/or approved manufacturer drawings.

11.12.3 The inside and outside thickness of coating shall be checked and it shall not be below the values indicated in Clause 9. The coating appearance shall be even on the whole surface.

12 Inspection

12.1 The manufacturer/supplier shall be responsible for carrying out all the tests and inspections required by Part 8 of this Standard specification, using his own or other reliable facilities, and he shall maintain complete records of all such tests and inspections. Such records shall be available for review by the Purchaser. Certified tests and inspection reports shall be properly identified with each batch (lot) of product. The manufacturer shall afford the Purchaser's inspector all reasonable facilities necessary to satisfy him that the insulating joint(s) are fabricated in accordance with the provisions of this Part of Standard specification.

12.2 The Purchaser reserves the right to perform any inspections set forth in this Part of Standard specification where such inspections are deemed necessary to assure that supplies and services conform to the prescribed requirements.

12.3 If the Purchaser desires that his representative inspect or witness the inspection and testing of the product prior to shipment, the manufacturer/supplier shall afford the Purchaser's representative all reasonable facilities to satisfy him that the product meets the requirements of this Specification. Such inspections in no way relieve the manufacturer/ supplier of his responsibilities under the term of this Part of Standard specification.

12.4 Purchaser's inspector(s) shall have free access to the manufacturer's works to follow up the progress of the materials covered by this Part of Standard specification and to check the quality of materials. The manufacturer/supplier shall place free of charge at the disposal of the Purchaser's inspector(s) all means necessary for carrying out their inspection: results of tests,

checking of conformity of materials with this Standard requirements, checking of marking and packing and temporary acceptance of materials.

12.5 An inspection certificate shall be provided by the manufacturer in accordance with the following:

- EN-10204 3.1 for chemical analysis, mechanical properties, notch toughness properties, hardness properties, heat treatment, non-destructive examination.
- EN-10204 3.2 for other tests, e.g. dimensional checks, pressure test (when specified), functional checks.

12.6 The insulating joints may be rejected if measurement, inspection and/or testing reveal discrepancies between quoted figures resulting in purchase order documents (including this Part of standard specification and its attachments), and those obtained actually.

13 Packing and shipment

13.1 Both ends of each insulating joint shall be closed with slip-on recessed end caps to protect the internal parts and also the beveled ends from any possible damage. Care shall be taken to prevent damage to the external and internal coatings.

13.2 Insulating joints shall be suitably packed and protected against all damages or defects which may occur during transit (sea shipment to the port and rough road haulage to site), and extended tropical open air storage up to 24 months.

13.3 Only those insulating joints which have been inspected and certified by Purchaser's inspector shall be shipped.

Note: Tack welding of protectors to the joints is not permitted.

14 Installation

14.1 The insulation joints shall not be in tension during installation by circumferential welding on both sides.

15 Labeling

15.1 Marking of insulating joints

All insulating joints furnished under this Part of Standard specification shall be clearly identified with the information marked with low stress die stamps or interrupted dot stamps on the outside of each completed insulating joint as follows:

a. Manufacturer's name;
b. joint serial No.;
c. size (DN);
d. thickness of ends;
e. material grade;
f. ANSI rating;
g. maximum working temperature rating, in °C;

h. the year of manufacturing;
i. tag No.;
j. weight.

Note: When sour service conditions are specified, the insulating joint shall be stamped "ANSI/NACE MR 0175/ISO 15156".

15.2 Marking of container

Each container of insulating joint(s) shall be marked with the following information:

- Name: Insulating joint.....
- Specification: IPS-M-TP-750: Part 6.....
- Order No.: .....
- M.E.S.C No.: .....
- Joint serial No.: .....
- Size (DN): .....
- Thickness of ends: .....
- Material grade: .....
- ANSI rating: .....
- Weight: .....
- Temperature rating, in °C: .....
- Batch No.: .....
- Stock No.: .....
- Date of manufacture: .....
- Quantity: .....
- Trademark of the manufacturer: .....
- Manufacturer's name and address: .....

Appendices

Appendix A

Data sheet

(to be submitted by the purchaser)

for

Insulating joint

Project title: Indent No.: Date: Quantity:	Purchaser: ☐ Oil industry ☐ Gas industry ☐ Petrochemical industry
ITEM	SELECTION
Pipeline design code	☐ ANSI B 31.4 ☐ ANSI B 31.8 ☐ Other:
Pipeline design factor	
Pipeline outside diameter	mm
Pipeline wall thickness	mm
Pipeline material	Specification: Type/grade:
Pipeline design pressure	bar (ga)
Pipeline design temperature	Minimum: °C Maximum: °C
Transported fluid	
Insulating joint length	mm
Sour services	☐ Yes ☐ No
Toxic services	☐ Yes ☐ No
Installation	☐ Buried ☐ Overground ☐ Offshore
ADDITIONAL DATA	
Made by: Date: Checked by: Date: Approved by: Date:	

Part 7
Flange insulation kit

1 Scope

This Part of IPS-M-TP-750 covers the minimum requirements for flange insulation kit, complete, intended for electrical insulation of standard, flat face, raised face, or ring joint type, flanges used for cathodically protected steel pipes and forming part of corrosion protection of the structure.

Appendix A is the data sheet which shall be used for ordering purposes.

2 References

Throughout this Standard the following dated and undated standards/codes are referred to. These referenced documents shall, to the extent specified herein, form a part of this standard. For dated references, the edition cited applies. The applicability of changes in dated references that occur after the cited date shall be mutually agreed upon by the Company and the Vendor. For undated references, the latest edition of the referenced documents (including any supplements and amendments) applies.

2.1 ASME B 16.5, Pipe flanges and flanged fittings, NPS 1/2 through NPS 24 metric/inch standard

2.2 ASME B 16.20, Metallic gaskets for pipe flanges ring, spiral-Wound and jacked

2.3 ASME B 16.21, Non-Metallic flat gaskets for pipe flanges

2.4 ASTM D 149, Standard test method for dielectric breakdown voltage and dielectric strength of solid electrical insulating materials at commercial power frequencies

2.5 ASTM D 229, Standard test methods rigid sheet and plate materials used for electrical insulation

2.6 ASTM D 374M, Standard test method for thickness of solid electrical insulation (metric)

2.7 ASTM D 570, Standard test method for water absorption of plastics

2.8 ASTM D 709, Standard specification for laminated thermosetting materials

2.9 ASTM D 638, Standard test method for tensile properties of plastics

2.10 ASTM D 883, Standard terminology relating to plastics

2.11 ASTM D 1505, Standard test method for density of plastics by the density-Gradient technique

2.12 ASTM D 4088, Standard practice for preparation for shipment of solid electrical insulating materials

2.13 ASTM F 118, Standard definitions of terms relating to gaskets

2.14 BS 3410, Specification for metal washes for general engineering purposes

2.15 US MIL-P-15035, Plastic sheet; laminated, thermosetting, cotton-Fabric-base, phenolic-resin

2.16 ANSI/NACE MR-01-75 ISO/15156, Material requirements sulfide stress cracking resistance-Metallic materials for oilfield equipment

2.17 ANSI/NACE MR 0103/ISO 17495-1, Petroleum, petrochemical and natural gas industries-Metallic materials resistant to sulfide stress cracking in corrosive petroleum refining environments

3 Definitions and terminology

For definitions of technical terms pertaining to gaskets and plastics used in this Part of Standard specification see ASTM D 883 and F 118.

4 Units

This Standard is based on International System of Units (SI), as per IPS-E-GN-100 except where otherwise specified.

5 Technical documents

5.1 The technical bid shall include the following:

a. Manufacturing specification and procedure;
b. Catalogue showing materials, dimensions, and configuration;
c. Material specification for the components to be offered;
d. Test specification and procedure;
e. Specification of packing.

5.2 The manufacturer/supplier shall provide sufficient information to identify the flange insulation kit and shall supply the technical information as a minimum requirement as follows:

a. ISO 9001 certification for design, manufacturing and quality control of the insulating gasket to be used for impressed current / sacrificial anode cathodic protection installation, issued by an internationally recognized body;

b. Original technical catalogue and data sheet, manufacturing procedure specification, quality control plan, application procedure recommendation and guidelines (installation instructions);

c. Filled, signed and stamped data sheets as shown in Appendices A;

d. All laboratory and shop testing shall be documented. The flange insulation kit shall be traceable to the manufacturing batch. Shipping, handling and storage procedures shall ensure that the flange insulation kits are not damaged;

e. Material certificate and specifications for the following items:

- Insulating central gasket
- Insulating bolt sleeves
- Insulating bolt washers
- Steel bolt washers
- Steel core

Note 1: Manufacturing procedures shall cover all stages of the manufacturing process, from receipt of raw materials to finishing and packing for shipment, including:

a. Chemical analysis;

b. Inspection and testing procedures and frequencies.

Note 2: The quality control at the flange insulation kit manufacturing plant shall include control systems on the following:

a. Raw materials, i.e. checking of documentation;

b. Production equipment and process;

c. Testing during and after production;

d. Identification of flange insulation kit;

e. Documentation (material certificates).

5.3 The manufacturer/supplier shall submit following certificates, as a minimum:

a. Test certificates relevant to the chemical and mechanical properties of the materials used for construction as per this part of standard specification and relevant standards;

b. Test certificate for electrical tests;

c. Test certificate for dimensions and sectional drawings;

d. Test certificate for insulation material.

In addition to the certified material test reports the manufacturer/supplier shall provide a user manual detailing the requirements for installation and inspection in service.

The certificates shall be considered valid only when signed by Purchaser's inspector.

6 General description

6.1 Each kit shall include the following components:

a. Insulating central gasket

b. Insulating bolt sleeves

c. Insulating bolt washers

d. Steel bolt washers

Note: The insulating sleeve and washer may be supplied as one-piece.

6.2 Gaskets shall be manufactured from material having low water absorption and high compressive strength. Preference shall be given to materials with low y and m factors. The y factor is a measure of the compressive load required to establish an initial seal, while the m factor is an indication of the additional load required to hold the fluid pressure needed to keep the seal in operation. The smaller these factors are, the less bolt loading is required.

Gasket materials shall withstand the expected bolt loading without injurious crushing, and which are suitable for the service conditions. It shall not crack or distort under load and shall be unaffected by salt water, hydrocarbons, natural gas, sunlight or atmospheric conditions.

Note: The m and y factors for various materials are included in the ASME Code, Section VIII

and ASME B 16.5.

6.3 Insulating bolt sleeves shall be manufactured from materials having low water absorption, high dielectric strength, and low cold-flow characteristics. They shall be suitable for the service conditions of the particular application.

6.4 Insulating washers shall be manufactured from materials having high compressive strength, low water absorption, high dielectric strength, and low cold-flow characteristics.

7 Materials

7.1 Unless otherwise specified by the purchaser, the central gasket for flat face or raised face flanges for different ASME design classes shall be made of as following:

7.1.1 For class 300 or less, flange fitting: One of the following material system can be chosen.

- Fabric-reinforced phenolic laminate core material[1] coated on both sides with a chloroprene polymer (i.e. neoprene) sheets,
- G10/G11, Laminated epoxy resin reinforced with glass fiber conforming to ASTM specification D 709 Type IV Group or equivalent standard
- Steel core gasket coated by G10/G11 on both sides

7.1.2 For class 600 or less, flange fitting: One of the following material system can be chosen.

- G10/G11
- Steel core gasket coated by G10 or G11on both sides

7.1.3 For above class 600 flange fitting: The following material system shall be chosen.

Steel core gasket coated by G10 or G11 on both sides

Note: Flange Isolation Material Compatibility in different media and temperature, is suggested in table 1. This table can be used as a guide for gasket material selection with considering the media properties.

7.2 The core material of metallic core gaskets shall be stainless steel 316 or other corrosion resistance material according to media corrosive severity. In case of none corrosive internal fluid, stainless steel 304 can be chosen, the external corrosive severity also shall be considered.

For sour system the metallic material shall be conformed with relevant standards same as ANSI/NACE MR0175 /ISO 15156 or ANSI/NACE MR 0103/ ISO 17495-1.

7.3 Insulating sleeves shall be G10 or fabricated from high density polyethylene material, to which shall be added only those antioxidants, UV stabilizers and pigments necessary for the manufacture of sleeves to the specification and to its end use.

Notes:

1) The choice of stabilizers and other additives is at the discretion of the manufacturer.

1- The fabric-reinforced phenolic laminated core material shall consist of a suitable cotton fabric base or filler properly impregnated and bonded with a phenolic thermosetting resin compound or binder, processed to meet the requirements of this Part of Standard specification, which meet US Military Specification MIL-P-15035 Type F.B.G or ASTM D 709 Type II Grade CE.

2) Moulding compounds of unknown composition shall not be used. Impurities which are occasionally contained in polymers shall not exceed 0.1% by mass**.**

7.4 Insulating washers, except when cast integrally with sleeves, shall be fabricated from fabric-reinforced phenolic material and shall be 3.2 mm thickness (nominal).

7.5 Combined insulating sleeve/insulating washer shall be fabricated from injection molded acetal copolymer or equivalent in the form of a one-piece casting.

7.6 In case of carbon steel flanges, steel washers shall be fabricated from plated mild steel as per BS-3410 (Table 7), 3.2 mm thickness, and shall be treated to prevent corrosion, otherwise these washers shall be made of flange material

Table 1- Suggested flange isolation material compatibility

Medium	Seal Retainer	Sealing Ring	Temperature Range C
Acetone	Phenol	EPDM	0 to +27
Air	G-10	Nitrile	-40 to +107
Ammonia Dry	G-10	Teflon	-54 to +104
Ammonia (Wet)	G-10	Teflon	0 to +38
Bleach	G-10	Teflon	0 to +27
Butylene (Butadiene)	G-10	Teflon	0 to +38
Carbon Dioxide	G-10	Nitrile	0 to + 66
Cryogenic	G-10	Teflon	-184 to + 138
Ethanol	G-10	EPDM	0 to +38
Ethylene	G-10	Teflon	0 to +27
Fuel Oil	G-10	Viton	-29 to +138
Natural Gas	G-10	Nitrile	-40 to +104
Sour Gas	G-10	Viton	-29 to +104
Petrol	G-10	Teflon	-54 to +107
Hydrogen	G-10	Nitrile	-40 to +121
Jet Fuel	G-10	Viton	-29 to +107
LNG Liquid Gas	G-11	Teflon	-184 to +38

Table 1- Suggested flange isolation material compatibility (continued)

Medium	Seal Retainer	Sealing Ring	Temperature Range C
Mercaptane	G-10	Teflon	-29 to +27
Methanol	G-10	Teflon	0 to +38
Nitrogen	Phenol	Nitrile	-40 to +104
Oil Crude	G-10	Viton	-29 to +138
Oxygen	G-10	Teflon	-54 to +121
Pentane	G-10	Teflon	0 to +27
Propane	G-10	Nitrile or Teflon	0 to +27
Propylene	G-10	Viton	0 to +27
Sewage	G-10	Viton	-29 to +138
Styrene	G-10	Teflon	0 to +27
Sulphur (Molten)	G-10	Teflon	0 to +138
Toluene	G-10	Viton or Teflon	0 to +66
Water (Hot)	G-10	EPDM	+79 to +138
Water (Potable)	G-10	EPDM	0 to +138
Water (Sea)	G-10	EPDM	0 to +138
White Liquor	G-10	Teflon	+27 to +138

8 Requirements

8.1 Dimensions

8.1.1 Unless otherwise specified by the Purchaser, gaskets for flat face or raised face flanges shall conform to the dimensions specified in ANSI ASME B 16.21. They shall have a nominal thickness of 3.2 mm and protrude into the bore of the pipe by 1.5 mm to prevent electrically conductive bridging over the insulation by debris, etc.

8.1.2 Insulating bolt sleeves are normally designed for standard bolting in standard bolt holes and shall be of sufficient length to extend halfway inside the steel washer. Care shall be taken to ensure that the dimensions selected will allow the use of the standard size bolt or one size smaller high tensile strength bolt.

8.1.3 Insulating bolt washers shall be sized internally so that the bolt sleeve will pass through, and the OD shall be sized so that the washer will fit inside the flange spot facing.

8.1.4 Steel washers shall be the same size as the insulating washer.

8.2 Uniformity

The materials shall be uniform in texture, finish, and specified properties.

8.3 Surface defects

The materials shall be free from blisters, wrinkles, air marks, or cracks, and reasonably free from other small defects such as scratches, dents, heat marks, etc.

8.4 Workmanship

All materials and workmanship shall be in accordance with good commercial practice, and the resulting products shall be free from porous areas, air pockets, foreign matter, or other defects affecting serviceability.

8.5 Detail requirements for insulating gaskets and sleeves

8.5.1 Gaskets

8.5.1.1 Type

Insulating gaskets can be categorized as following:

Full face E type

Self-centering flat ring F type

The type of insulating gaskets provided for herein which are suitable for uses with the flange facing indicated are as follows:

Gasket Type	Flange Facing
Full face (E type)	Flat face or raised face
Self-centering flat ring (F type)	Raised face
Ring joint (oval or octagonal)	Ring-joint

8.5.1.2 Sizes

The gasket nominal size shall be the same as used on the standard pipe flanges and flange fittings in accordance with ANSI ASME B 16.21 and/or ANSI ASME B 16.20.

8.5.1.3 Property values

Gasket materials shall conform to the requirements for physical and electrical properties prescribed in Table 2.

8.5.1.4 Machinability

The material shall be such that it can be drilled, tapped, sawed, and machined in all directions [1)] in accordance with the manufacturer's recommended technique without cracking, splitting, or otherwise impairing the material for general use.

Table 2- Properties of insulating gasket materials

Row	Characteristic	Unit	G10	G11	Phenolic	Test Method ASTM
1	Tensile Strength	psi	45,000	43,000	20,000	D229
2	Compressive Strength	psi	50,000	50,000+	25,000	D229
3	Flexural Strength	psi	60,000	75,000+	22,500	D229
4	Hardness Rockwell M	-	115	115	85	D229
5	IOZD Impact Strength	ft-lbs/inch	14	12	1.2	D229
6	Insulation Resistance	MΩ	-	-	40,000	D229
7	Dielectric Strength (short time)	Volts/Mil	500	550	85	D229
8	Water Absorption, 24 hrs.	%	0.1	0.1	1.6	D229
9	Max. Operating Temperature	C	138	178	79	D229

1) The nature of laminated materials necessitates special precaution when drilling and tapping parallel to laminations.

8.5.2 Sleeves

The insulating sleeves shall be made of high density polyethylene (see 7.3) or G10 material and high density polyethylene shall meet the requirements of Table 3.

Table 3- Properties of insulating sleeves

CHARACTERISTIC		UNIT	REQUIREMENT	TEST METHOD ASTM
Material		---	Polyethylene	---
Density	(min.)	g/cm³	0.941	D 1505
Thickness	(nominal)	mm	0.8	D 374
Dielectric strength	(min.)	kV/mm	16	D 149
Water absorption	(max.)	%	0.01	D 570
Tensile strength	(min.)	MPa	19	D 638

9 Packaging

The kits purchased according to this Part of Standard specification shall be packaged in suitable containers to ensure acceptance and safe delivery to their destination. Individual kits shall be packaged in such a manner as to protect the material against physical and mechanical damage and contamination during shipment, handling and storage. Each container shall contain application instructions. All packaging and packing provisions of ASTM practice D 4088 shall apply to this Part of Standard specification.

10 Quality assurance provisions

10.1 It is the responsibility of the manufacturer to establish quality assurance by quality control procedures which shall ensure that the product will meet the requirements of this Part of Standard specification.

10.2 The quality control at the manufacturing plant shall include control systems on the following:

- Raw materials, i.e. checking of documentation and/or testing for conformity with the specification;
- Production equipment and process;
- Testing during and after production;
- Identification of materials;
- Checking of dimensions;
- Documentation (material certificates).

11 Sampling

11.1 Lot

The lot or batch shall consist of an indefinite number of finished products offered for acceptance, of materials manufactured by a single plant run through the same processing equipment, with no change in ingredient materials.

11.2 Unless otherwise specified by Purchaser, the number of samples for inspection and/or testing shall consist of 10 percent of the lot, but in no case shall be less than one or more than ten kits.

11.3 Sampling shall be in accordance with the ASTM test methods for the specific properties to be determined.

11.4 The numbers and types of test specimens shall be in accordance with the ASTM test method for the specific properties to be determined.

12 Inspection and testing

12.1 All tests and inspections shall be made at the place of manufacture prior to shipment. The manufacturer shall be responsible for carrying out all the tests and inspections required by this

Part of Standard specification.

12.2 The manufacturer/supplier shall provide the Purchaser, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with this Part of Standard specification.

12.3 Samples of any or all ingredients used in the manufacture of this material may be requested by the Purchaser and shall be supplied upon request, along with the supplier's name and identification for the sample.

12.4 Purchaser's inspector(s) shall have free access to the manufacturer's work to follow up the progress of the materials covered by this Part of Standard specification and to check the quality of materials. The manufacturer/supplier shall place free of charge at the disposal of the purchaser's inspector(s) all means necessary for carrying out their inspection: results of tests, checking of conformity of materials with this Standard requirements and checking of marking and packing.

12.5 Samples submitted to the Purchaser and/or collected by the Purchaser will be tested in the Purchaser's laboratory or in a responsible commercial laboratory including manufacturer's laboratory designated by the Purchaser.

12.6 The manufacturer/supplier shall furnish the Purchaser with a certified copy of results of tests made by the manufacturer covering physical and performance characteristics of each batch of product to be supplied under this Part of Standard specification. The manufacturer/supplier shall furnish, or allow the Purchaser to collect samples of the material representative of each batch of product. Certified test reports and samples furnished by the manufacturer/supplier shall be properly identified with each batch of product.

12.7 Prior to acceptance of the supplier's and/or manufacturer's materials, samples of material submitted by the supplier, or collected by the Purchaser, will be tested by the Purchaser. If any of the samples is found not to conform to this Part of Standard, materials represented by such sample will be rejected. If samples of the supplier's and/or manufacturer's material that have been previously accepted are found not to conform to this Standard, all such material will be rejected.

13 Labeling

13.1 Marking of gaskets

Each gasket shall be marked with the clearly legible letters not exceeding 6.35 mm in height.

These markings shall include the gasket manufacturer's name or symbol, the flange size and class, the year of manufacture, and Purchaser's name and order No.

13.2 Marking of containers

Each container shall be marked with the following information:

- Name: Flange insulation kit .....
- Specification: IPS-M-TP-750: Part 7.....

- Order No.: .....
- M.E.S.C No.: .....
- Type of gasket: .....
- Gasket nominal diameter: .....
- Pressure rating: .....
- Temperature rating: .....
- Batch No.: .....
- Stock No.: .....
- Date of manufacture: .....
- Quantity: .....
- Storage condition: .....
- Manufacturer's name and address:.....

Appendix A

Data sheet

(to be submitted by the purchaser)

for

Flange insulation kit

<table>
<tr><td colspan="2">Project:
Indent No:
Date:</td><td colspan="3">Quantity:
Pipe size (DN):
Pipe wall thickness: mm
Flange standard :</td></tr>
<tr><td>PURCHASER</td><td colspan="4">INSTALLATION</td></tr>
<tr><td>☐ Oil industry
☐ Gas industry
☐ petrochemical industry</td><td colspan="2">☐ pipeline
☐ plant</td><td>☐ liquid
☐ Gas</td><td>☐ Buried
☐ overground
☐ oil shore</td></tr>
<tr><td colspan="2">SERVICE CONDITIONS</td><td colspan="3">OPERATING CONDITIONS</td></tr>
<tr><td>SITE CONDITIONS</td><td>ATMOSPHERE</td><td>FLUID TYPE</td><td colspan="2">OPERATING PARAMETERS</td></tr>
<tr><td></td><td rowspan="3">Solferous ☐
Dusty ☐
Corroslse ☐
Occasional ☐
storm</td><td rowspan="3">Fluid:
Corrosive ☐
Erosive ☐
Toxic ☐
Sour ☐</td><td colspan="2">Max. barg
Pressure
Min. barg</td></tr>
<tr><td>AV. Min. temp: °C
AV. Max. temp: °C</td><td colspan="2">Max °C
Temperature
Min °C</td></tr>
<tr><td>Max . Ret . Humidity</td><td colspan="2">ANSI rating PN</td></tr>
<tr><td colspan="2">CASKET TYPE</td><td>SLEEVE YPE</td><td colspan="2">WASHERS</td></tr>
<tr><td colspan="2">☐ Full face steel core ☐ Ring joint
☐ Self-centering flat ring steel core
☐ Full face none metallic core
☐ Self-centering flat ring none metallic core</td><td>☐ Full length
☐ Half length
☐ Integral sleeves and washers</td><td colspan="2">☐ SW- signal washer set
☐ DN- double washer set</td></tr>
</table>

Part 8
Polypropylene rope

1 Scope

This Part of IPS-M-TP-750 covers the minimum requirements for 3-strand (plain or hawser laid) rope made of polypropylene for use in dry and water type deep well groundbeds.

2 References

Throughout this Standard the following standards and codes are referred to. The editions of these standards and codes that are in effect at the time of publication of this Standard shall, to the extent specified herein, form a part of this Standard. The applicability of further updates in the referenced standards and codes shall be mutually agreed upon by the Company and the Vendor.

2.1 ASTM D 543, Standard Practices for Evaluating the Resistance of Plastics to chemical Reagents

2.2 ISO 2307, Fiber Ropes-Determination of Certain Physical and Mechanical Properties

3 Units

This Standard is based on International System of Units (SI), as per IPS-E-GN-100 except where otherwise specified.

4 Technical documents

4.1 The technical bid shall include the following:

- **a.** Catalogue
- **b.** Rope size, quantity (net and gross mass), material and construction
- **c.** Main characteristics and tolerances
- **d.** Production procedures that covers all stages of the manufacturing process, from receipt of raw materials to finishing and packing for shipment, including:
  - Measurement of diameter, weight, etc
  - Inspection and testing procedure, including acceptance criteria, and frequencies
  - Rope manufacture

4.2 The manufacturer/supplier shall provide sufficient information to identify the rope and shall supply the technical information as a minimum requirement as follows:

- **a.** ISO 9001 certification for design, manufacturing and quality control of the rope to be used for impressed current anode cathodic protection installation, issued by an internationally recognized body;
- **b.** Original technical catalogue and data sheet, manufacturing procedure specification, quality control plan, application procedure recommendation and guidelines (installation instructions);
- **c.** Filled, signed and stamped data sheet;
- **d.** All laboratory and shop testing shall be documented. The rope shall be traceable to the manufacturing batch. Shipping, handling and storage procedures shall ensure that the insulating joints are not damaged;

e. Material certificate and specifications.

Note 1: Manufacturing procedures shall cover all stages of the manufacturing process, from receipt of raw materials to finishing and packing for shipment, including:

a. Chemical analysis and physical properties;
b. Inspection and testing procedures and frequencies.

Note 2: The quality control at the rope manufacturing plant shall include control systems on the following:

a. Raw materials, i.e. checking of documentation;
b. Production equipment and process;
c. Testing during and after production;
d. Identification of rope;
e. Chemical analysis;
f. Documentation (material certificates).

4.3 The manufacturer/supplier shall submit following certificates, as a minimum:

a. Test certificates relevant to the chemical and mechanical properties of the materials used for construction as per this Part of Standard specification and relevant standards;
b. Test certificate for dimensions;
c. Test certificate for rope material.

Certified test reports furnished by the manufacturer shall be properly identified with each lot (batch) of products.

The certificates shall be considered valid only when signed by Purchaser's inspector.

5 Requirements

5.1 Material and manufacture

Only virgin polymeric material shall be used. The polymeric material used in manufacturing the rope shall be homopolymers or copolymers of polypropylene processed as continuous multi-filament, having a relative density of approximately (0.9-0.95) to produce rope having the characteristics specified in Table 1. The rope shall be stabilized against deterioration due to sunlight by the addition to the polymer of an additive or additives.

Note: Any Ultra-Violet (UV) inhibiting system may be used, such as pigmentation using carbon black, Iron (III) oxide (Fe_2O_3) or any other coloring product or special UV inhibitor.

It shall be resistant to sodium chloride solution when tested in accordance with ASTM method D543.

5.2 Flexibility and uniformity of strands

The finished rope shall be flexible and shall consist of uniform strands, well laid and as free as practicable from defects in the yarn, strand and finishing.

5.3 Linear density

The rope shall have a linear density (net mass, in grams per meter) given in Table 1, measured

when the rope is subjected to the tension called the reference tension, within a tolerance of ±10%.

Note: Reference tension to be applied to the rope, conforming to this Part of Standard specification, when measuring linear density and lay shall have the nominal value of 8 daN (deca newton) within a tolerance of ±5%.

5.4 Diameter

The diameter of rope shall vary by not more than ±4% from that specified in Table 1, measured at zero tension.

5.5 Securing rope ends

The ends of the rope shall be secured to prevent unlaying.

5.6 Yarn in the strands

Each strand shall consist of a sufficient and equal number of rope yarns to produce a rope which shall comply with the requirements given in Table 1. The rope yarns shall not contain fibers which have been used or recovered.

5.7 Structure

The rope and their strands shall be continuous throughout its length and shall not contain loose ends, splices or joints.

5.8 Lay

5.8.1 Direction of lay

The direction of lay shall be Z twist (right hand lay), their strands S twist and their roping yarns Z twist.

5.8.2 Length of lay

The maximum lay of the rope shall be as given in Table 1, measured with the rope under a specified tension.

5.9 Other characteristics

Other characteristics, for example the diameter of the circumscribed circle and the elongation of the rope under specific tensile conditions, may be specified, subject to agreement between the manufacturer and the Purchaser, where applicable with submission of a sample.

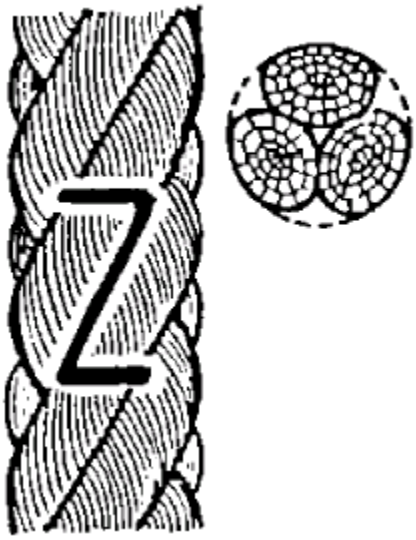


Fig. 1- Strands (plain or hawser laid) 'Z' or right-hand lay rope

Table 1- Requirements for polypropylene rope

CHARACTERISTIC	UNIT	REQUIREMENT	TEST METHOD
Nominal diameter (min)	mm	8	ISO 2307
Linear density (min)	ktex	30	ISO 2307
Rope lay (max.)	mm	28	ISO 2307
Breaking force (min.)	daN	1040	ISO 2307

Notes:

1) The linear density (in kilotex) corresponds to the net mass per meter (in grams per meter) or to the mass of rope (in kilograms) per thousand meters. The linear density (net mass per meter) is measured under tensile loading given in ISO 2307.

2) The SI unit for force is the newton. A load of 1 kg $\approx$ 1 decanewton (daN) or 0.01 kilonewton (kN).

6 Quality assurance provisions

6.1 It is the responsibility of the manufacturer to establish quality assurance by quality control procedures which shall ensure that the product will meet the requirements of this Part of Standard specification.

6.2 The quality control at the manufacturing plant shall include control systems on the following:

- Raw materials, i.e. checking of documentation and/or testing for conformity with the Specification;
- Production equipment and process;
- Testing during and after production;
- Identification of ropes;

- Weight and dimension tolerances;
- Documentation (material certificates).

7 Inspection and testing

7.1 The manufacturer is responsible for the performance of all inspection and tests required by this Part of Standard specification using his own or other reliable facilities and he shall maintain complete records of all such tests and inspections. Such records shall be available for review by the Purchaser.

7.2 All tests and inspections shall be made at the place of manufacture. The manufacturer shall afford the inspector representing the Purchaser all reasonable facilities to satisfy him that the rope has been manufactured in accordance with the requirements of this Part of Standard specification. Such inspections in no way relieve the manufacturer of his responsibilities under the terms of this Part of Standard specification.

7.3 Conformance of the rope to the requirements of this Part of Standard specification shall be determined on samples taken from each lot (see Note) of rope presented for acceptance. Unless otherwise agreed with the Purchaser, it shall be carried out at the manufacturer's factory prior to despatch, and the testing equipment shall be under the immediate direction of the Purchaser or his representative during the tests. The manufacturer shall prepare all the necessary test samples and provide the machinery, apparatus and labour required for the purpose.

Note: Unless otherwise specified by the Purchaser, a lot shall consist of all ropes made from the same production run offered for acceptance.

7.4 Sampling shall be in accordance with the requirements of ISO 2307.

8 Packaging and delivered length

8.1 Packaging

All ropes shall be coiled and protected to prevent damage in transit and storage. Coil lashings shall be of similar material to the rope. When the ropes are invoiced by gross mass, excluding packaging, the mass of the packaging shall not exceed 1.5% of the gross mass of the ropes.

8.2 Delivered length

8.2.1 Standard delivered length

The standard delivered length shall be the length measured at zero tension.

8.2.2 Shorter delivered length due to sampling

To carry out tests at the request of the Purchaser, test pieces may be taken from the ordered length of rope. The length of rope delivered will then be less than the ordered length because of these test pieces (which are considered to be part of the delivery).

9 Marking

The identification of the material, quality and origin of a polypropylene rope conforming to this Part of Standard specification shall be marked using a yarn or tape yarn, as defined below, of an easily identifiable brown color placed within the article so as to remain recognizable despite soiling, soaking and discoloration during use.

Tape yarn: a straight continuous strip, of thickness which is small compared with its width, obtained by cutting a film or by direct extrusion of man-made textile materials.

Note: This brown yarn or tape yarn, marked with required information concerning the rope, shall be incorporated into a strand.

10 Labeling

Each coil shall have a label, which is firmly fixed in place, giving the following information:

- Name: Polypropylene rope.....
- Specification: IPS-M-TP-750: Part 8.....
- Order No.: .....
- M.E.S.C No.: .....
- Rope size: .....
- Quantity: .....
- Maximum temperature resistance: .....
- Batch No.: .....
- Inspection Date: .....
- Stock No.: .....
- Date of manufacture: .....
- Storage condition: .....
- Manufacturer’s name and address: .....

Part 9
Splicing kit

1 Scope

This Part of IPS-M-TP-750 covers the minimum requirements for materials supplied in kits for making cable joints, in the voltage range up to 1000 V DC, for use in coating of buried or submerged electrical connections in cathodic protection systems.

Note: This Part of IPS-M-TP-750 shall preferably be in conjunction with Part 10. However due to variation in numbers, size and type of conductors, connector fittings are normally supplied as separate items.

2 References

Throughout this Standard the following dated and undated standards/codes are referred to. These referenced documents shall, to the extent specified herein, form a part of this standard. For dated references, the edition cited applies. The applicability of changes in dated references that occur after the cited date shall be mutually agreed upon by the Company and the Vendor. For undated references, the latest edition of the referenced documents (including any supplements and amendments) applies.

2.1 ANSI Z400.1/Z129.1, Safety data sheet and hazard evaluation and precautionary labeling preparation

2.2 ASTM D 149, Standard test method for

"Dielectric breakdown voltage and dielectric strength of solid electrical materials at commercial power frequencies insulating"

2.3 ASTM D 257, Standard test method for

"D.C. Resistance or conductance of insulating materials"

2.4 ASTM D 3892, Standard practice for "Packaging/packing of plastics"

2.5 ASTM D 3951, Standard practice for "Commercial packaging"

2.6 DIN 16945, Testing of resins, hardeners and accelerators, and catalyzed resins

2.7 ISO 62, Plastics-determination of water absorption

2.8 ISO 2592, Petroleum products-determination of flash and fire points-clevel and open cup method

2.9 ISO 2859, Sampling procedures for inspection by attributes Part 1: Sampling plans indexed by acceptable quality level (AQL) for lot- by-lot inspection

2.10 VDE 0291-1a:1973-07, Specifications for filling compounds for cable accessories and for scalding compounds; Amendment to VDE 0291 Part 1/2.72

2.11 BS EN 50393, 2015, Test methods and requirements for accessories for use on distribution cables of rated voltage 0/6/1/0 (1/2) Kv

3 Definitions and terminology

For the purposes of Part 11 of this standard specification the following definitions apply:

3.1

catalyzed resins (cold pour resin compound)

A resin system capable of being poured at ambient temperature and that cures to a solid state by an irreversible chemical reaction without the application of external heat.

3.2

cured casting resins

The cured casting resins are materials produced by curing catalyzed resins (cold pour resin compound) to form moulded parts by casting in moulds.

3.3

curing time

The curing time is the time between the exposure of the resin to the curing conditions (i.e. after the resin components have been mixed) and the time from which the mean value of the temperature of deflection does not increase by more than 3 hr.

3.4

epoxy resin

A synthetic resin containing a sufficient number of epoxide groups capable of cross linking, and in which the final polymer is formed because of a reaction-taking place substantially at the epoxide groups.

3.5

gel time

The period required for a cold pour resin to reach a level of cure as defined by a specified test.

3.6

hardeners and accelerators

Hardeners are substances or mixtures of substances, which promote polymerization or polyaddition, which cause the resins to cure.

Accelerators are substances which are used in small amounts to increase the reaction rate of a chemical system (e.g. cross linking).

3.7

hardness

The resistance to indentation as measured under specified conditions.

3.8

lot or batch

The lot or batch shall consist of an indefinite number of splicing kits (catalyzed resins, cast mold, etc.) manufactured by a single plant run through the same processing equipment with no change in ingredient materials, offered for acceptance.

3.9

nominal parameters

The nominal parameters are the parameters (e.g., weight, dimensions, density, etc.) specified on product labels, invoices, sales literature, and the like. The actual parameters shall not be less than 95% of nominal parameters.

3.10

polyurethane resin

A synthetic resin produced by the reaction of a poly hydroxy reactant, normally of polyester or polyether structure, with a poly-isocyanate.

3.11

pot life

The period from commencement of adding the reactive agents of the cold pour resin compound during which it may be poured without affecting its performance.

3.12

resins

For the purpose of this Standard, a resin is a liquid or liquefiable organic material that cures because of poly addition without releasing volatile components, with or without agents such as accelerators or hardeners being added.

3.13

shelf life

The period of time after production during which a material or product that is stored under specified conditions retains its intended performance capabilities.

3.14

total volume shrinkage

The volume shrinkage is the shrinkage during curing and the shrinkage on cooling the cured material from the curing temperature to ambient temperature.

The total volume shrinkage calculated from the density of the resin at curing temperature and the density of the cured material at 23°C.

For cold curing systems, the total volume shrinkage calculated from the density of the resin at 23°C and that of the cured material at 23°C.

3.15

volume resistivity

The ratio of the electric potential gradient to the current density when the gradient is parallel to the current in the material.

3.16

water absorption

The amount of water absorbed by a material under specified test conditions.

4 Units

This Standard is based on International System of Units (SI), as per IPS-E-GN-100 except where otherwise specified.

5 Technical documents

5.1 The technical bid shall include the following:

- catalogue showing materials, maximum voltage, dimensions and configuration;
- Material specification for the components to be offered (complete kit);
- Manufacturing specification and procedure;
- Inspection and testing specification and procedure;
- Installation instructions that are specific to the joint;
- The contents;
- The name of the manufacturer and the reference number;
- Instructions on how to use the resin compound in the manner necessary to develop the properties and to reach the level of performance specified in this Part of IPS-M-TP-750;
- Instructions on how to keep the resin compound before use in conditions that will comply with any relevant regulations and that will ensure that the resin compound retains its properties for two years (see 7-2-4);

- Specification of packaging.

5.2 The manufacturer/supplier shall provide sufficient information to identify the splicing kit and shall supply the technical information as a minimum requirement as follows:

a. ISO 9001 certification for design, manufacturing and quality control of the splicing kit to be used for impressed current/sacrificial anode cathodic protection installation, issued by an internationally recognized body;

b. Original technical catalogue and data sheet, manufacturing procedure specification, quality control plan, application procedure recommendation and guidelines (installation instructions);

c. Filled, signed and stamped data sheets;

d. All laboratory and shop testing shall be documented. The splicing kit shall be traceable to the manufacturing batch. Shipping, handling and storage procedures shall ensure that the splicing kit are not damaged;

e. Material certificate and specifications.

Note 1: Manufacturing procedures shall cover all stages of the manufacturing process, from receipt of raw materials to finishing and packing for shipment, including:

a. Chemical analysis;

b. Physical and electrical properties;

c. Inspection and testing procedures and frequencies.

Note 2: The quality control at the splicing kit manufacturing plant shall include control systems on the following:

a. Raw materials, i.e. checking of documentation;

b. Production equipment and process;

c. Testing during and after production;

d. Identification of splicing kit;

e. Chemical analysis;

f. Physical and electrical properties;

g. Documentation (material certificates).

5.3 The manufacturer/supplier shall submit following certificates, as a minimum:

a. Test certificates relevant to the chemical and electrical properties of the materials used for construction as per this Part of Standard specification and relevant standards.

Certified test reports furnished by the manufacturer shall be properly identified with each lot (batch) of products.

The certificates shall be considered valid only when signed by Purchaser’s inspector.

6 Description

6.1 General

Each splicing kit shall contain the following components:

- Two-piece snap-together plastic mold;
- Two-pack catalyzed resins (resin and hardener);
- Funnel/funnel cap;
- Proper electrical insulating and sealing tapes.

6.2 Types

The splicing kits, as will be specified by the Purchaser (see data sheet), shall be one of the following types:

"Branch" type:	Intended for use in shallow type ground beds
"Straight-through" (in-line) type:	Intended for use in deep-well type ground beds

7 Requirements

7.1 Materials and manufacture

7.1.1 Cast mold

The two-piece snap-together mold shall be made of synthetic thermoplastic material (i.e. polycarbonate), cast into a desired shape designed to provide a transparent, self-sealing, water proof and high strength product. The mold size shall be such as to form a water resistant seal over the connection giving a voltage rating of 600/1000 Volts. It shall withstand the weight and exotherm of the compound without undue distortion, such that when supported in accordance with the manufacturer's instructions the design clearances are maintained during setting.

Cast molds shall be provided with filling apertures to allow easy filling with resin compound and shall be designed such that the filling operation does not entrap air within the joint.

The molds shall be designed to permit a minimum of 10 mm thickness of cured compound over each joint component and cable component involved in the jointing procedure. The mold design shall allow the longitudinal seal on each cable sheath to be a minimum of 40 mm in length.

7.1.2 Catalyzed resins

The catalyzed resins (cold pour resin compound) shall be an unfilled two-component Epoxy (EP) or Polyurethane (PUR) resin conforming to DIN VDE 0291-1a, and this Part of Standard specification which, after mixing, sets quickly to form a stable, void-free resilient molded parts by casting in molds for low voltage cables rated up to 1 kV.

The base component not including curing systems shall contain no fatty acids, oils, chlorinated type plasticizers or polystyrene resins. The resin compounds shall contain no toluene disocyanate and no aromatic substituted isocyanates.

7.2 Properties of catalyzed resins

The catalyzed resins shall comply with the requirements of Table 1 and 7-2-1 to 7-2-4 inclusive.

7.2.1 Odor

The odor of the admixed cast resin, wet or dry, shall not be obnoxious.

7.2.2 Working properties

The cold pour resin compound shall be fresh and show no signs of partial cure from having been improperly stored. Neither shall it possess other detectable defects, which adversely affect the ultimate performance of the material.

The fully cured casting resins shall not be attacked by oils, patrols, water, salt and salt solution.

7.2.3 Toxicity

The manufacturer shall certify that the materials shall have no adverse effect on the health of personnel when used (mixed, applied, and cured).

7.2.4 Shelf life

The two-pack catalyzed resins when stored in the original container at ambient temperature, between 10 - 45°C, shall have a minimum shelf life of 24 months from the date of delivery and shall meet all the requirements specified herein. After such storage, the catalyzed resins shall show no instability, hardening of the resin components, settling out of the pigment, and deterioration of the two-compartment plastic mixing bag.

7.3 Dimensions

For specified cables and connectors to be joined (see attached data sheet), the dimensions of mold and required quantity of resin compound shall be submitted by the supplier.

Table 1- Properties of catalyzed resins (cold pour compound)

PROPERTY		UNIT	REQUIREMENT	TEST METHOD
Cast resin component	Open cup flash point (min.)	°C	> 100	ISO 2592
Reactant		°C	> 55	ISO 2592
Gel time; at 23°C (max.)		Minutes	30	DIN 16945
Total volume shrinkage (max.)		%	4	DIN 16945
Hardness (min.)		Shore D	70	-
Water absorption In cold water after 24 h at 23°C*		-	-	ISO 62
Electrolytic corrosion (at least)		Grade	A 1.2	-
Dielectric strength (min.)	at 23°C	kV	10	ASTM D 149
	at 80°C		10	
Volume resistivity (min.) at 23°C		Ohm. Cm	1×10^{12}	ASTM D 257

*** For information**

8 Packaging

8.1 Packaging shall be sufficient to ensure that deterioration of the components will not happen under covered, dry storage within the stated ambient air temperatures such that the performances of these components when forming part of the total joint are unaffected.

8.2 The splicing kits shall be packaged, in cardboard boxes, in accordance with the best commercial practice.

8.3 The resin and hardener components shall be packed in exact doses in a two-chamber transparent plastic bag, with aluminum resistive layer, sealed against air and damp. The complete package shall be designed to ensure the item against damage during shipment, handling and storage. The packaging/packing shall also meet the relevant requirements of ASTM Standard Practice D 3951 and D 3892.

8.4 All shipments shall be marked “store in cool place out of direct sunlight”.

9 Sampling

Sample splicing kits shall be selected from each lot in accordance with inspection Level II of ISO2859 (Part 1). The acceptable quality level shall be 4 percent for all visual, dimensional and weight defects combined and 2.5 percent for all other type of defects with reference to this Part of Standard specification. The single sampling plans for normal inspection (Table II A of ISO 2859 Part 1) shall be used.

10 Rejection

Where the numbers of splicing kits that do not conform to this Part of Standard specification exceed the acceptance numbers specified in 9, this shall be cause for rejection of entire lot.

11 Inspection and testing

11.1 The manufacturer and/or supplier shall be responsible for carrying out all the tests and inspections required by this Part of Standard specification, using his own or other reliable facilities, and he shall maintain complete records of all such tests and inspections. Such records shall be available for review by the Purchaser.

11.2 The manufacturer and/or supplier shall afford the Purchaser's inspector all reasonable facilities necessary to satisfy him that the product is being produced and furnished in accordance with this Part of Standard specification. Such inspections in no way relieve the manufacturer and/or supplier of his responsibilities under the terms of this Part of Standard specification.

11.3 The Purchaser reserves the right to perform any inspections set forth in this Part of Standard specification where such inspections are deemed necessary to assure that supplies and services conform to the prescribed requirements.

11.4 The purchaser's inspector(s) shall have access to the material subject to inspection for the purpose of witnessing the selection of the samples, the preparation of the test samples, and the performance of the tests.

11.5 Samples of any or all ingredients used in the manufacture of this material may be requested by the Purchaser and shall be supplied upon request, along with the supplier's name and identification for the sample.

12 Labeling

12.1 Refer to ANSI standard Z 129.1 "Precautionary labeling of hazardous industrial chemicals".

12.2 Each cast mold shall be plainly marked with the following information:

- **a.** The name and/or trademark of the manufacturer;
- **b.** The type and trade name of material;
- **c.** The size.

12.3 Each catalyzed resins-bag shall be legibly marked with the following information:

- **a.** The name and/or trademark of the manufacturer;
- **b.** The type and trade name of material;
- **c.** The size;
- **d.** The quantity (in both g and ml) ;
- **e.** The batch No;
- **f.** The data of manufacture;
- **g.** The pot life;
- **h.** The shelf life;
- **i.** The flash point;
- **j.** The direction for use (mixing instruction);
- **k.** The direction for safety;

l. The cleaning material;
m. The cautions.

12.4 Each kit box shall be marked with the following information:

- Name: Splicing kit .....
- Specification: IPS-M-TP-750: Part 9.....
- Order No.: .....
- M.E.S.C No.: .....
- Type and trade name of material: .....
- Dimensions of mold: .....
- Quantity of catalyzed resins (in both g and ml): .....
- Max. temperature resistance: .....
- Application temperature:.....
- Storage condition: .....
- Batch No.: .....
- Stock No.: .....
- Date of manufacture: .....
- Shelf life (min.): .....
- Contents of kit box:.....
- Information and warnings (if needed): .....
- Manufacturer's name and address: .....

12.5 Direction for use

The manufacturer shall supply complete instructions covering uses, preparation, mixing (of catalyzed resins), resin pressure method, pouring method, application method, application conditions, pot life, temperature and humidity limitation, drying time, etc., with each kit box.

12.6 Health and safety

The manufacturer shall make available to the Purchaser such information concerning the cold pour resin compound as will enable the Purchaser and his employees:

a. To be aware of the recommended immediate action in the case of the compounds coming in contact with skin, eyes or clothing;
b. To transport the compound outside the Purchaser's premises in a manner complying with any regulations relevant to the mode of transport to be used.

The manufacturer shall ensure that all the packages in which the compounds are supplied and the information given on these packages comply with the Classification, Packaging and Labeling of Dangerous Substances Regulations 1984, where applicable.

The manufacturer shall also make available such information as will enable the Purchaser to use the compound in a safe manner in accordance with the Health and Safety at Work, etc.

Appendices

Appendix A

Data sheet

(to be submitted by the purchaser)

for

IPS-M-TP-750**: Part 9** **Splicing kit**

Cable splicing kit, for use in coating of buried or submerged electrical connections in cathodic protection systems.
The kits shall be in accordance with the latest edition of above Iranian Petroleum Standard with the following specific requirements:

- Project title: - Date:
- Indent No.: - Purchaser:
- M.E.S.C No.:
- Mold type: □ "Branch" type □ "In Line" type
- Main (feeder) cable type & size:
- Branch cable type & size:
- Cable connector type & size:
- Quantity:

Part 10
Split bolt connector (line tap)

1 Scope

This Part of IPS-M-TP-750 covers the minimum requirements for mechanical split bolt connector (line tap) for use in making, through or tap, connections of stranded copper conductors, 600/1000 Volts rating, in cathodic protection installations.

2 References

Throughout this Standard the following dated and undated standards/codes are referred to. These referenced documents shall, to the extent specified herein, form a part of this standard. For dated references, the edition cited applies. The applicability of changes in dated references that occur after the cited date shall be mutually agreed upon by the Company and the Vendor. For undated references, the latest edition of the referenced documents (including any supplements and amendments) applies.

2.1 BS 1872, Specification for electroplated coatings of tin

3 Units

This Standard is based on International System of Units (SI), as per IPS-E-GN-100 except where otherwise specified.

4 Technical documents materials and manufacturer

4.1 The technical bid shall include the following:

a. Catalogue (including technical data of the offered connector);

b. Production procedures that cover all stages of the manufacturing process, from receipt of raw materials to finishing and packing for shipment, including:

- Chemical analysis;
- Material specification;
- Measurements of weight, dimensions, etc;
- Inspection and testing procedures, including acceptance criteria, and frequencies;
- Line tap manufacture;
- Specification of packaging.

4.2 The manufacturer/supplier shall provide sufficient information to identify the split bolt connector and shall supply the technical information as a minimum requirement as follows:

a. ISO 9001 certification for design, manufacturing and quality control of the split bolt connector to be used for impressed current/sacrificial anode cathodic protection installation, issued by an internationally recognized body;

b. Original technical catalogue and data sheet, manufacturing procedure specification, quality control plan, application procedure recommendation and guidelines (installation instructions) ;

c. Filled, signed and stamped data sheets;

d. All laboratory and shop testing shall be documented. The split bolt connector shall be traceable to the manufacturing batch. Shipping, handling and storage procedures shall ensure that the split bolt connectors are not damaged;

e. Material certificate and specifications.

Note 1: Manufacturing procedures shall cover all stages of the manufacturing process, from receipt of raw materials to finishing and packing for shipment, including:

a. Chemical analysis and physical properties;

b. Inspection and testing procedures and frequencies.

Note 2: The quality control at the split bolt connector manufacturing plant shall include control systems on the following:

a. Raw materials, i.e. checking of documentation;

b. Production equipment and process;

c. Testing during and after production;

d. Identification of split bolt connector;

e. Chemical analysis;

f. Documentation (material certificates).

4.3 The manufacturer/supplier shall submit following certificates, as a minimum:

a. Test certificates relevant to the chemical and electrical properties of the materials used for construction as per this Part of Standard specification and relevant standards.

Certified test reports furnished by the manufacturer shall be properly identified with each lot (batch) of products.

The certificates shall be considered valid only when signed by Purchaser's inspector.

5 Requirements

5.1 Materials and manufacture

a. The split bolt connectors as cast shall be manufactured from copper-zinc-lead alloy (leaded brass), having a chemical composition conforming to requirements specified in Table 1, tinned all over by electroplating to BS 1872 with the minimum thickness of 5 μm. The materials shall be of such quality and purity that the finished product have the properties and characteristics prescribed herein.

b. The bolt threads shall be of sufficient strength to withstand the tightening required to produce a zero resistance connection.

Table 1 - Chemical requirements

ELEMENT	COMPOSITION, %
Copper	55 – 60
Lead	2.0 – 3.8
Iron, max.	0.35
Zinc	Remainder

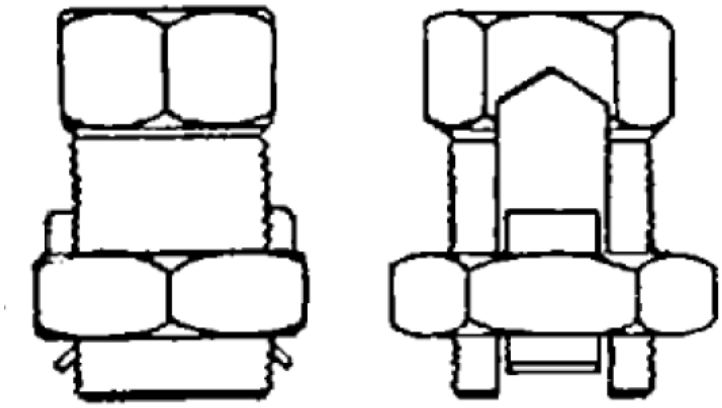


Fig. 1- Split bolt connector (line tap)

5.2 Dimensions

The split bolt connectors shall be of such dimensions as to be capable joining the specified of number of cables of specified dimensions (see data sheet) and shall be suitable for fittings into the splicing kit (IPS-M-TP-750: Part 9). The supplier shall submit to the Purchaser, the dimensions and contours, including dimensional tolerances of offered connectors, preferably by a drawing.

5.3 Workmanship, finish, and appearance

The split bolt connectors shall have a skillful “workmanlike” finish free of injurious burrs, seams, laps, irregular surfaces, and other imperfections affecting serviceability.

6 Quality assurance provisions

6.1 General

6.1.1 It is the responsibility of the manufacturer to establish quality assurance by quality control procedures, which shall ensure that the product will meet the requirements of this Part of Standard specification.

6.1.2 The quality control at the manufacturing plant shall include control systems on the following:

- Raw materials, i.e. checking of documentation;
- Production equipment and process;
- Testing during and after production;
- Identification of line taps;
- Chemical analysis;
- Weight and dimensional tolerances;
- Surface condition of produced line taps;
- Documentation (material certificates).

6.2 Responsibility for inspection

6.2.1 The manufacturer is responsible for the performance of all inspection and test requirements specified. Except as otherwise specified in the contract or purchase order, the manufacturer may use his own or any other suitable facilities for the performance of the inspection and test requirements unless disapproved by the Purchaser at the time the order is placed. The Purchaser shall have the right to perform any of the inspections and tests set forth in this Part of Standard specification when such inspections and tests are deemed necessary to assure that the material conforms to the prescribed requirements.

6.2.2 When specified on the inquiry or purchase order, the product shall be subject to inspection by the Purchaser at the place of manufacture prior to shipment. The inspector representing the Purchaser shall have controlled entry only to those parts of the manufacturer's operations that concern the manufacture of the ordered product and only when and where work on the contract of the Purchaser is being performed. The manufacturer shall afford the inspector all reasonable facilities to satisfy him that the product is being furnished in accordance with this Part of Standard specification.

6.3 Test Reports

The manufacturer and/or supplier shall furnish to the Purchaser a manufacturer's test report showing the results of the required tests.

6.4 Certification

A manufacturer's certificate of compliance shall be furnished to the Purchaser stating that each lot has been sampled, tested, and inspected in accordance with this Part of Standard specification and the requirements have been met.

7 Packaging

The materials purchased according to this Part of Standard specification shall be preserved and packaged for shipment in such a manner as to ensure acceptance by common carrier for transportation and to afford protection from the normal hazards of transportation.

Each package of materials shall contain cleaning and tightening instructions.

8 Labeling

8.1 Identification MARKING

The split bolt connectors shall be plainly marked for identification with the following information:

a. Manufacturer's name or trade mark;

b. A distinctive catalog number;

c. Wire-size or range of sizes.

8.2 Package marking

Each shipping unit shall be legibly marked with the following information:

- Name: Split bolt connector (line tap) .....
- Specification: IPS-M-TP-750: Part 10 .....
- Order No.: .....
- M.E.S.C No.: .....
- Catalog or type designation: .....
- Size: .....
- Weight (gross and net): .....
- Batch No.: .....
- Stock No.: .....
- Date of manufacture: .....
- Quantity: .....
- Trademark of the supplier: .....
- Manufacturer's name and address: .....

Appendices

Appendix A

Data sheet

(to be submitted by the purchaser)

for

IPS-M-TP-750**:** **Part 10 Split bolt connector (line tap)**

The connectors shall be in accordance with the latest edition of above Iranian Petroleum Standard with the following specific requirements:

- Project title:
- Indent No.:
- M.E.S.C No.:
- Main (feeder) cable type and size:
- Branch (anode) cable type and size:
- Quantity:
- Date:
- Purchaser:

Part 11
Splice coating materials

1 Scope

This Part of IPS-M-TP-750 covers the minimum requirements for the following coating materials as electrical insulation for use on joints and splices in wires and cables in accordance with the National Electrical Code.

a. Electrical insulating plastic tape;

b. Rubber splicing tape.

2 References

Throughout this Standard, the following dated and undated standards/codes are referred too. These referenced documents shall, to the extent specified herein, form a part of this standard. For dated references, the edition cited applies. The Company and the Vendor shall mutually agree upon the applicability of changes in dated references that occur after the cited date. For undated references, the latest edition of the referenced documents (including any supplements and amendments) applies.

2.1 ASTM D3006, Standard specification for polyethylene plastic pressure-sensitive electrical insulating tape

2.2 ASTM D2301, Standard specification for vinyl chloride plastic pressure-sensitive electrical insulating tape

2.3 ASTM D4388, Standard specification for nonmetallic semi-conducting and electrically insulating rubber tapes1

2.4 ASTM D2301, Standard test methods for rubber products - Chemical analysis1

2.5 ASTM D 1000, Standard methods of testing for pressure-Sensitive adhesive coated tapes used for electrical insulation

2.6 ASTM D 297, Standard methods of “Chemical analysis of rubber products”

3 Units

This Standard is based on International System of Units (SI), as per IPS-E-GN-100 except where otherwise specified.

4 Technical documents materials and manufacturer

4.1 The technical bid shall include the following:

a. Catalogue (including technical data of the offered connector);

b. Production procedures that cover all stages of the manufacturing process, from receipt of raw materials to finishing and packing for shipment, including:

- Chemical analysis;
- Material specification;
- Measurements of weight, dimensions, etc;
- Inspection and testing procedures, including acceptance criteria, and frequencies;
- Splice coating materials manufacture;

- Specification of packaging.

4.2 The manufacturer/supplier shall provide sufficient information to identify the Splice coating materials and shall supply the technical information as a minimum requirement as follows:

a. ISO 9001 certification for design, manufacturing and quality control of the Splice coating materials to be used for impressed current / sacrificial anode cathodic protection installation, issued by an internationally recognized body;

b. Original technical catalogue and data sheet, manufacturing procedure specification, quality control plan, application procedure recommendation and guidelines (installation instructions);

c. Filled, signed and stamped data sheets;

d. All laboratory and shop testing shall be documented. The Splice coating materials shall be traceable to the manufacturing batch. Shipping, handling and storage procedures shall ensure that the Splice coating materials are not damaged;

e. Material certificate and specifications.

Note 1: Manufacturing procedures shall cover all stages of the manufacturing process, from receipt of raw materials to finishing and packing for shipment, including:

a. Chemical analysis;

b. Electrical and physical properties;

c. Inspection and testing procedures and frequencies.

Note 2: The quality control at the Splice coating materials manufacturing plant shall include control systems on the following:

a. Raw materials, i.e. checking of documentation;

b. Production equipment and process;

c. Testing during and after production;

d. Identification of splice coating materials;

e. Chemical analysis;

f. Documentation (material certificates).

4.3 The manufacturer/supplier shall submit following certificates, as a minimum:

a. Test certificates relevant to the chemical and electrical properties of the materials used for construction as per this Part of Standard specification and relevant standards.

Certified test reports furnished by the manufacturer shall be properly identified with each lot (batch) of products.

The certificates shall be considered valid only when signed by Purchaser’s inspector.

5 Electrical insulating plastic tape

a. Materials and manufacture

The pressure sensitive adhesive layer shall be smooth, uniform, and as free from lumps and bare spots as the best commercial practice will permit. “Fish Eyes” shall not be cause for rejection. There shall be no adhesive transfer when the tape is unwound from the roll. The tape shall provide high electrical resistivity, resistance to corrosive environments, low

moisture absorption and permeability, and shall form watertight bond with itself and with rubber tape.

i. The tape shall consist of a plastic backing coated on one side with a pressure-sensitive adhesive. The backing shall be either PVC (Polyvinyl Chloride or copolymer of vinyl chloride and vinyl acetate), or PE (thermoplastic polyethylene) suitably compounded to meet the requirements of this Part of Standard specification. The backing shall be smooth and uniform. The tape edges shall be straight and unbroken;

ii. The backing shall be polyvinyl chloride plastic suitably compounded to meet the requirements of this specification. The backing shall be smooth and uniform. The tape edges shall be straight and unbroken;

iii. The pressure-sensitive adhesive coating shall be smooth and uniform and as free from lumps and bare spots as the best commercial practice will permit. There shall be no adhesive transfer when the tape is unwound from the roll;

iv. Black plastic backing shall be considered standard. Other colors, opaque or transparent, are acceptable when specified.

b. Polyethylene plastic pressure-Sensitive electrical insulating tape

i. Standard rolls

i.1 The standard widths and lengths shall be selected from the following:

i.1.1 Widths:

mm	in.	mm	in.
6	1.4	12	1.2
9	3.8	15	5.8
19	3.4	30	11.4
22	7.8	38	11.2
25	1	50	2

Widths greater than 50 mm (2 in.) shall be agreed upon between the purchaser and the seller.

i.1.2 Lengths:

m	ft
6	20
20	66
33	108

i.1.3 Nonstandard widths and lengths are permissible if agreed to between the purchaser and seller.

ii. Physical requirements

ii.1 The tape shall meet the requirements listed in Table 1.

ii.2 Black plastic backing shall be considered standard. Backing of a different color than black shall be specified on the purchase order.

iii. Test methods

iii.1 The selection of rolls, conditioning, and testing shall be in accordance with Test Methods ASTM D1000 except as noted.

iii.2 The Penetration Test shall be performed in accordance with Test Methods ASTM D876 except as follows: with no load on the rod, each specimen shall be inserted between the steel ball and the steel plate with the adhesive surface of the tape facing the plate. The tape shall be smooth against the plate and shall not be stretched.

iv. Rejection

If the test results of any roll do not conform to the requirements prescribed in the specification, two additional rolls shall be selected and tested. If one of the two additional sample rolls also does not conform to the requirements, the lot may be rejected at the option of the purchaser.

Table 1- Requirements for polyethylene plastic electrical tape

Property		Unit	Requirement	ASTM test method
Thickness (avg)		mm	0.241± 0.025	D1000
Width, (As Specified)		mm	± 0.8	D1000
Length, (As Specified) (min)		mm or m	minus 1%	D1000
Breaking Strength (avg) (min)		KN/mm	2.8	D1000
Elongation (avg) (min)		%	150	D1000
Dielectric breakdown (avg) (min)	Standard Condition	V	10000	D1000
	Wet Condition (96/23/96)		90% of avg value obtain under standard condition	D1000
Adhesion (avg) (min)	Steel	N/mm	0.175	D1000
	Backing		0.175	
	Backing at-7°C		0.175	
Unwind at -7°C (avg)	min	N/mm	0.175	D1000
	max		1.400	
Penetration (avg) (min)		°C	45	D1000
High-Humidity insulation resistance (min)		MΩ (median)	1 * 105	D1000
Flogging (avg) (max)		mm	13	D1000

c. Vinyl chloride plastic pressure-sensitive electrical insulating tape

i. Classification

i.1 This specification covers two types as follows:

i.1.1 *Type I*- General-purpose tape, nominal thickness 0.18 mm (0.007 in.).

i.1.2 *Type II*- General-purpose tape, nominal thickness 0.25 mm (0.010 in.).

ii. Requirements

ii.1 The tape shall meet the requirements given in Table 2 for the type specified.

iii. Standard Rolls

The standard widths and lengths shall be selected from the following:

iii.1 Widths:

mm	in.	mm	in.
6	1.4	22	7.8
9	3.8	25	1
12	1.2	30	11.4
15	5.8	38	11.2
19	3.4	50	2

iii.1.1 Widths greater than 50 mm (2 in.) shall be agreed upon between the purchaser and the seller.

iii.2 Lengths*:*

m	ft
6	20
20	66
33	108

iii.2.1 Lengths greater than 33 m (108 ft) shall be in multiples of 33 m. Additional lengths shall be agreed upon between the purchaser and seller

iv. Test methods

iv.1 The selection of rolls, conditioning, and testing shall be in accordance with Test Methods D1000.

v. Rejection

If the test results of any roll do not conform to the requirements prescribed in this specification, two additional rolls shall be selected and tested. If one of the two additional sample rolls also does not conform to the requirements, the lot may be rejected at the option of the purchaser.

Table 2- Requirements for vinyl chloride plastic electrical tape

Requirements	Type I	Type II
Thickness, mm (in.) avg	0.178 ± 0.025 (0.0070 ± 0.0010)	0.254 ± 0.025 (0.0100 ± 0.0010)
Width, as specified, mm (in.)	±0.8 (±1/32)	±0.8 (±1/32)
Length Tolerance, %	–1	–1
Breaking strength, min, N/10 mm (lbf/in.) avg	27 (15)	36 (20)
Elongation, min, % avg	125	150
Dielectric breakdown, min. V avg:		
(*a*) Standard condition	7000	9000
(*b*) Wet condition (96/23/96)	90 % of original	90 % of original
Adhesion, min, N/10 mm (ozf/in.) avg:		
(*a*) Steel	2.4 (22)	2.4 (22)
(*b*) Backing	2.0 (18)	2.0 (18)
High-humidity insulation resistance, min, MΩ median	2×10^4	2×10^4
Flagging, max, mm (in.) avg	2.5 (0.10)	2.5 (0.10)
Flammability, s burning time (max)	4	4

d. Packaging and package marking

i. *Packaging* - The package shall withstand shipment and shall give the product ample protection against damage. The individual rolls shall not adhere to each other or to the container.

ii. *Package Marking* - Each package shall be marked with the name of the manufacturer, the ASTM specification number, the type number, the thickness, the width, and the length on the roll.

6 Nonmetallic semi-Conducting and electrically insulating rubber tapes

This part covers nonmetallic semi-conducting and electrical insulating tapes designed for the splicing and repair of electrical wire and cables operating at voltages up to325 kV, phase to phase.

a. Classification

i. *Types:*

i.1 *Type I* - A low voltage rubber insulating tape designed for use on wires and cables operating up to 2000 V phase to phase in dry locations with conductor temperatures up to 80°C (176°F) for continuous operation, up to 95°C (203°F) for emergency overload conditions, and up to 150°C (302°F) for short-circuit conditions. For outdoor use, protect the tape from ozone attack and ultraviolet radiation by the use of a suitable overwrap. Apply the tape to the wire or cable within an ambient temperature range of -10 and 40°C (14 and 104°F).

i.2 *Type II* - A medium voltage, ozone-resistant, rubber insulating tape designed for use with wires and cables operating up to 35 000 V phase to phase in either wet or dry locations with conductor temperatures up to 90°C (194°F) for continuous operation, up to 130°C (266°F) for emergency overload conditions, and up to 250°C (482°F) for short-circuit conditions when installed in accordance with the manufacturer's instruction. For wet or dry outdoor use, protect the tape from ultraviolet radiation by the use of a suitable overwrap. Apply the tape to the wire or cable within an ambient temperature range of -10 and 40°C (14 and 104°F).

i.3 *Type III* - A high voltage, ozone-resistant, rubber insulating tape designed for use with wires and cables operating up to 138 000 V phase to phase in either wet or dry locations with conductor temperatures up to 90°C (194°F) for continuous operation, up to 130°C (266°F) for emergency overload conditions, and up to 250°C (482°F) for short-circuit conditions when installed in accordance with the manufacturer's

instructions. This tape is suitable for wet or dry outdoor use. Apply the tape to the wire or cable within an ambient temperature range of -10 and 40°C (14 and 104°F).

i.4 *Type IV* - A nonmetallic semi-conducting tape designed for shielding various portions of joints and terminations in electrical wires and cables operating at any voltage under wet or dry conditions with conductor temperatures up to 90°C (194°F) for continuous operation, or up to 130°C (266°F) for emergency overload conditions. This tape is suitable for wet or dry outdoor use. Apply the tape to the wire or cable within an ambient temperature range of -10 and 40°C (14 and 104°F).

i.5 *Type V* - A higher voltage, ozone-resistant, rubber insulating tape designed for use with wires and cables operating up to 325 000 V phase to phase in either wet or dry locations with conductor temperatures up to 90°C (194°F) for continuous operation, up to 130°C (266°F) for emergency overload, and up to 250°C (482°F) short-circuit conditions when installed in accordance with the manufacturer's instructions. This tape is suitable for wet or dry outdoor use. Apply the tape to the wire or cable within an ambient temperature of -10 and 40°C (14 and 104°F).

b. Physical properties

i. The tape shall consist of a non-cross linked or partially cross linked rubber nonmetallic semi-conducting or insulating compound. The compound shall be well, evenly, and smoothly processed, cut to the specified widths, and tightly wound in rolls with a separator between layers. Where a non-removable separator is used, the separator will be considered an integral part of the tape.

ii. The separator shall be parchment paper, glazed or plastic sheeting, or any suitable material interposed between adjacent layers. The removable or non-removable separator shall not interfere with the use of the roll during application. Where a removable separator is used, the separator shall be readily removable from the rubber insulation without tearing or damaging the tape insulation. The outside end of the roll shall be securely fastened.

iii. Rubber tapes shall conform to the requirements of Table 3.

c. Permissible variations in dimensions

i. The tape shall conform to the nominal dimensions found in Table 3 when tested in accordance with Test Methods ASTM D4325.

ii. The average thickness shall not vary from the nominal thickness by more than 60.076 mm (60.003 in.) and the average width by more than 60.76 mm (60.03 in.).

iii. The average length of the rolls in any sampling shall be no less than the nominal length.

Table 3- Physical properties for rubber insulating tape

Requirements	Type I	Type II	Type III	Type IV	Type V
Tensile strength, min, MPa (psi)	1.7 (250)	1.7 (250)	1.7 (250)	>0.69 (100)	2.4 (350)
Elongation at break, min, %	300	500	700	300	700
Dielectric strength, min, kV/mm (V/mil):					
0.51 mm (0.020 in.) thickness	...	...	28 (700)	...	32 (800)
0.76 mm (0.030 in.) thickness	14 (350)	20 (500)	24 (600)	...	28 (700)
1.016 mm (0.040 in.) thickness	...	16 (400)	...	...	
Dissipation factor, max:					
after water immersion	...	0.05	0.05	...	0.01
after hot water immersion	...	0.05	0.05	...	0.01
Permittivity, max:					
after water immersion	...	4.5	4.0	...	2.8
after hot water immersion	...	4.5	4.0	...	2.8
Volume resistivity, (ohm-cm):					
96 h at 23 °C and 50 % RH	...	10^{14} min	10^{14} min	10^{3} max	10^{16} min
96 h at 23 °C and 96 % RH	...	10^{13} min	10^{13} min	...	10^{15} min
168 h at 90 °C	...	...	...	5×10^{4} max	
Fusion—Flags 2 mm (5/64 in.) max	Pass at 200 % elongation	Pass at 300 % elongation	Pass at 300 % elongation	Pass at 300 % elongation	Pass at 300 % elongation
Ozone resistance	...	Pass if no visible signs of cracks	Pass if no visible signs of cracks	...	Pass if no visible signs of cracks
Heat exposure	Pass at 95 °C	Pass at 110 °C	Pass at 130 °C	...	Pass at 150 °C
UV resistance	...	...	Pass	Pass	Pass

d. Aging and storage

i. Tapes shall not become unduly attached to the separators within the period of time specified in table 4 pipes, radiators, or other sources of heat.

e. Test methods

i. Select rolls, conditioning, and testing in accordance with Test Methods ASTM D4325.

ii. Unless otherwise stated, measurements are made on tapes from which the removable separator has been removed.

f. Rejection and retest

i. If only one sample roll fails to meet the specification, take a second set of samples in accordance with Test Methods ASTM D4325. Failure of two sample rolls constitutes grounds for rejection.

g. Inspection

i. Inspection of the material shall be made as agreed upon by the purchaser and seller as part of the purchase contract.

ii. If inspection is required, the tape shall be tested and inspected either at the place of manufacture prior to shipment or at the place of delivery within four weeks from date of delivery.

h. Packaging and package marking

i. Packaging-Unless otherwise specified, the tape or carton shall be securely wrapped and sealed in a moisture proof material to protect the contents.

ii. Package Marking-Each box shall be marked with the name of the manufacturer or trademark, nominal width, thickness, and length of tape.

Table 4 - Typical nominal dimensions

Type	Width, mm (in.)	Thickness, mm (in.)	Length, m (yd)
III, V	19 (0.75)	0.508 (0.020)	9.1 (10.0)
I, II, III, IV	19 (0.75)	0.762 (0.030)	9.1 (10.0)
IV	19 (0.75)	0.762 (0.030)	4.6 (5.0)
IV	19 (0.75)	0.762 (0.030)	2.7 (3.0)
II, V	19 (0.75)	1.016 (0.040)	3.4 (3.7)
III	25 (1.00)	0.508 (0.020)	9.1 (10.0)
I, II, III	25 (1.00)	0.762 (0.030)	9.1 (10.0)
II	25 (1.00)	1.016 (0.040)	3.4 (3.7)
III, V	38 (1.50)	0.508 (0.020)	9.1 (10.0)
I, II, III	38 (1.50)	0.762 (0.030)	9.1 (10.0)
II	38 (1.50)	1.016 (0.040)	3.4 (3.7)
III, V	51 (2.00)	0.508 (0.020)	9.1 (10.0)
I, II, III	51 (2.00)	0.762 (0.030)	9.1 (10.0)
II	51 (2.00)	1.016 (0.040)	3.4 (3.7)
V	38 (1.50)	0.508 (0.020)	50 (55.0)

7 Inspection and testing

a. The manufacturer and/or supplier shall be responsible for carrying out all the tests and inspections required by this Part of Standard specification, using his own or other reliable facilities, and he shall maintain complete records of all such tests and inspections. Such records shall be available for review by the Purchaser.

b. The manufacturer and/or supplier shall afford the Purchaser's inspector all reasonable facilities necessary to satisfy him that the product is being produced and furnished in accordance with this Part of Standard specification. Such inspections in no way relieve the manufacturer and/or supplier of his responsibilities under the terms of this Part of Standard specification.

c. The Purchaser reserves the right to perform any inspections set forth in this Part of Standard specification where such inspections are deemed necessary to assure that supplies and services conform to the prescribed requirements.

d. The Purchaser's inspector shall have access to the material subject to inspection for the purpose of witnessing the selection of the samples, the preparation of the test samples, and the performance of the tests.

e. Samples of any or all ingredients used in the manufacture of this material may be requested by the Purchaser and shall be supplied upon request, along with the supplier's name and identification for the sample.

8 Certification

a. The manufacturer shall provide the Purchaser with a certification stating that the tapes meet the specified requirements of this Part of Standard specification.

b. The test report shall contain results of tests required by this Part of Standard specification and other tests specified by the Purchaser.

c. Each test report shall be signed by an authorized agent of the seller and/or manufacturer.

d. Certified test reports furnished by the manufacturer shall be properly identified with each lot (batch) of products.

9 Labeling

a. Marking of rolls

Each roll shall be marked with the following information:

- Name or trademark of the manufacturer;
- type or trade name of tape;
- Length of the roll (in m.);
- Width of the roll (in mm.);
- Thickness of the tape (in mm.).

b. Marking of containers

Each unit pack, and each package containing a number of unit packs, shall be plainly marked with the following information:

- Name: (I.e. electrical insulating tape or rubber tape) .....
- Specification: IPS-M-TP-750: Part 11 .....
- Order No: .....
- M.E.S.C No: .....
- Type or trade name of tape: .....
- Roll sizes: Length ..... m, width..... mm, thickness …….. mm .....
- Color: .....
- No. of rolls in the unit pack: .....
- Batch No.: .....
- Stock No.: .....
- Date of manufacture: .....
- Declared expire date (if applicable): .....
- Quantity (Number of rolls): .....
- Manufacturer’s name and address: .....

This Side Up or a similar indication, appropriately positioned, so that the rolls of tape will be laying flat on their cut edges.

Part 12
Thermit weld (cad weld) powder

1 Scope

This Part of IPS-M-TP-750 covers the minimum requirements for the supply of thermit weld (cad weld) powder for connection of cathodic protection leads to new or inservice steel pipes, tanks, and structures by thermit welding process.

2 References

Throughout this Standard the following dated and undated standards/codes are referred to. These referenced documents shall, to the extent specified herein, form a part of this standard. For dated references, the edition cited applies. The applicability of changes in dated references that occur after the cited date shall be mutually agreed upon by the Company and the Vendor. For undated references, the latest edition of the referenced documents (including any supplements and amendments) applies.

2.1 ISO 28591, Sampling procedures for inspection by attributes, Part 1: Sampling plans indexed by acceptable quality level (AQL) for lot by lot inspection

3 Definitions

For the purposes of this Part of Standard specification the following definitions apply:

3.1

thermit weld powder

The thermit weld (cad weld) powder is a mixture of finely ground aluminum powder and copper oxide.

3.2

Thermit welding

Welding in which welding heat is obtained from reacting a mixture of copper oxides with aluminum powder. The ignition of which produces aluminum oxide (in the form of slag) and supper heated molten copper that flows into the weld cavity and welds the cable to the pipe.

Notes:

1) Mixtures described are manufactured under the trade name “Thermoweld” by the burndy corporation, and under the trade name “Cad weld” by erico products inc.

2) For the purpose of this Part of Standard specification, thermit welds, thermowelds, and cad welds are synonymous.

4 Units

This Standard is based on International System of Units (SI), as per IPS-E-GN-100 except where otherwise specified.

5 Technical documents

5.1 The technical bid shall include the following:

a. Catalogue (including technical data of the offered material).

b. Production procedures that cover all stages of the manufacturing process, from receipt of raw materials to finishing and packing for shipment, including:

- Chemical analysis of alloy (material specification).
- Measurements of individual cartridge weight.
- Inspection and testing procedures, including acceptance criteria, and frequencies.
- Preservation, packing and shipping procedures, including methods, material and any requirement for periodic inspections.

5.2 The manufacturer/supplier shall provide sufficient information to identify the thermit weld powder and shall supply the technical information as a minimum requirement as follows:

a. ISO 9001 certification for design, manufacturing and quality control of the thermit weld powder to be used for impressed current/sacrificial anode cathodic protection installation, issued by an internationally recognized body.

b. Original technical catalogue and data sheet, manufacturing procedure specification, quality control plan, application procedure recommendation and guidelines (installation instructions).

c. Filled, signed and stamped data sheets.

d. All laboratory and shop testing shall be documented. The thermit weld powder shall be traceable to the manufacturing batch. Shipping, handling and storage procedures shall ensure that the thermit weld powder are not damaged.

e. Material certificate and specifications.

Note 1: Manufacturing procedures shall cover all stages of the manufacturing process, from receipt of raw materials to finishing and packing for shipment, including:

a. chemical analysis;

b. Electrical and physical properties;

c. inspection and testing procedures and frequencies;

Note 2: The quality control at the thermit weld powder manufacturing plant shall include control systems on the following:

d. Raw materials, i.e. checking of documentation;

e. Production equipment and process;

f. Testing during and after production;

g. Identification of thermit weld powder;

h. Chemical analysis;

i. Documentation (material certificates).

5.3 The manufacturer/supplier shall submit following certificates, as a minimum:

a. Test certificates relevant to the chemical properties of the materials used for construction as per this part of standard specification and relevant standards.

Certified test reports furnished by the manufacturer shall be properly identified with each lot (batch) of products.

The certificates shall be considered valid only when signed by Purchaser's inspector

6 General requirements

6.1 The thermit weld powder for all welds of copper cable to steel pipe irrespective of cable size shall be cartridge No. 15 (15 grams).

6.2 Each cartridge powder charge shall be enclosed in a separate polyethylene tube containing 15 grams with starting powder at the bottom.

6.3 Individual cartridge tubes along with the required metal discs shall be tightly packaged 20 nos. to a plastic box and nos. of plastic boxes shall be tightly packaged in a cardboard package.

6.4 The material shall be of such quality and purity that when applied, produces strong and permanent high conductivity connection.

7 Storage life

The material shall meet the initial properties after storage for at least 3 years from the date of delivery at normal storage conditions.

8 Packaging

The material purchased according to this Part of Standard specification, shall be packaged in suitable containers, in accordance with the best commercial practice. The complete package shall be designed to ensure the item against damage during shipment, handling and storage.

9 Sampling

9.1 Lot

Unless otherwise specified by the Purchaser, a lot shall consist of all thermit weld powders made from the same production run offered for inspection at one time.

9.2 Sampling for inspection

Sample cartridge powders shall be selected from each lot in accordance with inspection level II of ISO 2859 (Part 1). The acceptable quality level shall be 2.5 percent for all visual, weight and all other type of defects with reference to this Part of Standard specification. The single sampling plans for normal inspection (Table II A of ISO 2859 (Part 1)) shall be used.

10 Rejection

Where the numbers of thermit weld powders that do not conform to this Part of Standard specification exceed the acceptance numbers specified in 9.2, this shall be cause for rejection of entire lot.

11 Inspection

11.1 The manufacturer and/or supplier shall be responsible for carrying out all the tests and inspections required by this Part of Standard specification, using his own or other reliable

facilities, and he shall maintain complete records of all such tests and inspections. Such records shall be available for review by the Purchaser.

11.2 The supplier shall provide to Purchaser the following details as supported by actual test results:

- Weight of individual cartridges in grams.
- Analysis of alloy.

11.3 The manufacturer and/or supplier shall afford the Purchaser's inspector all reasonable facilities necessary to satisfy him that the material is being produced and furnished in accordance with this Part of Standard specification. Such inspections in no way relieve the manufacturer and/or supplier of his responsibilities under the terms of this Standard specification.

11.4 The Purchaser shall have the right to perform any of the inspections and tests set forth in this Part of Standard specification when such inspections and tests are deemed necessary to assure that the material conforms to the prescribed requirements.

12 Certification

12.1 The manufacturer shall provide the Purchaser with a certification stating that the thermit weld powders meet the specified requirements of this Part of Standard specification.

12.2 The test report shall contain results of tests required by this Part of Standard specification and other tests specified by the Purchaser.

12.3 Each test report shall be signed by an authorized agent of the seller and/or manufacturer.

12.4 Certified test reports furnished by the manufacturer shall be properly identified with each lot (batch) of products.

13 Marking

13.1 For the purpose of marking requirements, containers are defined as follows:

a) Unit container

The smallest container in which cartridge powders are packaged.

b) Packaging container

The container in which the unit containers are packaged.

13.2 Each unit container shall be marked with the following information:

- Type or trade name of material;
- Manufacturer's name;
- Distinctive catalog number;
- Size designation;
- Quantity (per box);
- Minimum shelf life.

13.3 Each packaging container shall be plainly marked with the following information:

Name: Thermit weld (cad weld) powder .....

Specification: IPS-M-TP-750: Part 12.....

Order No: .....

M.E.S.C No: .....

Type or trade name of material: .....

Catalog No.: .....

Size: .....

Maximum temperature resistance (°C): .....

Batch No.: .....

Stock No.: .....

Date of manufacture: .....

Quantity (of material in container): .....

Minimum shelf life: .....

Storage conditions: .....

Name or trademark of the supplier: .....

Manufacturer's name and address:.....

13.4 Each unit container shall contain instruction for use.