

**MATERIAL AND CONSTRUCTION STANDARD**  
**FOR**  
**THREE LAYER POLYETHYLENE COATING SYSTEM**

## **GENERAL REQUIREMENTS**

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## 1. SCOPE

This Standard deals with factory and field applied polyethylene coatings for external surfaces of buried or submerged steel pipes. The standard is comprised of three parts as follows:

- Part 1:** Requirements for Factory Applied Coating Materials and Methods of Test.
- Part 2:** Factory Applied Coatings.
- Part 3:** Field Applied Coatings.

The coating may be 2 or 3 layers as will be specified by the Company.

Two layers polyethylene coating consists of adhesive primer and polyethylene and is suitable for operating temperature up to 50°C.

Three layers polyethylene coating consists of epoxy primer, adhesive primer and polyethylene and is intended for operating temperature up to 80°C.

## 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 changes in standards and codes that occur after the date of this Standard shall be mutually agreed upon by the Company and the Vendor:

### API (AMERICAN PETROLEUM INSTITUTE)

- API PR5L5 "Recommended Practice for Marine Transportation of Line Pipe"

### ASTM (AMERICAN SOCIETY FOR TESTING AND MATERIALS)

- D 522 "Test Method for Elongation of Attached Organic Coating with Conical Mandrel Apparatus"
- D 570 "Test Method for Water Absorbtion of Plastic"
- D 696 "Test Method for Coefficient of Linear Thermal Expansion of Plastic"
- D 746 "Test Method for Brittleness Temperature of Plastic and Elastomers by Impact"
- D 1002 "Test Method for Strength Properties of Adhesive In shear by Tension Loading (Metal-to-Metal)"
- D 1525 "Test Method for Vicat Softening Temperature of Plastics"
- D 1603 "Test Method for Carbon Black in Olefin Plastic"
- D 1673 "Test Method for Relative Permittivity and Displation Factor of Expanded Cellular Plastics Used for Electrical Insulation"
- D 1693 "Test method for Environment Stress-Cracking of Ethylene Plastics"
- D 2240 "Test Method for Rubber Property-Durometer Hardness"
- D 3176 "Method for Ultimate Analysis of Coal and Cock"
- D 3180 "Method for Calculation Coal and Cock Analysis"
- G 8 "Test Method for Cathodic Disbanding of Pipeline Coating"
- G 14 "Test Method for Impact Resistance of Pipeline Coating (Falling Weight Test)"

**BSI (BRITISH STANDARD INSTITUTION)**

BS 3412	"Polyethylene Materials for Moulding and Extrusion"
BS 4232, 2nd Quality	"Specification for Surface Finish of Blast-Cleaned Steel for Painting"

**DIN (DEUTCHES INSTITUT FÜR NORMUNG)**

DIN 30670	"Polyethylene Sheathing of steel Tubes and Steel Pipes and Fittings"
DIN 50049 (Parts 1, 2 & 3) 1986	"Materials Testing Certificates"
DIN 53122	"Testing of Plastics Films; Elastomer Films; Paper, Board and Other Sheet Materials; Determination of Water Vapor Transmission Rate; Gravimetric Method"
DIN 53152	"Testing of Paints, Varnishes and Similar Coating Materials, Bend Test on Paint Coating and Similar Coatings"
DIN 53155	"Testing of Paints, Varnishes and Similar Coating Materials, Chip-Test of Coatings According to Peters"
DIN 53380	"Testing of Plastic Films; Determination of the Gas Transmission Rate"
DIN 53455	"Testing of Plastic; Tensile Test"
DIN 53460	"Determination of the Vicat Softening Temperature of Thermoplastic"
DIN 53479	"Testing of Plastics and Elastomers; Determination of Density"
DIN 53495	"Testing of Plastics; Determination of Water Absorption"
DIN 53505	"Testing of Rubber, Elastomers and Plastics; Shore Hardness Testing A and D"
DIN 53735	"Testing of Plastics, Determination of the Melt Flow Index of Thermoplastics"
DIN 55990 T2	"Testing of Paints, Varnishes and Similar Coating Materials-Powder Coatings, Determination of Particle Size Distribution"
DIN 55990 T3	"Testing of Paints Varnishes and Similar Coating Materials-Powder Coatings, Determination of Density"
DIN 55990 T8	"Testing of Paints-Varnishes and Similar Coating Materials, Powder Coatings Assessment of the Chemical Storage Stability"
DIN 67530	"Reflectometer as a Means for Glass Assessment of Plane Surfaces of Paint Coatings and Plastic"

**IEC (INTERNATIONAL ELECTROTECHNICAL COMMISSION)**

IEC 243	"Methods of Test for Electric Strength of Solid Insulating Materials"
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**ISO (INTERNATIONAL ORGANIZATION FOR STANDARDIZATION)**

ISO R527	"Testing of Plastic, Tensile Test"
ISO 868	"Testing of Rubber, Elastomer and Plastics Shore Hardness Testing A and D"

ISO 1133D	"Plastics-Determination of the Metal Mass-Flow Rate (MFR) and the Metal Volume-Flow Rate (MVR) of Thermoplastic"
ISO 4599	"Test Method for Environment Stress Cacking of Ethylene Plastics"
ISO 9002	"Quality Systems-Model for Quality Assurance in Production, Installation and Servicing"

#### **IPS (IRANIAN PETROLEUM STANDARDS)**

IPS-C-TP-101	"Surface Preparation"
IPS-C-TP-274	"Coating"
IPS-M-TP-313	"Hand Applied Laminated Tape Suitable for Cold Applied Coating Systems"
IPS-M-TP-314	"Hand Applied Laminated Tape Suitable for Hot Applied Coating Systems"
IPS-M-TP-317	"Petrolatum Impregnated Tape & Its Primer"
IPS-M-TP-318	"Wrap & Heat Shrinkable Sleeve"

#### **SIS (STANDARDISERINGS-KOMMISSIONEN I SVERIGE)**

SIS 05 5900	"Swedish Standards Institution Practice, Surface Preparation Standard for Painting Steel Surface"
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### **3. DEFINITIONS AND TERMINOLOGY**

#### **Batch**

A batch shall consist of all materials which is processed at the same conditions and submitted for inspection at one time.

#### **Homopolymer**

A polymer ( as polyethylene) consisting of identical monomer units.

#### **Typical value**

A value exhibiting the essential characteristic of a special type of material.

### **4. UNITS**

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

**PART 1**

**REQUIREMENTS FOR FACTORY APPLIED COATING MATERIALS**

**AND**

**METHODS OF TEST**

## **1. SCOPE**

**1.1** This Part 1 of the Standard specifies materials for use in 3-layer polyethylene coating system. It deals specifically with the properties, minimum requirements and related methods of tests to establish suitability for use with Part 2 and Part 3 of this Standard which cover factory applied coatings and field applied coatings respectively.

**1.2** Materials specifications and method of tests for two layer polyethylene coating system shall be in accordance with DIN 30670.

## **2. REFERENCES**

See General Requirements.

## **3. DEFINITIONS AND TERMINOLOGY**

See General Requirements.

## **4. UNITS**

See General Requirements.

## **5. COATING MATERIALS**

### **5.1 Selection of Coating Materials**

**5.1.1** Only coating systems which comply with this Part one of the construction standard shall be used.

**5.1.2** The coating materials supplied shall be certified by the manufacturer ensuring that all coating materials and equipment comply with all of the provisions contained in this Part one of standard originally and prior to application and the purchaser may make any investigations necessary, by way of testing, batch sampling, manufacturing and factory inspection, to satisfy itself of compliance by the contractor.

**5.1.3** The contractor shall be responsible for ensuring that the range of values for any material under consideration will be capable of providing a finished product in compliance with Part 2 (and Part 3 where applicable) of this Standard when related to the specific mode of operation to be used.

**5.1.4** It is intended that this specification be used to encourage and stimulate the development of progressively better external pipeline coatings. Thus, where certain minimum performance values are stated, should future coating material test submissions yield better than specification requirements then, after economic evaluation, these new values may be adopted as the minimum requirements and the specification would be upgraded accordingly.

### **5.2 Materials Handling and Storage**

**5.2.1** The materials shall be stored in the manufacturer's original packaging under ventilated conditions and away from direct sunlight. Where applicable air-conditioned storage shall be observed.

**5.2.2** The materials shall be handled in such a way that they do not suffer any damage.

### **5.3 Identification of Materials**

All materials supplied for coating operations shall be suitably marked giving the following information:

**5.3.1** The manufacturer's name and address.

**5.3.2** The material and order number.

**5.3.3** The batch number.

**5.3.4** Date of manufacture and stable working shelf life (including storage condition limits).

**5.3.5** Directions for mixing and/or thinning with solvents as required.

**5.3.6** Directions for handling and storing of the coating materials.

**5.3.7** Information and warnings (if needed).

The contractor shall require the material manufacturer to supply certificates confirming that tests detailed in this specification have been carried out on the batches supplied and that the materials meet this Standard. These certificates shall be made available for examination by company on request.

## **5.4 Production Data Sheets**

The contractor shall be responsible for obtaining data sheets from the materials manufacturer which shall include values for all the basic properties of the materials as specified in the "basic properties" clause in the appropriate section of this Standard. These data sheets shall be made available for examination by company on request.

## **6. EPOXY POWDER**

### **6.1 Basic Properties and Tests for the Raw Powder**

#### **6.1.1 General**

**6.1.1.1** Epoxy powder is a thermosetting material for use as primer in a three layer polyethylene coating system for steel pipe. It shall be specifically formulated and designed so as to be suitable for electrostatic application and to improve adhesion of the coating system and also provide maximum cathodic disbonding resistance.

**6.1.1.2** The contractor shall obtain from the manufacturer, specified and qualified ranges of values for all properties listed in Table 1.1 and detailed in 6.1.2 to 6.1.4 inclusive that will ensure an acceptable coating. The frequency of testing shall be in accordance with Clause 11 of Part 2.

#### **6.1.2 Infra red scan**

Using an approved method, an infra red spectrogram, preferably made by using a standard KBr (potassium bromide) disc, shall be obtained from a first batch of the powder epoxy. This shall subsequently be used for comparison with type spectrogram.

#### **6.1.3 Thermal analysis**

Thermal analysis data for each batch shall be made available showing, by use of a DSC (Differential Scanning Calorimeter) the Glass Transition (GT) of the raw powder and also the enthalpy of the curing powder. The Glass Transition Temperature (G.T.T) of the fully cured powder shall also be quoted. The reference curve shall be provided as part of the production data sheet. The limiting values of  $\Delta H$ , TG1 and TG2 shall be identified by the manufacturer.

#### 6.1.4 Stability

After storage for at least 180 days, at 25°C in a sealed container, from the date of delivery, the powder shall not exhibit any significant change either from the properties identified above including Table 1.1 or from those in 2.2.

**TABLE 1.1 - TYPICAL VALUES OF RAW EPOXY POWDER PROPERTIES**

PROPERTY	UNIT	TEST METHOD	TYPICAL VALUE
Gloss at 60° angle	%	DIN 67530	65 ±5
Gel time	sec	DIN 55990-T8	43 ±10
Density	g/cm <sup>3</sup>	DIN 55990-T3	1.5
Particle size	%	DIN 55990-T2	90 between 10 to 80 microns
Moisture content	% weight	Acceptable method to company	0.5 Max.
Shelf life at 30°C & %60 humidity	Month	—	12 Min.
Theoretical coverage	g/m <sup>2</sup>	Acceptable method to company	90 g for 60 microns DFT (Dry Film Thickness)

## 6.2 Basic Properties and Tests for Cured Coating

### 6.2.1 General

**6.2.1.1** The tests defined in 6.2.2 to 6.2.6 inclusive shall be carried out, on a laboratory coated steel plate with a coating thickness of 60 microns.

Prior to coating, the steel surface shall be blast cleaned to a level of Sa 2½ to Swedish Standard SIS 05 5900 and surface profile of approximately 50 microns peak to valley height.

**6.2.1.2** The contractor shall ensure that the powder manufacturer shall carry out the tests specified in 6.2.2 to 6.2.6 inclusive, on each batch.

### 6.2.2 Appearance

The coating shall exhibit uniform appearance.

### 6.2.3 Thermal analysis

Glass Transition Temperature (G.T.T) shall be measured on a prepared laboratory sample for record and checking purposes.

The typical value of G.T.T is above 100°C.

### 6.2.4 Flexibility/bending

The flexibility/bending shall be measured in accordance with DIN 53152; - typical value < 5 mm.

### 6.2.5 Hardness

The hardness of the cured epoxy film shall be more than 85 bucholtz when tested in accordance with DIN 53155.

### 6.2.6 Impact resistance

The impact resistance of the cured epoxy film shall be Min. 120 kg/cm at 20°C in accordance with ASTM G14 test method. (Test panel thick 3 mm)

## 7. BASIC PROPERTIES AND TESTS FOR BONDING AGENT (ADHESIVE)

**7.1** This adhesive is used as second layer in a three layer polyethylene coating system for steel pipes. It shall be an ethylene base copolymer, specifically formulated and designed so as to be suitable for extrusion application.

**7.2** The contractor shall obtain from the manufacturer specified values for all properties listed in Table 2.1 in accordance with 7.3.

**7.3** The contractor shall ensure that the adhesive manufacturer shall carry out the tests Nos. 1, 2 in Table 2.1 for each batch and the remaining tests shall be carried out as type tests twice per each order as a minimum.

**7.4** The adhesive shall be uncolored and made of raw material with the best quality to provide the following properties:

- Excellent peeling resistance.
- Excellent mechanical strength.
- Excellent thermal stability.
- Strong adhesion to fusion bonded epoxy film as well as to steel surface.
- Homopolar bond with the polyethylene top coat (third layer).

### 7.5 Stability

After aging for at least 180 days, at 30°C in a sealed and U.V resistant container, from the date of delivery, the adhesive shall not exhibit any significant change either from the properties identified above including Table 2.1 or from those in 5.3.

**TABLE 2.1 - PHYSICAL PROPERTIES OF ADHESIVE**

PROPERTY	UNIT	TEST METHOD	VALUE
1) Density	g/cm <sup>3</sup>	DIN 53479	0.900 - 0.950
2) Melting index (2.16 kg/190°C)	g/10 Min.	DIN 53735	5-8 or as suitable for application As PE (top coat)
3) Elongation	%	DIN 53455	95 (Min.)
4) Melting point	°C	DSC (Differential Scanning Calorimeter)	9 (Typical)
5) Comonomer content	%		

## 8. BASIC PROPERTIES AND TESTS FOR POLYETHYLENE

**8.1** Polyethylene is a thermoplastic resin for use as top coat in a three layer polyethylene coating system for steel pipe. It shall be specifically formulated and designed for extrusion application.

**8.2** The contractor shall obtain from the manufacturer specified values for all properties listed in Table 3.1 in accordance with 8.3.

**8.3** The contractor shall ensure that the polyethylene manufacturer shall carry out the tests Nos. 1, 2, 7 and 10 in Table 3.1 for each batch and the remaining tests shall be carried out as type tests twice per each order as a minimum.

**8.4** The polyethylene shall be made of raw material with the best quality to provide following properties:

- Excellent peeling resistance.
- Excellent mechanical strength.
- Excellent thermal stability.
- Excellent Impact resistance.
- Excellent penetration resistance.
- Strong adhesion to adhesive layer.
- Excellent stability against ultra violet rays.

**8.5** The polyethylene shall be adequately weather-resistant and stable for fabrication and use, for this purpose the nature and quantity of antioxidant shall be in accordance with BS 3412-76.

## **8.6 Color**

The polyethylene shall be uniform in color and free from obvious foreign matters; the color shall be black using carbon black; the carbon black characterization, dispersion and content shall be in accordance with BS 3412-76.

## **8.7 Stability**

After aging for at least 180 days, at 30°C in a sealed and U.V resistant container, from the date of delivery, the polyethylene shall not exhibit any significant change either from the properties identified above including Table 3.1 or from those in 5.3.

**TABLE 3.1 - PHYSICAL PROPERTIES OF BLACK POLYETHYLENE**

PROPERTY	UNIT	TEST METHOD	VALUE
1) Density (in black)	g/cm <sup>3</sup>	DIN 53479	0.946 Min.
2) Melting index (2, 16 kg/190°C)	g/10 Min.	DIN 53735 ISO 1133D	0.3 (Typical)
3) Elongation	%	DIN 53455	600 - 700
4) Tensile strength at yield	N/mm <sup>2</sup>	DIN 53455 or ISO R 527	15 Min.
5) Tensile strength at break		DIN 53455 or ISO R 527	25 Min.
6) Hardness	Shore. D	DIN 53505 or ISO 868	55 Min.
7) Vicat softening point	°C	DIN 53460	115 Min.
8) Melting point	°C	DSC	125
9) Low temperature brittleness	°C	ASTM D 746	-70 no fracture
10) Stress cracking resistance (methyl-ethylceton)	Hour	ASTM D 1693 or ISO 4599	>1000
11) Carbon black content	%	ASTM D 1603	2 - 2.5 Min.
12) Dielectric strength	kV/mm	IEC 243	30 Min.
13) Fungus bacteria	Pass no growth	ASTM D 3173 and ASTM D 3180	Pass no growth

## 9. QUALITY CONTROL REQUIREMENTS

Before dispatch, the materials manufacturer shall carry out sampling and testing of the manufactured materials covered by this specification in accordance with 7.3 and 8.3

## 10. QUALITY SYSTEMS

**10.1** The contractor shall set up and maintain such quality assurance and inspection systems as are necessary to ensure that the goods or services supplied comply in all respects with the requirements of this Standard.

**10.2** The company shall have the right to undertake inspection or testing of raw materials or purchased components before application.

**PART 2**  
**FACTORY APPLIED COATINGS**

## 1. SCOPE

This Part 2 of the standard specifies the operations and requirements for the factory application of materials identified in Part 1, to buried steel pipes providing a finished product capable of pipe laying and operating up to 80°C for 3-layer polyethylene coating.

## 2. REFERENCES

See General Requirements.

## 3. UNITS

See General Requirements.

## 4. MATERIALS

### 4.1 Acceptable Materials

**4.1.1** Only polymer systems conforming to this Standard shall be considered for use as coatings applied in accordance with this Part 2 and or Part 3 of this Standard.

**4.1.2** The contractor shall be responsible for the conformity with the requirements of this construction standard. The contractor shall obtain and retain all certificates and manufacturer's data sheets. Certificates shall be made available on request to company.

### 4.2 Identification of Coating Materials

The contractor shall ensure that all materials supplied for coating operations are clearly marked with the following information:

- Manufacturer's name, trade mark and address.
- Name of material, order number and L/C number.
- Batch number.
- Date of manufacture, and expiry date for use.
- Safety data sheet.
- Technical data sheet.

### 4.3 Storage of Coating Materials

To ensure that the properties of all coating materials are maintained in compliance with the relevant section of Part 1. All coating materials consigned to the coating plant shall be properly stored in accordance with the manufacturer's recommendations at all times to prevent damage and deterioration prior to use. Materials shall be used in the order in which they are delivered.

## 5. PIPES IDENTIFICATION

**5.1** All identification markings, whether internal or external to the pipes shall be carefully recorded before surface preparations begin.

**5.2** The date of coating finish and the coating factory markings including pipe identification shall be legibly marked on coating surface of each pipe.

## 6. PROTECTION OF PIPE END PREPARATION

**6.1** Pipe end preparations shall be protected from mechanical damage during handling, storage, surface preparation and the coating processes. The methods used shall also ensure that no damage occurs to the internal surface of the pipe.

**6.2** Pipe end preparations shall be protected from coating during the process by a suitable method approved by the Company.

**6.3** For technical welding reasons the ends of the pipes shall be free of any coating layer (cut back) over a length of 100 mm up to pipe size DN 500 mm (20 in.) inclusive and over a length of 150 mm for sizes over DN 500 mm, unless specified otherwise by the Company.

**6.4** The uncoated ends of pipes shall be temporarily protected against atmospheric corrosion by a temporary paint easily removable by brushing.

## 7. SURFACE PREPARATION

**7.1** The method of surface cleaning and surface preparation shall be specified by the contractor as part of the coating procedure qualification and shall take into account the requirements specified in 7.2 to 7.5 inclusive, in accordance with (IPS-C-TP-101).

**7.2** Where oil, grease or other contaminants are present they shall be removed, without spreading them over the surface, with a suitable solvent. For pipes which have been subjected to contamination, the contaminant shall be removed by washing either with potable water or an approved chemical cleaner. If a chemical cleaner is used, subsequent washing with potable water will be necessary. The pipe shall be dried before blast cleaning. All processes shall be in accordance with IPS-C-TP-101.

**7.3** Pipes shall be blast cleaned to a minimum of Sa 2½ finish to SIS 05 5900. The blast profile shall be between 40 µm and 75 µm height, measured by an agreed method. The blast cleaning medium used shall be according to IPS-C-TP-101.

**7.4** The metal surface shall be inspected immediately after blast cleaning and all slivers, scabs, etc., made visible by blast cleaning and detrimental to the coating process shall be removed using a method approved by company. After the removal of defects, the remaining wall thickness shall comply with the relevant pipe specification. Any rectified areas shall be blast cleaned to meet the requirements of 7.3.

**7.5** Any pipe found to have defects which exceed the levels permitted in the relevant pipe specification shall be set aside for examination by an authorized company representative and no subsequent action taken without the agreement of the Company.

**7.6** Directly before coating, any dust, grit or other contaminants shall be removed from the pipe surface by a method established as acceptable by the relevant coating procedure test and recorded in the relevant coating procedure.

**7.7** Where rust blooming or further surface contamination has occurred, the pipe shall be cleaned again in accordance with 7.2 and again blast cleaned in accordance with 7.3. Coating shall take place before any further contamination or rust blooming appears.

## 8. COATING PROCEDURE TESTS

The coating process shall comply with the procedure established in the coating procedure qualification (see 11). Any changes in coating materials, pipe dimensions, pipe manufacturing process or the coating process may, at the discretion of Company, necessitate a new coating procedure approval tests.

Additionally, approved procedure tests shall be confirmed as proving tests, at intervals of not more than 1 year for each type of powder, adhesive and polyethylene used by the contractor and for each size of pipe and pipe manufacturing process as requested by the Company.

## 9. INSPECTION AND TESTING (QUALITY CONTROL)

**9.1** The quality control system shall include as a minimum the requirements listed in Table 1.2.

**9.2** All inspections and testings listed in Table 3.2 shall be made by the contractor and witnessed and certified by the inspector.

**9.3** After examination or test, should the inspector find out that any pipe has not been cleaned or coated in accordance with this Standard, the contractor shall be required to remove the coating which is considered defective or inadequate, and to reblast and recoat the pipe to the requirements for approval of the inspector.

**9.4** The inspector shall have access at any time to the construction site and to those parts of all plants that are concerned with the performance of work under this standard.

**9.5** The contractor shall provide the necessary inspection tools and instruments for the inspector as well as normal facilities necessary for inspection.

**TABLE 1.2 - MINIMUM QUALITY CONTROL REQUIREMENTS**

REQUIREMENTS	CLAUSE REFERENCE
1. Check cleanliness of pipes immediately prior to blast cleaning.	7.2
2. Monitor size, shape and cleanliness of the blast cleaning material and process.	7.3
3. Check visually in good light, the surface of the pipes for metal defects, dust and entrapped grit.	7.4
4. Check pipe surface blast profile.	7.3
5. Check for residual contamination of pipe surface.	7.4
6. Pipe temperature control of the pipe surface (pipe temperature shall not exceed 250°C).	—
7. Check recycled coating material for contamination and moisture.	—
8. Check the coating thickness (first, second layers and total)	14.2
9. Check the temperature control of quenching system.	—
10. Check the coating adhesion.	14.4
11. Holiday detection of 100% of the surface area of all coated pipes.	14.3
12. Supervision to ensure the adequate and proper repair of all defects.	18
13. Check on coating color and appearance, e.g. uniformity and flow.	13.2
14. Check for damage to pipe end preparations.	6

## 10. QUALITY SYSTEMS

**10.1** The contractor shall set up and maintain such quality and inspection systems as are necessary to ensure that the goods and services supplied comply in all respects with the requirements of this Standard.

**10.2** The Company shall assess such systems against the recommendations of the applicable parts of ISO 9002 and shall have the right to undertake such surveys as are necessary to ensure that the quality assurance and inspection systems are satisfactory.

**10.3** The Company shall have the right to undertake inspection and testing of the goods and services during any stage of manufacturing at which the quality of the finished goods may be affected and to undertake inspection or testing of raw materials and/or purchased pipes.

#### **10.4 Compliance Certificates**

For each contract, the contractor shall issue the required certificates in accordance with DIN 50049 (Par.: 2.1-1986) and presented to the Company.

#### **10.5 Test Certificates**

**10.5.1** The contractor shall issue the required certificates in accordance with DIN 50049 (Par.: 2.3-1986) for all coating production tests identified in 14.1 to 14.3 inclusive and presented to the Company.

**10.5.2** For all tests witnessed by the inspector a certificate shall be prepared and issued by the contractor and certified by the inspector in accordance with DIN 50049 (Par.: 3.1.A-1986).

### **11. COATING PROCEDURE QUALIFICATION**

#### **11.1 General**

**11.1.1** Before bulk coating of pipes commences the requirements of 11.2 and 11.3 shall be met and a detailed sequence of operations to be followed on the coating of pipe shall be presented to the Company for checking the compliance with this Standard and formal approval.

**11.1.2** The Company shall also specify which coated pipes are to be subjected to the test specified in 10.3.2 and 10.3.3 for formal approval of coating procedure. No coated pipes shall be dispatched to the Company or no coating process shall be done until the coating procedure has been approved and approval confirmed in writing by the Company.

#### **11.2 Coating Procedure Specification**

The coating procedure specification shall incorporate full details of the followings, but not limited to them:

- a) The polyethylene coating system to be used together with appropriate data sheets as defined in Clause 4.
- b) pipe cleaning,
- c) blast cleaning medium and technique,
- d) blast cleaning finish, surface profile and surface cleaning,
- e) dust removal,
- f) preheat time and temperature,
- g) powder epoxy, adhesive and polyethylene including use of recycled material,
- h) curing and quenching time and temperature,
- i) repair technique,
- j) coating stripping technique.

#### **11.3 Coating Procedure Approval Tests**

##### **11.3.1 General**

**11.3.1.1** A batch of 10 to 20 pipes of any specific pipe mill shall be selected by the inspector and coated by the contractor in accordance with the approved coating procedure specification (see 11.2), the coating operations being witnessed by the inspector. Three pipes from the coated pipes shall be selected by the inspector and subjected to the complete set of tests specified in 11.3.2 and 11.3.3. Testing shall be witnessed by the inspector and a full set of records shall be presented to the Company for consideration.

**TABLE 2.2 - MINIMUM COATING THICKNESS IN mm**

<b>PIPE DIAMETER mm (in)</b>	<b>POWDER EPOXY RESIN (1ST LAYER)</b>	<b>ADHESIVE (2ND LAYER)</b>	<b>POLYETHYLENE (3RD LAYER)</b>
Up to DN 250 (10")	0.060	0.30	2.5
DN 250 (10") up to DN 500 (20")	0.060	0.30	3.0
>DN 500 (20")	0.080	0.35	3 (Normal) or 3.5 (reinforced) when specified

**11.3.1.2** Bulk coating of pipes shall not commence until all short and long term tests (see 11.3.2 and 11.3.3) results have been approved officially by company, unless the contractor takes responsibility of failure for any long term test.

**11.3.1.3** All test methods shall be in accordance with Table 3.2.

### **11.3.2 Short term approval tests**

#### **11.3.2.1 Thickness**

For this purpose, at least two measurements shall be made in accordance with Table 3.2 at locations uniformly distributed over the length and periphery of each pipe selected for the test and checked for compliance with Table 2.2.

50% of these measurements shall be made along and over the longitudinal weld seam, if any.

#### **11.3.2.2 Porosity**

Each pipe selected for the test shall be holiday detected over 100% of its coated surface and checked for compliance with Table 3.2.

#### **11.3.2.3 Adhesion**

This test shall be carried out on each pipe at 5 locations uniformly distributed over the length and periphery of the pipe, in this respect the mean force necessary to pull off the coating shall comply with Table 3.2. None of these tests must fail.

### **11.3.3 Long term approval tests**

The tests identified in 11.3.3.1 to 11.3.3. Inclusive shall be performed on test sections taken from all three coated pipes selected for the coating procedure approval tests.

#### **11.3.3.1 Adhesion**

This test shall be carried out at 5 different locations on 5 test sections in accordance with 11.3.2.3, but after 30 days keeping in the hot air of 80°C. No change in the mean force necessary to pull of the coating must occur.

#### **11.3.3.2 Cathodic disbonding**

The test sections shall be tested and checked for compliance with Table 3.2.

**11.3.3.3 Environmental stress cracking resistance**

The test sections shall be tested and checked for compliance with Table 3.2.

**11.3.3.4 Thermal cycle resistance**

The test sections shall be notched with a length of 30 mm and a depth of 0.3 mm and then tested and checked for compliance with Table 3.2.

**11.3.3.5 Impact resistance**

The test sections shall be tested and checked for compliance with Table 3.2.

**11.3.3.6 Thermal aging**

The test sections shall be tested and checked for compliance with Table 3.2.

**11.3.3.7 Elongation**

The samples taken from the three pipes shall be tested and checked for compliance with Table 3.2.

**11.3.3.8 Specific electrical resistance**

The samples taken from the three pipes shall be tested and checked for compliance with Table 3.2.

**11.3.3.9 Indentation resistance**

The samples taken from the three pipes shall be tested and checked for compliance with Table 3.2.

**TABLE 3.2 - COATING REQUIREMENTS AND TEST METHODS FOR COATING PROCEDURE APPROVAL TESTS**

<b>TESTS/INSPECTION</b>	<b>TEST METHODS AND REQUIREMENTS</b>
1. Surface preparation	1. Visual inspection 2. Acceptable limit: as specified in 7.3
2. Coating thickness	- Electro-magnetic thickness gage is used. - The gage shall be calibrated daily with the standard calibrated plates. - Min. requirements: As specified in Table 2.2.
3. Porosity	DIN 30670 No defect at 25 kV
4. Adhesion	DIN 30670, Method I Acceptable limit: 75 N/cm (mean force) for both room temp. and 80°C
5. Impact resistance	DIN 30670 Acceptable limit: Zone A
6. Elongation	DIN 30670 Acceptable limit: Min. 200% for extruded coating and Min. 100% for melted on coating.
7. Indentation (hardness)	DIN 30670 Acceptable limit: 0.3 mm
8. Thermal cycle resistance	- 1 cycle: -30°C 1 Hr +60°C 1 Hr - Number of cycles: 100 Acceptable limit: No crack.
9. Environmental stress cracking resistance	ASTM D 1693 Acceptable limit: No crack after 300 Hr.
10. Thermal aging	DIN 30670 Acceptable limit: ±35% change in melting index value.
11. Specific electrical	DIN 30670 Acceptable limit: $10^8 \Omega m^2$ Min.
12. Cathodic disbonding	ASTM G8 Acceptable limit: 5 mm

## **12. PRODUCTION COATING REQUIREMENTS**

### **12.1 Surface Preparation**

The surface of the pipe to be coated shall be prepared in accordance with Clause 7.

### **12.2 Coating Process**

**12.2.1** The production coating process shall be carried out using a procedure approved in accordance with Clauses 4, 8 and 11.

**12.2.2** The thickness of each layer and the total thickness shall comply with the values in the Table 2.2 when tested in accordance with DIN 30670.

### **12.3 Protection of Pipe end Preparations**

Protection of weld end preparations shall be in accordance with Clause 6.

## **13. INSPECTION OF FINISHED COATING**

### **13.1 General**

The inspection of finished coating shall be in accordance with Clause 14. The quality and values to be achieved shall be the same as those identified in 13.2 and Clause 14.

### **13.2 Check on coating Color and Appearance**

Coating color and appearance shall be uniform and free from runs, sags, blistering, roughness, foaming and general film defects.

## **14. COATING REQUIREMENTS AND TEST METHODS**

### **14.1 General**

**14.1.1** After formal approval of all short and long term tests by Company, the contractor will be authorized to commence the bulk production.

**14.1.2** The contractor shall perform the routine inspection and tests in accordance with 14.2 to 14.4 inclusive during coating production.

**14.1.3** All the inspection and tests witnessed by the inspector shall be certified.

**14.1.4** The pipe coating shall comply with all requirements identified in 14.2 to 14.4 inclusive.

### **14.2 Thickness**

This test shall be carried out 3 times during each 8 hour production shift and each time on 4 consecutive pipe lengths in accordance with DIN 30670 (Sections 5.2.1 and 6.3) every pipe which does not comply with the minimum requirements of Table 3.2 shall be rejected for subsequent stripping and recoating. Should two consecutive pipes fail to satisfy the requirement, the cause shall immediately be investigated. If the cause is not resolved after four consecutive pipes, the coating process shall be stopped for full investigation; this shall involve checking all pipes back to the preceding acceptable pipe.

### **14.3 Porosity**

Each individual line pipe shall be holiday detected over 100% of its coated surface in accordance with DIN 30670. Up to 2 holidays per pipe length will be allowed for repair on a max. of 5% of coated pipe lengths during each 8 hour production shift.

Any individual pipe with more than 2 holidays shall be rejected for subsequent stripping and recoating. If more than 2 holidays per pipe length are detected on two consecutive pipes, the cause of the high holiday rate shall immediately be investigated. If the cause is not resolved after four consecutive pipes, the coating process shall be stopped for full investigation. All holidays detected on non-rejected pipes shall be repaired in accordance with Clause 15 and satisfactorily retested.

### **14.4 Adhesion**

This test shall be carried out 3 times during each 8 hour production shift, each time on one individual line pipe. The test shall be carried out at room temperature and at 2 ends of the pipe coating surface and checked for compliance with Table 3.2. If the coating adhesion at any location is below the requirement of Table 3.2 the pipe shall be rejected for subsequent stripping and recoating; in this case the second consecutive pipe shall be checked. Should two consecutive pipes fail to satisfy the requirement, the cause shall immediately be investigated; if the cause is not resolved after four

consecutive pipes, the coating process shall be stopped for full investigation, this shall involve checking all pipes back to the preceding acceptable pipe.

## **15. DEFECT RATE**

Should tests specified in 14.2 to 14.4 inclusive in any production shift show a rejection rate of more than 10% for 50-457 mm (2"-18") and 5% for 508-1420 mm (20"-56") of coated pipes for any one test, then every pipe in that shift shall be individually subjected that test.

In such cases the contractor shall simultaneously conduct an investigation to establish the cause of the defect.

The cost of retrieval and/or any additional expenses incurred as a result of additional examination shall be borne by the contractor.

## **16. HANDLING AND STORAGE REQUIREMENTS**

**16.1** All coated pipes shall be handled and stored in such a manner as to prevent damage to the pipe walls, the weld end preparations and the coating.

**16.2** Nylon slings or protected hooks which do not damage pipe ends shall be used for loading, unloading and stacking.

**16.3** The coated pipes shall be stored at all times free from the ground. Storage may be effected by the use of battens suitably covered with soft material such as rubber sheet.

**16.4** The coated pipes may only be stacked to a height such that no flattening of the coating occurs, in this respect the formula given in API RP 5L5 shall be used for the calculation of static load stress.

**16.5** The pipes shall be separated from each other with sufficient and proper dunnage.

**16.6** During long storage the polyethylene coating shall be protected from contact with petrol, oil or grease, as some of these substances can cause swelling in the polyethylene layer.

## **17. TRANSPORTATION LOADING**

**17.1** The loading operations shall be witnessed and certified by the inspector.

**17.2** The coated pipes shall be loaded on trucks with provisions of 16.2.

**17.3** The Contractor shall provide all necessary means, such as saddles, battens, etc., for safe transporting of the coated pipes.

## **18. REPAIRS**

Repairs of holidays and damaged areas due to destructive tests shall be made in accordance with Clause 8 of Part 3 of this Standard.

All repairs shall be retested for holidays in accordance with DIN 30670.

## **19. STRIPPING OF COATING**

Rejected coating shall be removed only by the procedures specified by the Company. The process shall cause no mechanical damage to the pipe and the steel temperature shall not exceed 250°C.

**PART 3**  
**FIELD APPLIED COATINGS**

## **1. SCOPE**

This Part 3 of standard deals with field applied coating operations. The particular objectives are to effect compatible coating protection in areas of weld joints made in the field, to coat bare fittings, to rectify incorrectly coated components and also to carry out repairs to damage that may have occurred to an original factory applied coating.

## **2. REFERENCES**

See General Requirements.

## **3. UNITS**

See General Requirements.

## **4. SAFETY**

All safety regulations regarding the job requirements shall be considered during the installation of pipeline.

## **5. PROTECTION OF FACTORY APPLIED POLYETHYLENE COATINGS**

The protection of coated steel pipe from Factory to storage site and onwards to the pipe laying site shall at all times comply with the requirements specified in Part 2 of this Standard and IPS-C-TP-274.

Fittings which have been factory coated shall also be subject to these requirements.

## **6. FIRST TIME COATING APPLICATIONS (SEE APPENDIX C)**

### **6.1 Welded Joints**

**6.1.1** The choice of coating material to be applied to field welded joints, fittings and special sections shall be made taking into consideration the type of coating already applied to components either side of the joint and fitting.

**6.1.2** The preferred choices for the coating of the weld zone are given in Table 1.3.

**6.1.3** In all cases the choice of coating and method of application shall be agreed with the Company diagrammatic application chart is presented in Appendix B.

**TABLE 1.3 - LIST OF PREFERRED MATERIALS FOR COATING WELDED JOINTS**

TYPE	POSSIBLE COMBINATIONS OF DIFFERENT TYPES OF COATING EACH SIDE OF WELD		CHOICE OF COATING	
			1st Choice	2nd Choice
A	Fusion bonded epoxy	Fusion bonded epoxy	Fusion bonded epoxy (see IPS-G-TP-335)	Two component liquid epoxy
B	Two-component liquid epoxy (if any)	Two-component liquid epoxy (if any)	Two-component liquid epoxy (if any)	Hand applied laminated tape with 50% overlap (IPS-M-TP-314) (First choice for types F and H)
C	Fusion bonded epoxy	Two-component liquid epoxy (if any)		
D	Coal tar or bitumen enamel	Fusion bonded epoxy	Two-component liquid epoxy Overlap sealed with hand applied laminated tape (IPS-M-TP-314)	
E	Coal tar or bitumen enamel	Two-component liquid epoxy (if any)		
F	Coal tar or bitumen enamel	Coal tar or bitumen enamel		
G	Polyethylene plastic tape	Fusion bonded epoxy	Hand applied laminated  IPS-M-TP-313	Heat shrinkable tape IPS-M-TP-318 (see Note 4)
H	Coal tar or bitumen enamel	Polyethylene		
I	Polyethylene	Multi-component liquid (if any)		
J	Polyethylene	Polyethylene		

**Notes:**

- 1) Bare or painted pipe or fittings shall be coated with hand applied tape (IPS-M-TP-313) before the relevant butt joint coating is applied).
- 2) When the butt weld to be coated is on a pipeline that will operate at less than 30% (Specified Minimum Yield Strength (SMYS)) and less than 20°C, the use of joint coatings other than those detailed in this Table may be considered the specialist advise shall be taken.
- 3) Polyethylene is referred to both 2 and 3 layers polyethylene coatings.
- 4) In case where the operation temperature of the pipeline is about 80°C then a special heat shrinkable tape with multi-component liquid epoxy primer shall be used. Materials specifications shall be approved by company and the field application of materials shall be in accordance with manufacturer instructions.

## 6.2 Fittings

The choice of coating material to be applied to fittings in the field will be dependent on the type of fitting and type of coating applied to the line pipe either side of the fitting. Coating material shall be in accordance with Table 1.3.

## 6.3 Special Sections

Special sections shall be coated in the field with hand applied laminated tape system with 50% overlap (IPS-M-TP-313).

## 6.4 Valves

Buried valves shall be coated with petrolatum tape IPS-M-TP-317.

## 6.5 Holiday Detection

**6.5.1** All coating applications shall be subjected to holiday detection procedure prior to any subsequent operation to be performed on the component.

**6.5.2** 100% holiday detection of all pipe shall be carried out after joint coating operations.

**6.5.3** All holiday detection shall be carried out in accordance with the requirements of Appendix A, except where adhesive tapes are used when holiday detection shall be in accordance with the relevant supplement to IPS-C-TP-274.

## 7. COATING REPAIR

### 7.1 Methods for Removal of Coatings

When it is necessary to remove areas of coating, e.g. where flame cutting (or similar) of coated pipe is to be undertaken, the relevant method, selected from Table 2.3 shall be used.

Due care and attention should be given to the necessity for eye, ear and respiratory protection during the removal of all coatings.

### 7.2 Selection of Repair Coatings

Reference to Table 1.3 shall be made to select the material to be used for repair coatings. However the final choice of type and quality of material shall be approved by the Company.

**TABLE 2.3 - PREFERRED METHODS FOR THE REMOVAL OF COATINGS**

TYPE OF COATING	PREFERRED METHOD OF REMOVAL INDICATED BY x (SEE NOTE 1)		
	HEATING (SEE NOTE 2) AND/OR SCRAPING FOLLOWED BY BLAST CLEANING	PROLONGED BLAST CLEANING	POWER WIRE BRUSHING
Fusion bonded epoxy	×	×	×
Multi component liquid epoxy	(See Note 3)	×	
Coal tar enamel	×	×	
Polyethylene	×		
Wrapping tape	×		

**Notes:**

- 1) Any method that risks damaging the pipe is unacceptable.
- 2) The metal temperature shall not exceed 250°C.
- 3) The use of heat is prohibited since some multi-component liquids may release toxic particles or fumes.

### **7.3 Preparation for Holiday Repair**

#### **7.3.1 General**

All holidays, imperfections and damage to coatings shall receive surface preparation prior to the application of any repair material used.

#### **7.3.2 Pinholes and small areas (up to 100 mm<sup>2</sup>) of damaged coating**

**7.3.2.1** The area of the pinholes and small areas of damaged coating, together with the adjacent coatings, shall be thoroughly abraded using a coarse grade of emery paper (e.g. 100 grade) to remove all corrosion products. All loose coating shall be removed. Wire brushes may be used as an alternative to emery paper.

**7.3.2.2** All dust and corrosion products shall be removed using a clean, dry, lint free cloth.

**7.3.2.3** The surface shall be dry before application of the repair material.

#### **7.3.3 Large damaged areas (greater than 100 mm<sup>2</sup>)**

**7.3.3.1** All large damaged areas to be patch repaired shall be thoroughly cleaned by wire brush technique to remove all loosely bonded coating and to lightly abrade the sound coating around the area to be repaired for at least 10 mm from the perimeter of the exposed substrate.

**7.3.3.2** Where the metal substrate is visible, it shall be cleaned to SIS 05 59 00, Sa 2½ quality (BS 4232, 2nd quality).

**7.3.3.3** Corrosion products and dust from the cleaning operation shall be removed using clean, dry, oil free compressed air.

**7.3.3.4** The pipe surface shall be maintained in a dry condition during application of the repair material.

### **7.4 Application of Repair Materials**

#### **7.4.1 Melt stick repair materials**

Approved melt stick repair materials may only be used on small areas up to 100 mm<sup>2</sup> and then only with the agreement of Company representative.

An approved propane or butane torch shall be used to heat the area to be repaired and the heat shall be applied in a manner which avoids burning or charring the existing coating. The melts stick shall be introduced into the flame while continuing to heat the repair area. As the material melts, the stick shall be wiped onto the heated surface with a circular motion to achieve a smooth patch with a thickness equal to the base coating.

#### **7.4.2 Repairs using hand applied laminate tape materials**

**7.4.2.1** It shall only be applied to full circumferential repair areas and in accordance with the approved application instructions.

**7.4.2.2** Surface preparation as detailed in 7.3.3 shall be carried out.

**7.4.2.3** The primer, appropriate to the tape to be used, shall be applied to the clean, abraded steel surface and allowed to dry for the specified time.

**7.4.2.4** The tape shall be applied circumferentially to the pipe, utilizing a 50% overlap with a minimum of a 75 mm overlap from the periphery of the defect using a minimum of two complete turns terminating in a downward direction at the 3 o'clock position.

## **7.5 Two-Component Liquid Epoxy Coatings**

**7.5.1** Where fittings or valves have been previously coated with a multi-component liquid epoxy coating, the repair of damaged areas shall only be carried out with compatible material, the mixing and application of which shall comply with the manufacturer instructions. The area to be repaired and the sound coating to be overlapped shall be lightly abraded using wire brushing techniques.

**7.5.2** The area to be overlapped shall extend to at least 50 mm from the periphery of the defect. The repair material shall be applied to the prepared surfaces using a scraper, palette knife or wire brush as appropriate.

## **7.6 Holiday Detection After Repairs**

After repairing and curing (where required) and prior to lowering operations, all repaired areas shall be subjected to holiday detection in accordance with Appendix A.

## APPENDICES

### APPENDIX A HOLIDAY DETECTION OF COATINGS

**A.1** Holiday detection shall be carried out using equipment approved by Company on surfaces which are at ambient temperature and free from moisture.

**A.2** For all coatings (except adhesive tape) the operating voltage shall be 125 V per 25  $\mu\text{m}$  of coating thickness (e.g. 2 kV for 400  $\mu\text{m}$ ).

The rate of travel of the probe over the surface, shall be a maximum of 300 mm/s. All holidays shall be repaired.

**A.3** For fusion bonded epoxy coating systems carbon impregnated neoprene or rolling spring types of electrodes shall be used. For other coatings the splayed brush electrode may also be used, if authorized by the Company.

**A.4** The brush and carbon impregnated neoprene types of electrode shall be of the curved type, conforming to the contour of the pipe.

**A.5** All holidays, imperfections and damaged areas shall be identified with a waterproof marker.

All markings shall be sufficiently distant from the holiday, imperfection or damaged area to allow surface preparation and patching to take place without detriment to the adhesion of the coating.

**A.6** All holiday detectors shall be calibrated at the start of every work day and additionally when requested by the Company.

## APPENDIX B

### COATING OF BUTT JOINTS - MATERIAL APPLICATION CHARTS

EXISTING COATING	BUTT JOINT	EXISTING COATING	TABLE 1.3 REFERENCE
FBE	FBE	FBE	A
MCL	MCL	MCL	B
FBE	MCL	MCL	C
CTE	MCL + TAPE or H-TAPE	FBE	D
CTE	MCL + TAPE or H-TAPE	MCL	E
CTE	TAPE or H-TAPE	CTE	F
PE	TAPE or H-TAPE	FBE	G
CTE	TAPE or H-TAPE	PE	H
PE	TAPE or H-TAPE	MCL	I
PE	TAPE or H-TAPE	PE	J

Key to abbreviations and markings:

FBE	Fusion Bonded Epoxy Coating
MCL	Multi Component Liquid Coating
TAPE	Hand Applied Laminate Tape Epoxy
H-TAPE	Heat Shrinkable Tape
	Tape Wrapped Zone
CTE	Coal Tar Enamel
PE	Polyethylene

#### Notes:

Bare or painted pipe or fittings shall be coated with tape (see Note 1 g Table 1.3) before the relevant butt joint coating is applied (see 4.2 and 4.3).

## **APPENDIX C**

### **APPROVAL OF FIELD JOINT AND FITTING COATING EQUIPMENT AND APPLICATORS**

#### **C.1 Process Approval**

All processes/equipment for applying field joint coating shall be approved by the Company prior to applicator qualification trials.

#### **C.2 Field Joint Coating Applicators**

##### **C.2.1 General requirements**

Written procedures and drawings must be submitted prior to undertaking qualification trials, providing all details of the method of working and parameters to be used. These procedures must have the acceptance of the Company representative before trials commence.

##### **C.2.2 Test procedure**

Ten welded joints shall be coated under the supervision of Company representative under simulated or actual field conditions. All ten joints produced shall meet the requirements of Appendix A.

#### **C.3 Operator Qualification**

**C.3.1** All operators who carry out successfully the coating including heating when required applications shall be deemed to be qualified to carry out production work on any contract, using the same process and equipment within 12 months of completing the trial.

**C.3.2** Additional and subsequent operators shall demonstrate their ability to coat joint within the specification requirements on production work, which shall be supervised or carried out by previously qualified operators in the ratio of four skilled/two unskilled.