## MATERIAL AND CONSTRUCTION STANDARD

FOR

## THREE LAYER POLYETHYLENE COATING SYSTEM

**ORIGINAL EDITION** 

DEC. 1997

This standard specification is reviewed and updated by the relevant technical committee on Aug. 2002. The approved modifications are included in the present issue of IPS.

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## **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.

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.

## Note:

This standard specification is reviewed and updated by the relevant technical committee on Aug. 2002. The approved modifications by T.C. were sent to IPS users as amendment No. 1 by circular No. 192 on Aug. 2002. These modifications are included in the present issue of IPS.

## 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 Permitivity 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"			

<b>I?</b>	5	Dec. 1997	IPS-G-TP-335
	D 3180 G 8 G 14	"Method for Calculation Coal and Co "Test Method for Cathodic Disbandi "Test Method for Impact Resistanc Weight Test)"	ock Analysis" ng of Pipeline Coating" e of Pipeline Coating (Falling
BSI	(BRITISH STANDARI	D INSTITUTION)	
	BS 3412	"Polyethylene Materials for Moulding	and Extrusion"
	BS 4232,	"Specification for Surface Finish Painting"	of Blast-Cleaned Steel for
	2nd Quality		
DIN	(DEUTCHES INSTITU	FÜR NORMUNG)	
	DIN 30670	"Polyethylene Sheathing of steel Fittings"	Tubes and Steel Pipes and
	DIN 50049	"Materials Testing Certificates"	
	(Parts 1, 2 & 3) 1986		
	DIN 53122	"Testing of Plastics Films; Elastor Other Sheet Materials; Determination Rate; Gravimetric Method"	ner Films; Paper, Board and n of Water Vapor Transmission
	DIN 53152	"Testing of Paints, Varnishes and S Test on Paint Coating and Similar Co	imilar Coating Materials, Bend patings"
	DIN 53155	"Testing of Paints, Varnishes and S Test of Coatings According to Peters	imilar Coating Materials, Chip- "
	DIN 53380	"Testing of Plastic Films; Determina Rate"	ation of the Gas Transmission
	DIN 53455	"Testing of Plastic; Tensile Test"	
	DIN 53460	"Determination of the Vicat Thermoplastic"	Softening Temperature of
	DIN 53479	"Testing of Plastics and Elastomers;	Determination of Density"
	DIN 53495	"Testing of Plastics; Determination of	Water Absorbtion"
	DIN 53505	"Testing of Rubber, Elastomers a Testing A and D"	nd Plastics; Shore Hardness
	DIN 53735	"Testing of Plastics, Determination Thermoplastics"	of the Melt Flow Index of
	DIN 55990 T2	"Testing of Paints, Varnishes and Sir Coatings, Determination of Particle S	nilar Coating Materials-Powder ize Distribution"
	DIN 55990 T3	"Testing of Paints Varnishes and Sin Coatings, Determination of Density"	nilar Coating Materials-Powder
	DIN 55990 T8	"Testing of Paints-Varnishes and Sin Coatings Assessment of the Chemic	nilar Coating Materials, Powder al Storage Stability"
	DIN 67530	"Reflectometer as a Means for Surfaces of Paint Coatings and Plast	Glass Assessment of Plane ic"

## IEC (INTERNATIONAL ELECTROTECHNICAL COMMISSION)

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IEC 243	"Methods of Test for Electric Strength of Solid Insulating Ma	aterials

## 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"
<u>IPS-M-TP-313</u>	"Hand Applied Laminated Tape Suitable for Cold Applied Coating Systems"
<u>IPS-M-TP-314</u>	"Hand Applied Laminated Tape Suitable for Hot Applied Coating Systems"
<u>IPS-M-TP-317</u>	"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"

## 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 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 costruction 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 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 Identification of Materials

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

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

5.2.2 The material and order number.

5.2.3 The batch number.

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

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

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



## 5.2.7 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.

## 5.3 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 disbanding 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 6.1.3 inclusive that will ensure an acceptable coating. The frequency of testing shall be in accordance with Clause 11 of Part 2.

#### 6.1.2 Infrared scan

Using an approved method, an infrared 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.



### 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/cm³	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/m²	Acceptable method to company	90 g for 60 microns DFT (Dry Film Thickness)

#### Note:

#### The test for raw epoxy power properties is under the responsibility of manufacturer.

#### 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).

PROPERTY	UNIT	TEST METHOD	VALUE
1) Density	g/cm³	DIN 53479	0.900 - 0.950
2) Melting index (2.16 kg/190°C)	g/10 Min.	DIN 53735	0.5-8 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) Co monomer content	%	, ,	

TABLE 2.1 - PHYSICAL	PROPERTIES OF ADHESIVE
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#### Note:

The test for raw epoxy power properties is under the responsibility of manufacturer.

## 8. BASIC PROPERTIES AND TESTS FOR POLYETHYLENE

**8.1** Polyethylene is a thermoplastic resin for use as topcoat 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, 10 and 14 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.

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/mm²	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		ASTM D 3173 and	Pass no growth
14) 01T in 200C°	C°/min	EN 728	30 min

TABLE 3.1 - PHYSICAL PROPERTIES OF BLACK POLYETHYLENE

#### 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 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, trademark 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.

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## 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 (-0, +20) mm up to pipe size DN 500 mm (20 in.) inclusive and over a length of 150 (-0, +20) 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 (<u>IPS-C-TP-101</u>).

**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 <u>IPS-C-TP-101</u>.

**7.3** Pipes shall be blast cleaned to a minimum of Sa  $2\frac{1}{2}$  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 <u>IPS-C-TP-101</u>.

**7.4** The metal surface (RZ) 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.

#### CLAUSE REQUIREMENTS 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 guenching 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

## **TABLE 1.2 - MINIMUM QUALITY CONTROL REQUIREMENTS**

#### 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 EN 10204 and presented to the Company.



## 10.5 Test Certificates

**10.5.1** The contractor shall issue the required certificates in accordance with EN 10204 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 EN 10204.

## **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.

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

## TABLE 2.2 - MINIMUM COATING THICKNESS IN mm

**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 disbanding

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

TESTS/INSPECTION	TEST METHODS AND REQUIREMENTS
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: min 23°C 8Kg/cm
	min 80°C 2Kg/cm
<ol><li>Impact resistance</li></ol>	DIN 30670
	Acceptable limit: 5 Jul/mm
6. Elongation	DIN 30670
	Acceptable limit: Min. 200% for extruded coating.
<ol><li>Indentation (hardness)</li></ol>	DIN 30670
	Acceptable limit: 0.3 mm
<ol><li>Thermal cycle resistance</li></ol>	-30°C 1 Hr
	- 1 cycle:
	+60°C 1 Hr
	- Number of cycles: 100
	Acceptable limit: No crack.
<ol><li>Environmental stress</li></ol>	ASTM D 1693
cracking resistance	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 <sup>8</sup> $\Omega$ m <sup>2</sup> 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 dun age.

**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

The procedure for repairs of holidays and damaged areas due to destructive test should be prepare by manufacturer and approved by A.R.

#### **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.

## 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  $\mu$ m of coating thickness (e.g. 2 kV for 400  $\mu$ 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 workday 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	В
FBE	MCL	MCL	С
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	Н
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.