MATERIAL AND CONSTRUCTION STANDARD

FOR

THREE LAYER POLYETHYLENE COATING SYSTEM

ORIGINAL EDITION

DECEMBER 1997

This standard specification is reviewed and updated by the relevant technical committee on Aug. 2002(1), Feb. 2007(2) and Oct. 2013(3). The approved modifications are included in the present issue of IPS.

GENERAL REQUIREMENTS

FOREWORD

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

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

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

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

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

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GENERAL DEFINITIONS:

Throughout this Standard the following definitions shall apply.

COMPANY:

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

PURCHASER:

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

VENDOR AND SUPPLIER:

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

CONTRACTOR:

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

EXECUTOR:

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

INSPECTOR:

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

SHALL:

Is used where a provision is mandatory.

SHOULD:

Is used where a provision is advisory only.

WILL:

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

MAY:

Is used where a provision is completely discretionary.

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APPENDICES:

AMENDMENTS:

1. SCOPE

This Standard deals with factory polyolefin (PP/PE) 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 1:

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.

Note 2:

This standard specification is reviewed and updated by the relevant technical committee on Feb. 2007. The approved modifications by T.C. were sent to IPS users as amendment No. 2 by circular No. 305 on Feb. 2007. These modifications are included in the present issue of IPS.

Note 3:

This standard specification is reviewed and updated by the relevant technical committee on Oct. 2013. The approved modifications by T.C. were sent to IPS users as amendment No. 3 by circular No. 406 on Oct. 2013. These modifications are included in the present issue of IPS.

2. REFERENCES

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

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"
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,	"Specification for Surface Finish of Blast-Cleaned Steel for Painting"
2nd Quality	

DIN (DEUTCHES INSTITU FÜR NORMUNG)

DIN 30670	"Polyethylene Sheathing of steel Tubes and Steel Pipes and Fittings"
DIN 50049	"Materials Testing Certificates"
(Parts 1, 2 & 3) 1986	
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 Absorbtion"
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"

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"

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), as per IPS-E-GN-100 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 General 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 ΔH, TG1 and TG2 shall be identified by the manufacturer.

TABLE 1.1 - TYPICAL VALUES OF RAW EPOXY POWDER PROPERTIES (SEE PAGE 26)

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 polyolefin (PP/PE) 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).

TABLE 2.1 - PHYSICAL PROPERTIES OF ADHESIVE (SEE PAGE 26)

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	%		

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.

TABLE 3.1 - PHYSICAL PROPERTIES OF BLACK POLYETHYLENE (SEE PAGE 26)

PROPERTY	UNIT	TEST METHOD	VALUE
1) Density (in black)	g/cm³	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 ASTM D 3180	Pass no growth
14) 01T in 200C^{o}	C^{o}/min	EN 728	30 min

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.

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 (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 (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.

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 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.

TABLE 2.2 - MINIMUM COATING THICKNESS IN mm

PIPE DIAMETER Mm (in)	POWDER EPOXY RESIN (1ST LAYER)	ADHESIVE (2ND LAYER)	POLYETHYLENE (3RD LAYER)
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 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
5. Impact resistance	DIN 30670 Acceptable limit: 5 Jul/mm
6. Elongation	DIN 30670 Acceptable limit: Min. 200% for extruded coating.
7. Indentation (hardness)	DIN 30670 Acceptable limit: 0.3 mm
8. Thermal cycle resistance	-30°C 1 Hr - 1 cycle: +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 Ω 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 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 µm of coating thickness (e.g. 2 kV for 400 µm).

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	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.

AMENDMENTS

Tables of IPS	Instead
1.1	1
2.1	2
2.2	4
3.1	3
3.2	5,6,7

0. INTRODUCTION

This attachment is intended to be used as amendments to the Iranian petroleum standard no. IPS-G-TP-335.

All new underground steel oil, gas and water line pipes shall be coated in accordance with IPS-G-TP-335 with the following amendments.

1. TITLE OF STANDARD

Due to addition of the "3 layer polypropylene coating system" to the standard, the title modified as follows:

"Three layer polyolefin (PP/PE) polyethylene and polypropylene coating for line pipe"

2. GENERAL REQUIREMENTS

The new "general requirements" as attachment no.1 is substituted.

3. PART 1

3.1 The title modified to "requirements for coating materials"

3.2 The "scope" modified as follows: this part 1 of the standard specifies requirements of materials for use in three layer polyethylene and polypropylene coating system. It deals specifically with the properties, minimum requirements and related methods of tests to establish for use with part 2 of this standard.

3.3 The clauses 5, 6,7,8,9 and 10 to be deleted and the attachment no.2 are substituted.

4. PART 2

4.1 The title modified to "requirements for factory applied coating"

4.2 The scope modified as follows: "this part 2 of the standard specifies the operations and requirements for the factory application of materials identified in part 1, to buried and submerged steel pipes providing a finished product capable of pipe laying and operating up to 80^0c for 3 layer polyethylene and up to 110^0c for 3 layer polypropylene coating".

4.3 The clauses 6,7,8,9,11,12,13,14,15 and 18 to be deleted and the attachment no.3 is substituted .

4.4 APPENDIX A DELETED.

4.5 APPENDIX B DELETED.

4.6 APPENDIX C DELETED.

ATTACHMENT NO. 1

GENERAL REQUIREMENTS

1. SCOPE

This standard deals with plant applied 3 layer PE and 3 layer PP coatings for external surfaces of buried or submerged steel line pipes. This standard is comprised of two parts as follows:

Part 1: Requirements for coating materials

Part 2: Requirements for plant applied coatings

The coating system shall consist of three layers:

— 1st layer: Fusion Bonded Epoxy (powders sprayed)

— 2nd layer: Adhesive (powder sprayed or extruded)

— 3rd layer: PE/PP top layer (applied by extrusion**)**

The Polyethylene coating system shall be suitable for the service temperatures of -20 ℃ to +80 ℃.

The Polypropylene coating system shall be suitable for the service temperatures of -30 ℃ to 110 ℃.

2. REFERENCES

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

ISO INTERNATIONAL ORGANIZATION FOR STANDARDISATION

ISO 179 -1	Plastics: Determination of Charpy impact properties – Part 1: Non-instrumented impact test
ISO 179 -2	Plastics: Determination of Charpy impact properties – Part 2: Instrumented impact test
ISO 306	Plastics: Thermoplastic materials — Determination of Vicat softening temperature (VST))
ISO 527-2	Plastics: Determination of tensile properties — Part 2: Test conditions for moulding and extrusion plastics
ISO 527-3	Plastics: Determination of tensile properties — Part 3: Test conditions for films and sheets
ISO 868	Plastics and ebonite: Determination of indentation hardness by means of a durometer (Shore hardness*)*
ISO 1133	Plastics: Determination of the melt mass-flow rate (MFR) and the melt volume-flow rate (MVR) of thermoplastics
ISO 1183 (all parts)	Plastics: Methods for determining the density and relative density of non-cellular plastics
ISO 1872	Plastics: Polyethylene (PE) moulding and extrusion materials – Part 2: Preparation of test specimens and determination of properties
ISO 1873 –2	Plastics: Polypropylene (PP) moulding and extrusion materials – Part 2: Preparation of test specimens and determination of properties

ISO 2808	Paints and varnishes: Determination of film thickness
ISO 3146	Plastics -- Determination of melting behavior (melting temperature or melting range) of semi-crystalline polymers by capillary tube and polarizing-microscope methods
ISO 4892-2	Plastics: Methods of exposure to laboratory light sources — Part 2: Xenon-arc sources
ISO 6964	Polyolefin pipes and fittings: Determination of carbon black content by calcinations and pyrolysis; test method and basic specification
ISO 8130 (all parts)	Coating Powders
ISO 8501 (all parts)	Preparation of steel substrates before application of paints and related products — Visual assessment of surface cleanliness
ISO 8502 – 3	Preparation of steel substrates before application of paints and related products – test for the assessment of surface cleanliness – Part 3: Assessment of dust on steel surfaces prepared for painting (pressure sensitive tape method)
ISO 8502 – 9	Preparation of steel substrates before application of paints and related products – test for the assessment of surface cleanliness – Part 9: Field method for the conduct metric determination of water –soluble salts
ISO 8503 (all parts)	Preparation of steel substrates before application of paints and related products — Surface roughness characteristics of blast-cleaned steel substrates
ISO 8504-2	Preparation of steel substrates before application of paints and related products -- Surface preparation methods -- Part 2: Abrasive blast-cleaning
ISO 10474	Steel and steel products - Inspection documents
ISO 11124 (all parts)	Preparation of steel substrates before application of paints and related products – specification for metallic blast-cleaning abrasives
ISO 11125 (all parts)	Preparation of steel substrates before application of paints and related products -- Test methods for metallic blast-cleaning abrasives
ISO 11126	Preparation of steel substrates before application of paints and related products – Specification for non –metallic blast cleaning abrasives
ISO 11127 – 6	Preparation of steel substrates before application of paints and related products –Test methods for non –metallic blast cleaning abrasives – Part 6: Determination of water –soluble contaminants by conductivity measurement
ISO 11357 (all parts)	Plastics: Differential scanning calorimetric (DSC) — Part 2: Determination of glass transition temperature
ISO 18533	Method for the assessment of the degree of pigment or carbon black dispersion in polyolefin pipes, fittings and compounds
ISO 15512	Plastics: Determination of water content
ISO 21809-1	petroleum and natural gas industries-External coatings for buried or submerged pipelines used in pipelines transportation systems-part 1:poly olefin coatings (3 layer PE and 3 layer PP)

ASTM AMERICAN SOCIETY FOR TESTING AND MATERIALS

ASTM D257	Test Methods for DC Resistance or Conductance of Insulating Materials
ASTM D 870	Standard Practices for Testing Water Resistance of Coatings Using Water Immersion
ASTM D 1603	Test Method for Carbon Black in Olefin Plastic
ASTM D 1693	Standard Test Method for Environmental Stress-Cracking of Ethylene Plastics
ASTM E 29-02	Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications
ASTM D 4940	Standard Test method for conductimetric analysis of water soluble ionic contamination of blasting abrasives.

CSA CANADIAN STANDARD ASSOCIATION

CSA Z245.20	External Fusion Bonded Epoxy Coating for Steel Pipe

NF FRENCH STANDARD

NF A 49-710	Steel Tubes-Three-Layer External Coating Based on Polyethylene - Application by Extrusion

EN EUROPEAN STANDARD

EN 728	Plastics Piping Systems - Polyolefin Pipes and Fittings - Determination of Oxidation Induction Time
EN 10204	Metallic Products - Types of Inspection Documents

SSPC SOCIETY OF PROTECTIVE COATINGS

SSPC SP1	“Solvent Cleaning”

DIN (DEUTCHES INSTITU FÜR NORMUNG)

DIN 30670	Polyethylene Sheathing of Steel Tubes and Steel Pipes and Fittings
DIN 30678	Polypropylene Coatings for Steel Pipes

3. DEFINITIONS AND TERMINOLOGY

Application Procedure Specification (APS)

Document describing procedures, methods, equipment and tools to be used for coating application.

Batch

Quantity of material produced in a continuous manufacturing operation using raw materials of the same source and grade.

Batch Certificate

Certificate of analysis issued by the manufacturer.

Certificate of Compliance

One of the types of documents defined by ISO 10474 to be issued in accordance with the purchasing requirements.

Contractor (applicator)

Company which undertakes the coating application in accordance with the provisions of this standard specification.

Cut-back

Length of pipe left uncoated at each end for joining purposes (e.g. welding).

Design Temperature Range

Temperature range including maximum and minimum temperature likely to be reached during transport, handling, installation and operation.

End User

Company operating the pipeline system.

Holiday

Coating discontinuity that exhibits electrical conductivity when exposed to a specific voltage.

Inspection and Testing Plan (ITP)

Document providing an overview of the sequence of inspections and tests, including appropriate resources and procedures Symbols and abbreviated terms.

Manufacturer

Company responsible for the manufacture of coating material(s).

Manufacturer's Specification

Document which specifies the characteristics, test requirements and application recommendations for the coating materials.

Operating Temperature

Temperature experienced by the pipe or pipeline system during operation which should not exceed the design temperature.

Pipeline

Those facilities through which fluids are conveyed, including pipe, pig traps, components and appurtenances, up to and including the isolating valves.

Pipeline System

Pipeline with compressor or pump stations, pressure control stations, flow control stations, metering, tankage, supervisory control and data acquisition system (SCADA), safety systems, corrosion protection systems, and any other equipment, facility or building used in the transportation of fluids.

Procedure Qualification Trial (PQT)

Application of a coating and subsequent inspection/testing of its properties to confirm that the APS is adequate to produce coating of specified properties.

Purchaser

Company responsible for providing the product order requirements.

Test Report

Document that provides the quantitative test results for tests conducted in accordance with the requirements of this standard specification.

Symbols:

ΔT_g : Variation of the Glass Transition Temperature (T_{g2} - T_{g1}) in °C

Tg : Glass Transition Temperature in °C

T_{Max} : Maximum Operating Temperature

Abbreviations:

DSC	**Differential Scanning Calorimetry**
ESCR	**Environmental Stress Cracking Resistance**
FBE	**Fusion Bonded Epoxy**
HDPE	**High Density Polyethylene**
MFR	**Melt Flow Rate**
PE	**Polyethylene**
PP	**Polypropylene**
SAW	**Submerged Arc Welding**
3LPE	**Three Layer Polyethylene Coating**
3LPP	**ThreeLayer Polypropylene Coating**

4. UNITS

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

ATTACHMENT NO.2

REQUIREMENTS FOR COATING MATERIALS

1. MATERIAL APPROVAL

1.1 The coating materials within the three-layer coating system shall be approved by company before application. The polymeric adhesive and polyolefin compound shall be supplied by the same coating materials manufacturer.

1.2 The manufacturer shall qualify each type of coating material in compliance with the requirements of this part of standard. The qualification shall be repeated in case of changes in the material composition, changes in the production process which influence the material processing behaviour and change in production facility.

1.3 The supplier shall obtain from the coating material manufacturer technical data sheets showing, at least, the properties described in Table 1, Table 2 and Table 3.

1.4 A certificate of analysis (COA) should be issued by the manufacturer of each component. The manufacturer shall supply an inspection certificate for each batch.

1.5 Each batch of all coating materials shall be accompanied by a certificate of analysis (COA) according to EN 10204, 3.1.B stating that all the tests have been carried out and results are in accordance with the manufacturer's product specifications and requirements of Table 1, Table 2 and Table 3.

2. COATING MATERIAL

2.1 Epoxy Material

The applicator shall use epoxy material that is in compliance with Table 1.

TABLE 1- REQUIREMENTS FOR THE FBE POWDER PRIMER

No.	Properties	Units	Requirements	Test Method
1	Density	g/cm^3	As per manufacturer's specification ±0.05	ISO 8130-2
2	Gel time	Sec	Within 20% of manufacturer's specification	ISO 8130-6
3	Particle size: Maximum powder retained on 150 µm mesh Maximum powder retained on 250 µm mesh	%	 3.0 0.2	CSA Z 245.20-02
4	Specific coating resistance after 100 days of exposure in 3% NaCl solution @ 23^oC	Ohm.m	$>10^8$	NF A 49-710
5	3.0°flexibility test @ 23^oC, 0^oC & -20^oC		No cracking	CSA Z 245.20-02
6	Cathodic disbondment after 28 days@ 65^oC in 3% NaCl solution at -1.5 volts (calomel electrode) potential, initial defect diameter Do=6 mm	Mm	7 (max.)	NF A 49-710
7	Moisture content (max.)	% by mass	0.5	ISO 21809-1 (Annex K)
8	Degree of cure (differential thermal analysis)	^oC	$-2^oC \leq \Delta Tg \leq +3^oC$	ISO 21809-1 (Annex D)
9	Glass transition temperature (Tg_2) (DSC Analysis)	^oC	≥95 (for 3LPE) ≥120 (for 3LPP)	ISO 21809-1 (Annex D)
10	Water resistance (1000 hrs @ 80 ^oC)	-	No blistering, swelling < 5%, loss of hardness <10%	ASTM D 870
11	Adhesion to pipe surface	-	Max. rating 2	CSA Z 245.20-02

Notes:

1- **The epoxy powder should not contain any calcium carbonate.**
2- **Determination of the particle size by MALVERN instrument instead of sieving method is acceptable.**

2.2 Adhesive Material

The applicator shall use adhesive material that is in compliance with Table 2.

TABLE 2 – REQUIREMENTS FOR THE ADHESIVE MATERIAL (CO-POLYMERIC OR GRAFTED ADHESIVE IN PELLET OR POWDER FORM)

No.	Properties	units	Requirement		Test Method
			PE	PP	
1	Density	Kg/m^3	Within 1% of Manufacturer's specified nominal		ISO 1183
2	Melt Flow Rate (190°C, 2.16 Kg)	g/10min	Within 20% of manufacturer's specified nominal		ISO 1133
3	Oxidation induction time @ 210°C	Minutes	≥ 20	≥ 20	EN 728 ISO 11357
4	Tensile strength at break @ 23°C	MPa	≥ 15	≥ 20	ISO 527
5	Ultimate elongation 2 23°C	%	≥ 600	≥ 400	ASTM D 638 ISO 527
6	Hardness	Shore D	≥ 47	≥ 55	ISO 868
7	Melting point (D.S.C)	°C	≥ 120	≥ 160	ISO 3146
8	Vicat softeninig temperature A/50 (10 N)	°C	≥ 95	135	ISO 306
9	Water content (Max.)	%	0.1	0.1	ISO 15512

2.3 Polyolefin (HDPE/PP) Top Coat Material

The applicator shall use PE/PP material that is in compliance with Table 3.

TABLE 3 - MINIMUM REQUIREMENTS FOR POLYETHYLENE AND POLYPROPYLENE TOP COAT

No.	Properties	Units	Requirement		Test method
			HDPE	PP	
1	Density, compound	g/cm^3	≥ 0.946	≥ 0.09	ISO 1183
2	Melt flow rate	g/10 min.	0.15-0.8 (190 °C,2.16 Kg)	0.5-4 (230°C,2.16 Kg)	ISO 1133
3	Oxidation induction time	Minutes	≥ 30 @210 °C	≥ 30 @220 °C	EN 728
4	Tensile strength at break @ 23°C	MPa	≥ 18	≥ 24	ISO 527
5	Carbon black content	%	2.0-2.5	-	ASTM D 1603 ISO 6964
6	Elongation at break @ 23°C	%	≥ 600	≥ 400	ISO 527
7	Hardness	Shore D	≥ 55	≥ 60	ISO 868
8	Melting point	°C	≥ 125	≥ 160	ISO 3146
9	Vicat softening temperature A50/(10N)	°C	≥ 120	≥ 140	ISO 306
10	ESCR	Hour	≥ 1000	N.A	ASTM D 1693 (Condition B)
11	Volume resistivity	Ohm.cm	$\geq 10^{16}$	$\geq 10^{16}$	ASTM D 257
12	Water content	%	≤ 0.05	≤ 0.05	ISO 15512
13	UV resistance and thermal ageing	%	Δ MFR ≤ 35	Δ MFR ≤ 35	ISO 21809-1 (Annex G)

ATTACHMENT NO.3

REQUIREMENTS FOR FACTORY APPLIED COATINGS

1. COATING SYSTEM QUALIFICATION

1.1 Each coating system shall be qualified by the applicator to meet the requirements of Table 5. Qualification shall be carried out separately for each coating line.

The applicator shall apply coating materials qualified in accordance with the requirements of 1.2.

Qualification shall be repeated in case of modifications to the coating line, coating materials or application procedures.

1.2 Application Procedure Specification

Prior to the start of coating production and any specified PQT, the applicator shall prepare an APS, including:

- Incoming inspection of pipes and pipe tracking
- Data sheets for coating materials, including any materials to be used for coating repairs
- Data sheets for abrasive blasting materials
- Certification, receipt, handling and storage of materials for coating and abrasive blasting
- Preparation of the steel surface including control of environmental parameters, methods and tools for inspection and testing of surface preparation
- Coating application, including tools/equipment for control of process parameters essential for the quality of the coating
- Lay-out sketch or flow diagram for the coating plant
- Methods and tools/equipment for inspection and testing of the applied coating
- Repairs of coating defects and any associated inspection and testing
- Stripping of defective coating
- Preparation of coating cutback areas
- Marking and traceability
- Handling and storage of pipes
- Any special conditions for dispatch of coated pipes including protection of pipe ends
- Documentation
- The APS shall cover all items associated with quality control as defined in this part of standard.

The APS shall be approved by the purchaser prior to the start of production. It shall be available to the purchaser's inspector(s) on request at any time during production. Coating work and associated inspection and testing shall be carried out in accordance with the APS.

2. COATING SYSTEM APPLICATION

2.1 Surface Preparation

Prior to commencement of grit blast cleaning the steel shall be checked for freedom from grease or other such contamination and shall be cleaned if such contamination is found as per SSPC SP1. Chemical cleaning and remaining detergents shall be removed.

Grit blast cleaning shall be carried out by machine as per ISO 8504 part 2, to a cleanliness standard of Sa 2½ in accordance with ISO 8501/1.

The abrasive used shall be steel or chilled shot and iron grit conforming to ISO 11124 parts 1-4. Abrasive material that becomes worn or dirty shall be replaced with frequent small additions of new grit. Infrequent large addition shall be avoided. The compressed air for blasting shall be free of water and oil. Adequate separators, filters or traps shall be provided. Supplier shall submit for approval a procedure to periodically verify re-cycled grit quality in accordance with ISO 11125 parts 1-7.

The surface profile shall be within the range Rz 60 to 100 microns and shall be measured according to ISO 8503/4 (measured with 2.5 mm cut off) or using replica tape system. Surface profile shall be checked at a frequency of once every hour. The value shall be recorded in the in the inspection report.

The steel surface shall be 100% visually inspected immediately after blast cleaning and all defects shall be removed by filling/grinding. The blast cleaned surface shall not be contaminated with dust, metal particles, hydrocarbons, water, etc. or foreign matters which could be detrimental to the applied coating. Test for dust contamination shall be carried out in accordance with ISO 8502/3. Requirements for dust contamination shall be class 2 maximum. The coating process shall commence after completion of blast cleaning of the steel surface. The total elapsed time between the start of blasting of any line pipe and the heating to the specified temperature shall not exceed the following time-humidity table:

Relative humidity (R.H)	Maximum elapsed time
R.H.>80%	2 hours
70%<R.H.≤80%	3 hours
R.H. ≤70%	4 hours

Any pipe surface not processed within the above time-humidity table shall be completely re-blasted before coating.

Note:
In order to avoid risk of condensation, temperature of environment and/or steel surface must be 3°C higher than the dew point.

2.2 Chemical Pretreatment

After blast cleaning and before application of the epoxy primer, Soluble salts (Chloride contamination) on the steel surface shall be checked using an approved salt detector instrument measuring conductivity, SCM400 or equivalent. Soluble salt content shall not excess 2 micrograms/cm^2. Line pipes with Chloride contamination in exceed of 2 micrograms/cm^2 shall be subject to chemical pretreatment using an approved Phosphoric acid solution.
The surface to be coated shall be heated to a temperature of 45° - 65°C, and treated with a low pressure (0.5 – 2.0 bar) spray application of a max. 10% v/v solution of an approved acid washing material and process. A uniform PH of 1 or less shall be maintained over the entire surface of the treated area. The acid washed pipe surface shall remain wetted for approximately 20 seconds (15 – 30) and then rinsed with clean potable water, before its starts to dry out.
High-pressure water rinses at 700-1000 psi (50-70 bar) shall be used to remove any treatment residue. The wetted surface of the rinsed pipe shall have a PH of 6 or greater.
Water must be clean with less than 200 ppm total dissolved solids and <50 ppm chlorides, and a conductivity of <100 microns Siemens. The water shall not be reused.
The chloride level shall be retested.

2.3 Chromate Pretreatment

The Contractor shall ensure that the temperature of the substrate is maintained between 45 -60°C and Chromate solution temperature does not exceed 45°C.
The diluted solution of Chromate (typically 10% v/v in clean potable water as in 2.2 above) shall be applied to the blast-cleaned steel surface by a suitable method that results in a completely wetted

surface with a uniform film of Chromate solution remaining on the surface. Any drainage concentration, drips, etc. shall be removed by wiping or other suitable means.
The Contractor shall be fully responsible for adherence to local regulations and material safety sheets for using chromate solution.

2.4 Coating Application

2.4.1 Pre-Application heating

The pipe shall be uniformly heated in accordance with the manufacturer's specified temperature limits, but shall not exceed 270°C.
The surface temperature of the pipe immediately prior to epoxy powder application shall be monitored and controlled within the limits recommended by the powder manufacturer.
The temperature control shall be in accordance with the description in paragraph 1.4.2.
Oxidation of the steel prior to coating in the form of "blueing" or other apparent oxide formation is not acceptable. If such oxidation occurs, the pipe shall be set aside and re-cleaned.

2.4.2 FBE layer Coating

The coating shall be applied to the pipe surface by electrostatic spray with the pipe at earth potential and the epoxy powder charged to high potential.
Pipe temperature shall be checked and recorded periodically by Tempil sticks (3-6 times per pipe joint) or a recording Pyrometer.
If a Pyrometer is used, it shall be checked for error not less that every four hours against a calibrated temperature measuring instrument.
Prior to starting the FBE powder application, the recovery system shall be thoroughly cleaned to remove any unused powder.
Recycled powder is permitted only when collected and processed through a closed system, which controls the ratio of recycled to virgin powder. The ratio of recycled powder to virgin powder shall not exceed 20%.
When coating application on a pipe length is discontinuous, the pipe shall be rejected, stripped of its coating and prepared for recoating.
The minimum thickness of the FBE layer at any point shall be 200µm.

2.4.3 Adhesive layer coating

The contractor shall ensure that the rollers push adhesive film to eliminate any air entrapment or voids. The adhesive layer shall be applied before gel time of the FBE has expired by using either the Cross-head or Side extrusion technique. Application of the adhesive shall not be permitted after the FBE has fully cured. The Contractor shall establish to the satisfaction of purchaser's representative that the adhesive is applied within the gel time window of the FBE and at the temperature specified by the FBE manufacturer. The Contractor shall state the proposed minimum and maximum time interval between FBE and adhesive applications at the pipe temperature range and overlap.
The minimum thickness of the adhesive shall be 150µm and in accordance with the coating material manufacturer's recommendations.

2.4.4 High density polyethylene/polypropylene top layer coating.

The H.D.PE/PP shall be applied over the adhesive immediately after the adhesive layer. The extrusion process shall be controlled such that no air is trapped between the adhesive and polyethylene/Polypropylene layer or internally within the polyethylene/Polypropylene. The tension applied to the polyethylene/Polypropylene layer shall be kept at a minimum level to prevent additional stresses being built into top coat.
The polyethylene/Polypropylene top coat shall be applied to have a minimum three-layer coating total thickness as specified in table 4.

TABLE 4 - MINIMUM TOTAL COATING THICKNESS

Pipe Diameter Mm (in)	Powder Epoxy Resin (1st layer) mm (µm)	Adhesive (2nd layer) mm (µm)	Total Thickness, mm	
			3LPE	3LPP
Up to DN 500 (20)	0.2 (200)	0.15 (150)	2.5	2.5
DN 500 (20) up to DN 900 (36)	0.2 (200)	0.15 (150)	3.0	2.5
> DN 900 (36)	0.2 (200)	0.15 (150)	3.5	3

2.4.5 Cut Back

Coating shall be removed (Cut back) from the pipe ends.
The amount of cut back required for different pipe diameter shall be as follow:
For pipe sizes up to 20 inches: 100 mm.
For pipe sizes 20 inches and larger: 150 mm.
Cut back includes full removal of both Polyethylene/Polypropylene and of the adhesive; the Epoxy primer shall be left to a minimum distance of 10 mm from the edge of the PE cutback.
The Cut back end shall be tapered to an angle of 30 degrees (max.) to the metal surface. This taper of the coating shall be achieved preferably using rotating metal brushes, and shall not in any way cause cuts on the metal and lifting or disbanding of the tapered part. A butyl primer shall be applied by brush, sealing the tapered part and the nearby metal zone for a length of about 20 mm.
The pipe bar ends shall be properly cleaned and shall be free from fabrication residues.
A temporary protective agent (Varnish) shall be applied to pipe bare ends (Cut back), and shall be easily removable by brushing.

Note:
The increased cut back length up to 30 Cm. on maximum 2% of coated line pipes may be Acceptable, subject to the purchaser's approval. In this case, the applicator shall Supply the suitable size and quantities of Heat Shrinkable sleeve and relevant accessories.

3- Quality Control Requirements

The minimum tests to be carried out and the frequencies in qualification (pre-production) and production stages are specified in table 6 and table 7. All tests listed in table 6 and table 7 shall be addressed in the APS.

TABLE 5 - PROPERTIES OF THE APPLIED COATING

Properties	Unit	Test Method	3LPE	3LPP
Appearance and continuity	-	ISO 21809-1 (Annex B)	Uniform colour, free of defects and discontinuities, delaminations, separations and holidays.	
impact strength at 23 ± ℃ e	J/mm	ISO 21809-1 (Annex E)	>7	>10
Indentation resistance At 23 ± 2℃ e at maximum class temperature	mm	ISO 21809-1 (Annex F)	≤0,2 ≤0,4	≤0,1 ≤0,4
Elongation at break at 23± 2℃ e	%	ISO 527	≥400%	≥400%
Peel strength	N/mm	ISO 21809-1 (Annex C)	≥15 at 23℃ ≥3 at 80℃	≥25 at 23℃ ≥4 at 90℃ or at maximum operating temperature if above 90℃
Degree of cure of the epoxy	℃	ISO 21809-1 (Annex D)	-2℃ ≤ Δ T_g :≤3℃	
Product stability during extrusion of the PE/PP top layer process	%	ISO 1133	≤ 20% Δ MFR for 3LPE ≤ 35% Δ MFR for 3LPP (virgin compounded granulate before extrusion/extruded foil after extrusion of the same batch)	
Flexibility at 0℃	-	ISO 21809-1 (Annex I)	No cracking at 2.5°/ pipe diameter length	
UV Resistance and Thermal ageing	%	ISO 21809-1 (Annex G)	Max. ±35% change of MFI	
Porosity (Air entrapment)	-	See 4.5	No voids or air entrapment	
Average radius of cathodic disbondment at: 23℃/28 days; -1,5 V 65℃/48h; -1,5 V Maximum operation Temperature/28days/1.5 V	mm	ISO 21809-1 (Annex H)	≤7 ≤7 ≤15	
Specific Electrical Insulation Resistance	$\Omega.m^2$	DIN 30670 DIN 30678	$\geq 10^{10}$	

TABLE 6 - REQUIREMENTS FOR INSPECTION OF SURFACE PREPARATION

Properties	Test Method	Requirement	Frequency Qualification	Frequency Production
Surface condition before blasting	Visual inspection	free of contaminations	each pipe	each pipe
Surface condition after blasting	Conductive measurement, ISO 8502-9	salt content max. 20 mg/m^2	each pipe	5 pipes at start of production and 1 pipe/shift
Environmental conditions	Calculation	as determined at time of measurement	once	every 4 h
Pipe temperature before blasting	thermocouple	Minimum 3°C above the dew point	once	every 4 h
shape and properties of abrasive	Visual + Certification ISO 11124 resp. ISO 11126	conformity to certificate, compliance to manufacturing/ working procedures	once	1/shift
Water soluble contamination of abrasives	ASTM 4940	Conductivity max. 60 mS/cm	once	1/shift
Surface roughness of blasted surface (R_z)	ISO 8503-4	60 mm to 100 mm	5 pipes	every 1 h
Visual inspection of blasted surface	ISO 8501-1	grade Sa 2 ½	each pipe	each pipe
Presence of dust after dust removal	ISO 8502-3	Max. class 2	5 pipes	every 1 h
Chromate Solution Temperature	thermometer	<45°C	once	Once per shift
Chromate Concentration (Titration test) and uniformity/color appearance	-	As per manufacturer's instructions	once	Once per shift
Pipe condition prior to coating	monitoring	no rust, pipe temperature at least 3°C above the dew point	continuously	continuously
Temperature of extruded adhesive and polyolefin	thermometer	compliance to APS	once	every 1/h
Preheating temperature before coating	thermometer	compliance to APS	each pipe	every 5^{th} pipe

TABLE 7- REQUIREMENTS FOR INSPECTION AND TESTING OF APPLIED COATING

Properties	Test Method	Requirement	Frequency Qualification	Frequency Production
Minimum epoxy thickness	ISO 2808	200 mm	at start up	once per shift
Minimum adhesive thickness	ISO 2808	150 mm on pipe body	at start up	once per shift
Degree of cure of the Epoxy	ISO 21809-1 (Annex D) ISO 11357-2	$-2°C \leq \Delta T_g \leq +3°C$	at start up	once per shift
Appearance	Visual	Uniform colour, free of defects and discontinuities, declamations and separations	continuously	continuously
Holiday detection	ISO 21809-1 (Annex B)	No holidays at 25 Kv.	each pipe	each pipe
Total thickness of coating	ISO 21809-1 (Annex A)	Table 4	5 pipe	every 10 pipes
Impact resistance	ISO 21809-1 (Annex E)	Table 5	3 pipe	once per PE/PP batch
Peel strength @ 23°C @ T_{max} [a)]	ISO 21809-1 (Annex C)	Table 5	5 pipe 3 pipe	every 4 h once per 100 pipe
Indentation resistance @ 23°C @ T_{max}	ISO 21809-1 (Annex F)	Table 5	once	once per PE/PP batch
Elongation at break	ISO 527	Table 5	once	once per PE/PP batch
Cathodic disbondment test @ 23°C/28 days/-1.5V @ 65°C/2 days/-1.5V @ 80°C/28 days/-1.5V	ISO 21809-1 (Annex H)	Table 5	once once -	once per 4000 pipe once per week once per order
Flexibility	ISO 21809-1 (Annex I)	Table 7	once	-
Residual magnetism	See 4.1	Average: 25gauss Max: 30 gauss	each pipe	each pipe
In process degradation of PE/PP	ISO 1133	Δ MFR max. 35% for PP; 20% for PE between raw and extruded material	once	once per PE/PP batch
Thermal cycle resistance 1 cycle: -30°C/1 hr 1 cycle: +70°C/1 hr No. of cycles: 100	-	See Note "b" below	No crack	Thermal cycle resistance 1 cycle: -30°C/1 hr 1 cycle: +70°C/1 hr No. of cycles: 100
Porosity (Air entrapment)	See 4.5	No voids or air entrapment	5 pipes	every 4 h
Bonding of coating on longitudinal weld	See 4.4	No voids or air entrapment	Once	Once per week
Hot water soak test (for FBE) hours @ 80°C	See 4.3	No disbondment or blistering	2 pipes	Once per FBE batch
Adhesion of FBE	See 4.2	Refusal to peel or a cohesive failure	2 pipes	Once per FBE batch
Specific Electrical Insulation Resistance	DIN 30670 DIN 30678	$\geq 10^{10}\ \Omega.m^2$	Once	Once per PE/PP batch
UV Resistance and Thermal ageing	ISO 21809-1 (Annex G)	Max. ±35% change of MFI	Once	Once per PE/PP batch
Cutback	Measuring	100 ±5 mm up to 20" 150 ±10 mm ≥20"	each pipe	each pipe
Coating repairs	Visual/Holiday detection (see clause 6)	no holidays	once for demonstration	each defect

Notes:
a) For peel testing at T_{max}' a sample of coated pipe shall be conditioned (or heating the internal surface of the pipe at test location) for at least one hour at the test temperature. The surface temperature shall be monitored during the test and the results reported.

The test sections shall be notched with a length of 30 mm and a depth of 0.3 mm and then Tested.

4. Some Test Procedures

4.1 Residual Magnetism

Measurements shall be made using a Hall-effect gaussmeter or other type of calibrated instrument approved by Coater. The gaussmeter shall be operated according to the Manufacturer's instructions. The accuracy shall be verified at least once per day.

Four readings 90° apart shall be taken around the circumference of each end of the line pipe. The average of the four readings shall not exceed 25 gauss and no single reading shall exceed 30 gauss with a Hall-effect gaussmeter, or equivalent values with other types of Coater approved instrument.

Coater shall submit for approval a procedure to verify the residual magnetism on the line pipe.

Any line pipe that does not meet the above requirements shall be considered defective. All defective line pipes shall be degaussed and re-measured, or segregated.

4.2 Adhesion of FBE Primer

The adhesion test for FBE primer shall be carried out on dummy pipes in accordance with the following procedure. The acceptance criteria shall be rating 1-2.

Inscribe a V-cut with two 20 mm lines intersecting at approximately 5 mm from their ends at 30° to 45°.

Insert the blade of the knife (strong pointed type) at the point of the V-cut, 45° to the surface. Then with an upward flicking action attempt to dislodge the coating within the V. If little or no coating is removed, repeat this action within the 'V' at least 4 times to confirm the integrity of the coating.

4.3 Hot Water Soak Test (For FBE Primer)

An adhesion test as detailed below shall be carried out on two pipes coated with FBE layer only.

A coated sample of 200mm × 100mm machined from a pipe ring of the coated pipe shall be immersed in tap water of 800C for 24 hours.

The bare edges of the sample shall be coated to prevent ingress of moisture beneath the coating.

Directly after 24 hours exposure, the coated sample shall be removed and allowed to cool to ambient temperature. Subsequently the coating adhesion shall be tested by the following method:

Using a sharp and pointed knife, two incisions of approximately 15mm in length shall be made through to the steel surface to form an "X" with an angle of intersection of approximately 30 degrees. Commencing at the intersection, an attempt shall be made to lift the coating from the steel substrate using the bland of the knife.

Refuse of the coating to peel or a cohesive failure entirely within the coating in the absence of excessive voids caused by foaming constitutes a pass. Partial or complete adhesion failure between the coating and the metal substrate constitutes a failure.

Cohesive failure caused by voids in the coating leaving a honeycomb structure on the steel surface also constitutes a failed condition.

In addition, the coating shall not show any tendency towards disbanding or blistering. A slight discolouration of the coating is acceptable.

4.4 Bonding of the Coating on Longitudinal Weld

The coating application process shall be such as to ensure a fully satisfactory interlayer bonding at all parts of the circumference of the line pipe. This shall in particular apply to the longitudinal weld and the region adjacent to the edges of the final weld cap. Voids and interlayer bond checks shall be verified by means of peeling tests or partial stripping of coating along the longitudinal weld.

Void or air entrapments at any location, including alongside the weld, shall not be allowed.

4.5 Porosity (Air Entrapment) Test

After adhesion (peeling) test all the peeled strips of coating shall be examined for porosity (air entrapment) according to the Annex A. No air entrapment shall be allowed.

5. RE-TEST

In case of failure of any required test, the Coater shall test two additional pipes, one pipe before and after the failed one. If the follow-up tests are successful, all pipe coated since the last acceptable test shall be considered acceptable except for the failed pipe that will be rejected.

If the follow-up tests also fail to meet the requirements of this specification, all pipes coated since the last acceptable test shall be rejected.

6. REPAIR OF COATING DAMAGE

All defects detected by holiday detector and damaged coating areas less than 50cm^2 resulting from destructive testing or mechanical accidents shall be repaired at the Applicator's expence according to the following:

If one individual damaged area is greater than 50cm^2, the pipe shall be rejected, stripped, cleaned and re-coated.

A maximum of three repairs per line pipe is allowed, but in no case the total repaired areas shall exceed 100cm^2.

A maximum of 2% of damaged line pipes is allowed. In case the amount of damaged line pipes will be greater than the above stated percentage, Applicator shall perform immediate corrective actions.

Damages on polyethylene Top Coat layer not decreasing the total coating thickness as per Table 4 shall not be repaired.

All the repaired areas shall be subjected to the following check and acceptance criteria:

Visual inspection on 100% of repairs

holiday detection test on 100% of repairs

thickness test on 100% of repairs

All the repairs carried out on defects with exposed steel, shall be recorded by the Applicator.

Recording shall include:

line pipe No.;

dimension of any damage;

results of checks.

The Applicator shall prepare detailed coating repair procedure, including all types of expected defects, and coating stripping procedure for line pipes. Coating repair and stripping procedures shall be both approved and qualified by Purchaser before start of production.

Annex A: Porosity (Air Entrapment) test

1. SCOPE

Determining the presence of air entrapment (porosity or bubbles) in the plant applied coating.

2. EQUIPMENT

Microscope – Hand Held 30X.

Utility knife.

3. TEST SPECIMEN

Strips from adhesive (peeling) tests of coated line pipe shall be used to determine the air entrapment.

4. PROCEDURE

Adhesion (peeling) strip shall be viewed from the side and the failure interface. At the line pipe adhesion (peeling) test site use a utility knife to cut the edge of the coating to a 45° angle and view with a microscope.

Perform a similar test in the cutback area. This should be used for information to determine if further testing is required.

5. REPORTING

Report line pipe number, date pipe was coated, coating batch number, and date of test.

Report cross-section and interface air entrapment (if any).