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امورتدوین استانداردها

IGS

پوشش FBE دولایه برای سطوح خارجی خطوط لوله گازطبیعی

External Dual Layer Fusion Bonded Epoxy Coating for Line Pipe

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دفترمدیرعامل

شرکت ملی گازایران

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ابلاغ مصوبه هیأت مدیره

مدیر محترم پژوهش و فناوری و رئیس شورای استاندارد

باسلام،

به استحضار می رساند در جلسه ۱۵۱۳ مورخ ۱۳۹۱/٦/۱۲ هیأت مدیره، نامه شماره گ۹/۰۰۰/۷٦٤٦۹ مورخ ۱۳۹۱/٦/٤ آن مدیریت در مورد تصویب نهایی استاندارد تحت عنوان " مشخصات استاندارد پوشش FBE دو لایه برای سطوح خارجی خطوط لوله گاز طبیعی به شماره تقاضای(0)IGS-M-TP-026 "مطرح و مورد تصویب قرار گرفت.

این مصوبه در حکم مصوبه مجمع عمومی شرکتهای تابعه محسوب و برای کلیه شرکتهای تابعه لازم الاجراء می باشد.

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FOREWORD

This standard is intended to be mainly used by NIGC and Applicator s and has been prepared on interpretation recognized standards, technical documents, knowledge, backgrounds and experiences in gas industries at national and international levels.
Iranian gas standards (IGS) are prepared, reviewed and amended by technical standard committees within NIGC Standardization division and submitted to the NIGC's "STANDARDS COUNCIL" for approval.
IGS Standards are subject to revision, amendment or withdrawal, if required, thus the latest edition of IGS shall be checked/inquired by NIGC users.
This standard must not be modified or altered by the end users within NIGC and her Applicators. Any deviation from normative references and / or well known manufacturers specifications must be reported to Standardization division.
Any comments from concerned parties on NIGC distributed IGS are welcome to technical standards committees and will receive serious attention and consideration should a revision to standards is recommended .

GENERAL DEFINITIONS :

Throughout this standard the following definitions, where applicable, should be followed:
1- "STANDARDIZATION DIV." has been organized to deal with all aspects of industrial standards in NIGC. Therefore, all queries for clarification or amendments are requested to be directed to mentioned div.
2- "COMPANY" : refers to national Iranian gas company .
3- "SUPPLIER" : refers to a firm who will supply the service , equipment or material to IGS specification whether as the prime producer or manufacturer or a trading firm .
4- "SHALL " : is used where a provision is mandatory .
5- "SHOULD" : is used where a provision is advised only .
6- "MAY" : is used where a provision is completely discretionary .

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1. SCOPE

This standard specification specifies the NIGC minimum requirements for materials, qualification, application, testing, inspection, repair and handling of plant-applied dual layer fusion bonded epoxy (FBE) coating to the external surface of high pressure gas transmission pipeline systems, pipe joints, bends and fittings, for buried or submerged service with cathodic protection. The dual layer FBE coating system will provide improved resistance to both elevated temperature and abrasion.

Notes:
A) An anti-slip coating is not considered a dual layer system for the purposes of this standard specification. Dual layer FBE consist a corrosion coating layer and a gouge resistance overcoat.

B) The service temperature for dual layer FBE is -20 ^{0}C to +90 ^{0}C.

C) If a concrete weight coating is required, this will be applied on site by a method approved by the purchaser and in accordance with the relevant project specification that will apply in conjunction with this FBE coating specification. If slippage of the concrete during transportation and installation may be a problem, an outer rough coat of FBE, or spiral non-slip bands, shall be considered as part of the FBE coating system.

2. REFERENCES

Throughout this standard specification, the following standards and codes are referred to, the edition of them, that are in effect at the time of issue of this standard specification (2012) shall, to the extent specified herein, form part of this standard specification. The applicability of changes in standards and codes that occur after the date of standards that referred shall be mutually agreed upon by the purchaser and manufacturer or applicator.

2.1 Normative References

API 5L9 (2001) "Recommended Practice for External Fusion Bonded Epoxy of Line Pipe**"**

ASTM D 4060 (2004) "Standard Test Method for Abrasion Resistance of Organic Coatings by the Taber Abraser**"**

ASTM D 4940 (2004) "Standard Test Method for Conductmetric Analysis of Water Soluble Ionic Contamination of Blasting Abrasives**"**

BS EN 10204 (2004) "Standard for Metallic Products – Types of Inspection Documents**"**

IPS-M-PI-190(2) (2004) "Material and Equipment Standard for Line Pipe**"**

ISO 8501-1 (1994) "Preparation of Steel Substrates before Application of Paints and Related Products – Visual Assessment of Surface Cleanliness – Part1: Rust Grades and Preparation Grades of Uncoated Steel Substrates after Overall Removal of Previous Coatings**"**

ISO 8502-3 (2000) "Preparation of Steel Substrates before Application of Paints and Related Products – Tests for Surface Cleanliness – Part 3: Assessment of Dust on Steel Surfaces Prepared for Painting (Pressure-Sensitive Tape Method)**"**

ISO 8502-6 (2000) " Preparation of Steel Substrates before Application of Paints and Related Products – Test for the Assessment of Surface Cleanliness – Part 6: Extraction of Soluble Contaminants for Analysis – The Bresle Method**"**

ISO 8502-9 (2001) "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 8503-4 (1995) "Preparation of Steel Substrates before Application of Paints and Related Products – Surface Roughness Characteristics of Blast-Cleaned Steel Substrate**"**

ISO 8503-5 (2003) "Replica Tape Method for the Determination of the Surface Profile**"**

ISO 9001 (2008) "Quality Systems – Model for Quality Assurance in Design, Development, Production, Installation and Servicing**"**

ISO 10474 (1991) "Steel and Steel Products – Inspection Documents**"**

ISO 11124 (all parts) (1997) "Preparation of Steel Substrates before Application of Paints and Related Products – Specification for Metallic Blast-Cleaning Abrasives**"**

ISO 11126 (1997) "Preparation of Steel Substrates before Application of Paints and Related Products – Specification for Non-Metallic Blast-Cleaning Abrasives**"**

ISO 21809-2 (2006) "Petroleum and Natural Gas Industries – External Coatings for Buried and Submerged Pipelines Used in Pipeline Transportation Systems – Part 2: Fusion-Bonded Epoxy Coatings**"**

ISO 21809-3 (2008) "Petroleum and Natural Gas Industries – External Coatings for Buried and Submerged Pipelines Used in Pipeline Transportation Systems – Part3: Field Joint Coatings**"**

NACE RP0490 (2001) "Holiday Detection of FBE External Pipeline Coatings of 250 to 760 Micrometers**"**

2.2 Informative References

CSA Z245.20 (2006) "Standard for External Fusion Bond Epoxy Coating for Steel Pipe**"**

NACE RP0394 (2002) "Recommended Practice for Application, Performance, and Quality Control of Plant-Applied Fusion-Bonded Epoxy External Pipe Coating**"**

SHELL 31.40.30.32 (2011) "DEP Specification for Fusion-Bonded Epoxy Powder Coating for Line Pipe (Amendments/Supplements to ISO 21809-2)**"**

3. DEFINITIONS

Anti-Slip Coating
A fusion bond epoxy coating applied over on FBE coating system for the purpose of increasing the shear resistance between concrete coating and the coated steel pipe.

Applicator (Contractor)
The organization responsible to the purchaser for the application of the coating.

Batch
The quantity (not more than 20 tones) of epoxy powder of the same source produced during a continuous production run of not more than eight hours.

Bolster
Support for coated pipes during transport and storage.

Certificate of Compliance
Document issued according to ISO 10474 or EN 10204 stating compliance with the purchase order for coated pipes, but without mention of any test results, issued in accordance with the purchasing requirements.

Corrosion Coating
A fusion bond epoxy coating applied directly on steel for the purpose of corrosion protection.

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.

Drop
Non-homogenous or partially cured lump of powder deposited on the surface of the coating.

Glass Transition
The reversible change in an amorphous polymer or in amorphous regions of a partially crystalline polymer from (or to) a viscous or rubbery condition to (or from) a hard and relatively brittle one.

Glass Transition Temperature
Approximate midpoint of the temperature range over which the glass transition takes place.

Note:
The assigned glass transition temperature, Tg, can vary, depending on the specific property and on the method and conditions selected to measure it.

Gouge Resistant Overcoat
A fusion bonded epoxy coating applied over a FBE corrosion coating for the purpose of gouge or other mechanical damage resistance.

Inspection Certificated 3.1.B
Inspection Certificate 3.1
Document in accordance with ISO 10474 or EN 10204 giving the results of the testing of coated pipes, supplied and signed by a representative of the manufacturer or applicator, authorized to issue such documents.

Manufacturer
The company responsible for the manufacture of coating materials.

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.

Purchaser (Company)
The company responsible for providing the product order requirements.

Rust Bloom
Visual detectable color change on the surface of the pipe due to oxidation, other than as a result of pre-treatment.

Strain Ageing
A change in the properties of steel associated with ageing at elevated temperature subsequent to cold working.

Test Panel
Sample of steel plate coated with fusion bonded epoxy for laboratory tests.

4. GENERAL REQUIEMENTS

4.1 Purchasing Requirements

4.1.1 Information to be supplied by the purchaser

The following information shall be included in purchase order:

a) IGS standard designation and year of publication (IGS-M-TP-026);
b) Line pipe standard, quantity, outside diameter, wall thickness, nominal length and grade of steel;
c) Minimum and maximum permissible thickness of the coating system and the minimum and maximum permissible thicknesses of individual layers;
d) Maximum/minimum design and operating temperature (^{0}C) of pipeline;
e) Other special requirements or additional tests (if any).

4.1.2 Information to be supplied by the coating applicator

The following information shall be supplied by the coating applicator:

(a) A quality assurance manual in accordance with ISO 9001;
(b) Name and location of the coating materials manufacturer;
(c) Technical data sheets obtained from the coating material manufacturer, showing at least, the properties and test results for items specified in Tables 1 and 2;
(d) Results of DSC and Infra-red scan tests on the fusion-bonded epoxy resin powders in the form of a graph and typical of the powders proposed;
(e) Production rates of pipe coating;
(f) Handling, transport and storage methods for powders, uncoated pipe and coated pipe in accordance with the powder manufacturer's recommendations;
(g) Safety procedures;
(h) Identification of powders, pipe coating;
(i) Material manufacturer’s recommended methods of application of powders;
(j) Quality plan consisting of Manufacturing Plan (MP) and Inspection and Test Plan (ITP)
(k) Other special requirements.

Note:
The same documents (b, c, d, h, i & k above) shall be submitted for repair material by the applicator.

4.2. Quality Control Plan (QCP)

Prior to the start of coating production, the applicator shall submit a detailed technical procedure, including description of the coating equipment, materials, surface preparation, coating application and repair, handling and stacking, testing and inspection and frequencies in the form of a Quality Control Plan (QCP) specific to the order for purchaser's review and approval.

The description shall be accompanied by full technical details and results of tests on similar coatings, using similar line pipe (diameters, lengths and wall thickness), or trials performed by applicator, which document the quality of the finished coating. Such test results and/or trials shall demonstrate, to the satisfaction of purchaser, that applicator equipment, procedures and materials can supply a finished coating meeting the requirements of this standard specification.
The coating procedure and QCP shall include, but not necessarily be limited to the following:

- Safety aspects;
- Traceability;
- Incoming Inspection of line pipes and pipe tracking;
- Lay-out sketch or flow diagram for the coating plant;
- Data sheets for coating materials, repair material, abrasive blasting materials, chemical pretreatment material, etc;
- Pipe handling and storage (incoming and preparation for shipment);
- Pipe cleaning;
- Substrate preparation and blast cleaning media;
- Pipe pre-heating;
- Chemical treatment
- Application method;
- Testing and inspection;
- Quality control;
- Repair procedures, including stripping and re-coating;
- Preparation of coating cutback areas;
- Marking and traceability;
- Any special conditions for dispatch of coated pipes including protection of pipe end;
- Documentation.

The QCP shall cover all items associated with quality control as defined in this standard specification.
The QCP shall be approved by the purchaser prior to the start of production.
The QCP 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 approved QCP.

4.3 Compliance

The applicator shall be responsible for complying with all of the requirements of this standard specification. The purchaser may make any investigation necessary in order to be assured of compliance by the applicator and to reject any material that does not comply.

4.4 Raw Material Sampling

For each batch of FBE powders, the applicator shall, in the presence of the purchaser's representative, select three 100 gr. samples of powders for long-term quality assurance and guarantee purposes.

One sample shall be given to the purchaser's representative. The second sample shall be stored by the applicator at a temperature not to exceed 25 ^{0}C for a period of two years from the coating contract completion date. The third sample shall be used by the applicator to check the stability of the powders by measuring the properties of Table 1.

5. MATERIAL REQUIREMENTS

5.1 Fusion Bonded Epoxy Powders

5.1.1 The FBE powders (first and second layers of the coating system) shall be supplied by the same manufacturer and shall have a proven track record in pipeline coating applications.

5.1.2 The epoxy powders properties shall be in accordance with the requirements of Table 1. At least once per batch, the epoxy powders manufacturer shall conduct tests and provide the applicator with a test report for the epoxy powders properties specified in Table 1.

5.1.3 Each batch of epoxy powders shall be identified with the following:

- Powder manufacturer's name;
- Product description;
- Mass of material;
- Batch number;
- Location of manufacture;
- Manufacturing identification number;
- Temperature requirements for transportation and storage;
- Year, month and day of manufacture;
- Year, month and day of expiry date.

5.2 Abrasive Materials

Abrasive materials shall comply with the requirements of ISO 11124. They shall be free from contamination and contain less than 100 mg/kg chlorides and less than 0.3% copper.
Abrasives shall be shot or grit, or both, in accordance with ISO 11124. The particle size shall be such that the blasted steel pipe surface complies with Clause 7.3.

5.3 Repair Materials

The repair material shall be a two-component 100% solids liquid epoxy coating material that is compatible with the original coating. The liquid epoxy coating shall meet the requirements of Clause 13 of ISO 21809-3.
The liquid epoxy coating for dual layer system shall be of gouge resistant type.

Table 1. Epoxy Powders Requirements

Item	Test	Requirement	Test Method
1	Cure time	within the manufacturer's specification	ISO 21809-2 Annex A (A2)
2	Cure curve	within the manufacturer's specification	ISO 21809-2 Annex A (A2)
3	Gel time	within the manufacturer's specification	ISO 21809-2 Annex A (A3)
4	Particle size	within the manufacturer's specification	ISO 21809-2 Annex A (A6)
5	Thermal characteristics T_{g2}	within the manufacturer's specification ≥ 5 ^{0}C above the maximum pipeline design temperature	ISO 21809-2 Annex A (A8)
6	Density	within the manufacturer's specification ± 3.5%	ISO 21809-2 Annex A (A7)
7	Total Moisture content*	0.5% max	API 5L9 Appendix D
8	Total Volatile content*	0.6% max	API 5L9 Appendix E

* Either total volatile or moisture content may be determined at applicator's discretion.

Table 2. Qualification Test Requirements

Item	Property	Acceptance criteria	Number of test specimens	Test method
1	Thermal characteristics T_{g2}	within the manufacturer's specification ≥ 5 ^{0}C above the maximum pipeline design temperature	2	ISO 21809-2 Annex A (A8)
2	Cathodic disbondment, 48 h, -3.5 V, at 80 ^{0}C ± 3 ^{0}C, max radius	5 mm	3	ISO 21809-2 Annex A (A9)
3	Cathodic disbondment 28 day, -1.5 V, at 80 ^{0}C ± 3 ^{0}C, max radius	10 mm	3	ISO 21809-2 Annex A (A9)
4	Cathodic disbondment 28 day, -1.5V, 20 ^{0}C ± 3 ^{0}C, max radius	5 mm	3	ISO 21809-2 Annex A (A9)
5	Hot water adhesion 48 h, at 80 ^{0}C ± 3 ^{0}C, max	< 5% of the test area blistering or disbonding no failure of adhesion	3	ISO 21809-2 Annex A (A15) and Appendix D
6	Hot water adhesion 28 days, at 80 ^{0}C ± 3 ^{0}C, max	< 10% of the test area blistering or disbonding no failure of adhesion pull off min 7 N/mm^2 (> 50% surface area cohesive)	3	ISO 21809-2 Annex A (A15) and Appendix D
7	Cross – section porosity	rating 2 (refer to figure 1)	2	ISO 21809-2 Annex A (A11)
8	Interface porosity	rating 2 (refer to figure 2)	2	ISO 21809-2 Annex A (A11)
9	Flexibility at 0 ^{0}C and -20 ^{0}C	no cracking at 2^0 ppd* length	3	ISO 21809-2 Annex A (A12)
10	Impact, min at 20 ^{0}C at 30 ^{0}C	 3.6 J 1.5 J	3	ISO 21809-2 Annex A (A13)
11	Strained coating, cathodic disbondment 28 day , 20 ^{0}C ± 3 ^{0}C , -1.5 V	no cracking and no disbondment (1.5^0)	3	ISO 21809-2 Annex A (A14)
12	Gouge resistance test, max	250 µm Gouge depth	2	APPENDIX E

***ppd :** per pipe diameter

6. COATING SYSTEM QUALIFICATION

6.1 Qualification by Manufacturer

Each batch of epoxy powders shall be tested by the manufacturer for the properties specified in Table 2 except for the 28 day tests.
The tests to be conducted, the number of test specimens, the test methods to be used, and the acceptance criteria shall be as given in Table 2. These test results shall be made available to the applicator.

Note:
Alternatively, if purchaser approves the material manufacturer may provide a certificate of compliance, confirming that the powders supplied meets the requirements of Table 2, or a test certificate detailing the test methods used and results which demonstrate equivalent performance.

The manufacturer shall issue an “inspection certificate” for each batch of coating material in accordance with ISO 10474 (type 3.1.B) or EN 10204 (type 3.1) stating that the tests of Table1 have been carried out on every batch and results are in accordance with the manufacturer's product specifications.
The same “inspection certificate” shall be furnished by repair material manufacturer.
Material which is not traceable to satisfactory test certificates shall not be used.

Note:
The coating system shall be requalified in case of any changes in the material formulation, manufacturer, changes in the production process which influence the material processing behavior and change in production facility.

6.2 Qualification by Applicator

The production coating shall be qualified by the applicator for each coating system. Applicator shall use coating materials qualified in accordance with the requirements of clause 6.1.
Qualification shall be achieved by successful evaluation of laboratory coated specimens and pipe coated using the specified coating line. The requirements for testing of laboratory coated specimens are given in Table 3 and the requirements for testing pipe samples are given in Table 4.
The qualification shall be repeated in case of essential modifications of the coating line, coating materials and coating procedures.

6.2.1 Preparation of laboratory – coated test specimens

Mild steel panels shall be used to prepare Coated Test Specimens. The panels shall have dimensions in accordance with the applicable test method (Annex A ISO 21809-2). The substrate of panels shall be abrasively blast cleaned with steel grit to provide cleanliness in accordance with the requirements of ISO 8501-1 grade Sa3.

Two Coated Test Specimens shall be required for FBE coating system, one specimen of the corrosion coating (first layer) and a second specimen of the full coating system. The surface profile shall have a peak to trough height of between 60 µm and 100 µm as measured in accordance with the requirements of ISO 8503-4 (stylus method) or ISO 8503-5 (replica tape method).

For coating system, the thickness of the individual layers shall be 400 µm ± 50 µm for the corrosion coating and minimum 400 µm ± 50 µm for top coat and the thickness of the cured dual layer FBE coating shall be 800 µm ± 100 µm. This should be measured by a calibrated coating thickness gauge verified to +/- 5% of full scale range.

6.2.2 Preparation of pipe samples

Pipe samples shall be prepared and coated as per clauses 7 and 8. Test specimens cut from pipe samples shall be tested as per Table 4.

Purchaser reserves the rights to increase inspection and testing frequency if warranted by the circumstances or to select the pipes for testing.

6.3. Coating Procedure Qualification Testing (PQT)

In addition to the tests required on the material batches, the applicator shall perform the PQT and production tests detailed herein on finished coated pipes to demonstrate compliance with this standard specification. Details of all inspections and testing, shall be fully documented in accordance with clause 11. These requirements apply to each pipe diameter size and wall thickness unless otherwise agreed by the purchaser.

This section is applicable only for PQT of pipes that are to be coated using automatic or semi-automatic coating equipment (for fittings refer to Appendix C).

Prior to commencing full production, five pipe lengths shall be coated with the project approved FBE coating system. One of the five pipe lengths of the dual FBE layer system pipes shall contain a length of the base layer only to confirm the applied base layer thickness is within specification and this shall be tested.

The PQT surface preparation, coating application, testing and inspection shall be witnessed by the purchaser's designated representative.

All five pipes shall be subjected to the tests as specified in Tables 4 and 5 by an independent laboratory or, if approved by purchaser, by the applicator. The number of pipes to be tested is given in Tables 4 and 5.

Pipes selected for PQT testing shall pass all the criteria contained in Tables 4 and 5 before production commences.

Table 3. Laboratory Coating Test Requirements by the Applicator

Item	Property	Requirement	Number of test specimens	Test method
1	Cathodic disbondment, 48h, -3.5V, at 80 ^{0}C ± 3 ^{0}C, max radius	5 mm	2	ISO 21809-2 Annex A (A9)
2	Cross – section porosity	rating 2 (refer to figure 1)	2	ISO 21809-2 Annex A (A11)
3	Interface porosity	rating 2 (refer to figure 2)	2	ISO 21809-2 Annex A (A11)
4	Flexibility at 0 ^{0}C and -20 ^{0}C	no cracking at 1.5^0 ppd* length	2	ISO 21809-2 Annex A (A12)
5	Hot water adhesion, 48 h at 80 ^{0}C ± 3 ^{0}C	< 5% of the test area blistering or disbonding no failure of adhesion	2	ISO 21809-2 Annex A (A15)
6	Impact at 25 ^{0}C, min	3.6 J	2	ISO 21809-2 Annex A (A13)
7	Abrasion resistance (CS-17 wheels, 1000 g. load, 1000 cycle), max.	40 mg	2	ASTM D 4060
8	Gouge resistance test, max.	250 µm Gouge depth	2	APPENDIX E

***ppd :** per pipe diameter

Table 4. PQT and Production Coating Testing Requirements

Item	Property	Requirement	Test Frequency Qualification	Test Frequency Production	Test method
1	Coating thickness	800 ± 100 µm (base & top coat 400 ± 50 µm)	5 pipes	each pipe	Clauses 8.4 & 9.4
2	Degree of cure DSC – Δ Tg T_{g2}	-2 ^{0}C and +3 ^{0}C ≥ 5 ^{0}C above the maximum pipeline design temperature	5 pipes	twice per shift	ISO 21809-2 Annex A (A8)
3	Cross section/interface Porosity	rating 2 [b]	5 pipes	1 per 50 pipes	ISO 21809-2 Annex A (A11)
4	Dry adhesion [a], max Pull off, min	2 mm 10 N/mm^2 (failure made shall be cohesive for more than 75% of surface area)	5 pipes	twice per shift	Appendix D
5	Flexibility at 0 ^{0}C & -20 ^{0}C for 700-900 µm coating thickness	no cracking at 1.5^0 ppd length	2 pipes	1 per 200 pipes	ISO 21809-2 Annex A (A12)
6	Hot water adhesion, 48 h, at 80 ^{0}C ± 3 ^{0}C	< 5% of the test area blistering or disbonding no failure of adhesion	2 pipes	1 per 200 pipes	ISO 21809-2 Annex A (A15)
7	Cathodic disbondment, 48 h, -3.5V at 80 ^{0}C ± 3 ^{0}C	5 mm (max)	2 pipes	1 per 200 pipes	ISO 21809-2 Annex A (A9)
8	Interface contamination, max	10%	2 pipes	1 per 100 pipes	ISO 21809-2 Annex A (A10)
	a) This test can be done on the pipe or on a test ring. b) refer to figures 1 and 2.				

7. PRODUCTION APPLICATION PRACTICES AND EQUIPEMENT

7.1 Inspection before Cleaning

Pipes shall be inspected for corrosion in accordance with ISO 8501-1.
All steel defects and irregularities shall be removed by an approved grinding method. Grinding of steel defects shall not reduce the wall thickness below the specified minimum wall thickness of the pipe as per line pipe specification (see IPS-M-PI-190(2)).

Note:
Line pipe manufactured in accordance with approved standard and specification may not be suitable for application of FBE coating without surface preparation. Surface imperfections in the form of steel slivers, burrs and laminations can cause excessive holidays, resulting in the need for extra surface cleaning, grinding or filing.

7.2 Cleaning Prior to Blast Cleaning

Prior to blast cleaning, all surface contaminants, such as oil, grease, tar, chlorides and soluble salts, or other contaminants on the pipe shall be removed by an appropriate method(s).
The methods of removal shall include washing with clean, neutral water and rinsing using de-mineralized water and solvent cleaning as per SSPC SP1, followed by steam or hot-bath cleaning.
A purchaser approved salt test meter shall be used to carry out salt contamination tests after blast cleaning (after the first blast if a two blast system is used). One salt contamination test shall be carried out at each end of the pipe and one at the center of the pipe using SCM 400 equipment. Any areas indicating chloride presence shall be water jet blast cleaned using clean chloride free water.
The frequency of the salt testing shall be at least twice per shift or more as agreed upon between the applicator and the purchaser during the pre-production meeting.
The salt test meter shall be calibrated and used in accordance with the manufacturer's recommendation. The acceptance criteria shall not exceed 2 microgram/cm^2.

7.3 Blast Cleaning

After cleaning, and prior to abrasive blast cleaning, the line pipe shall be uniformly heated to 60 ^{0}C by open flame to remove surface moisture and preclude any condensation of moisture on the pipe surface after blast cleaning. The heating method employed shall not cause hydrocarbon contamination of the blasted steel surface. The pipe surface shall be simultaneously higher than 5 ^{0}C and more than 3 ^{0}C above the ambient dew point during blast cleaning and inspection.
Ends of the pipe shall be fitted with temporary non-metallic plugs so as to prevent entry of abrasive into the pipe during the blast cleaning operation. Alternatively the applicator may link the pipes together with couplers to prevent entry of abrasive.

Using dry blasting techniques only, the exterior surface of the pipe lengths shall be abrasively cleaned to remove all mill scale, and other impurities from the pipe surface. Any compressed air shall have been proved to be clean and dry and free of oil and condensed water.
The abrasive used shall be in accordance with ISO 11124-3 and shall be maintained clean, dry and free from contaminants in accordance to SSPC AB -1, 2 , 3.
Blasting abrasive shall be kept dry, clean and free from contamination, including chlorides. When recovered metallic grit systems are used, a stabilized working mix of blast cleaning material shall be established and maintained by frequent small additions from fresh stock at a rate sufficient to replenish consumption. Large additions of new material shall be avoided.
Blasting and other dust producing areas shall be screened, or kept separate, from coating application areas using positive segregation or air management techniques.
No blast cleaning shall take place when the prevailing relative humidity is greater than 85 percent unless pipe is preheated to at least 3 ^{0}C above the dew point or 25 ^{0}C whichever is greater.
The surfaces of the pipes shall be blasted until a finish of ISO 8501-1 Sa3 is attained.
The surface profile (anchor pattern) shall be between 60 and 100 microns, (measured peak to trough) according of ISO 8503-5 (stylus or replica tape).

7.4 Surface Preparation Inspection before Coating Application

The blast cleaned surface shall not be contaminated, or become contaminated, with dirt, dust, metal particles, hydrocarbons, water, chlorides, sulfates or any other foreign matter or residues that would be detrimental to the coating or its application and adhesion or future stability.
Prior to coating application, the full exterior surface shall be thoroughly inspected visually under adequate lighting. All surface imperfections such as slivers, scabs, burrs, gouges, or sharp edge defects, shall be removed by grinding to an approved procedure and the area re-blast cleaned.
Any pipe length containing a dent shall be set aside for the purchaser's representative to determine its disposition. Gouges in a dent shall not be ground without purchaser's approval.
Pipes with ground repair areas shall be re-blast cleaned when the repaired area is greater than 25 cm².
No grinding shall be permitted that reduces the wall thickness of the pipe below the minimum wall thickness specified in the pipe specification (see IPS-M-PI-190(2)). Any pipe failing this thickness requirement shall be quarantined for purchaser inspection.
External pipe varnishing and the application of temporary corrosion protection of the pipe ends during the pipe manufacturing process shall be avoided. If the pipe was supplied varnish coated, the pipe shall be blast cleaned and inspected with a magnifying glass (X30) to ensure complete removal of the varnish before pipe coating.
Any temporary corrosion protection of the pipe ends shall be completely removed prior to pipe blast cleaning.

Any dust or loose residue that has accumulated during blast cleaning and/or grinding operations shall be removed by the use of clean compressed air and by vacuum extraction that exhausts into a contamination-safe area. This shall include cleaning or blow out performed just before the coating operation. It is essential that only clean blasted pipes are presented for coating. Alternative methods for removing dust and lint require approval by the purchaser.
The total elapsed time between the start of blast cleaning of a pipe and the heating of that pipe to the specified temperature shall not exceed the following time-humidity Table:

Relative Humidity (R.H)	Maximum Elapsed Time
R.H.> 85%	1 hours
R.H. ≤ 85%	4 hours

Pipe shall not be blast cleaned until the coating plant is fully operational and ready to coat the cleaned pipe within the agreed time scale. Any pipe surface not processed within the above time-humidity Table shall be completely reblasted before coating. Pipe with a visible rust bloom shall not be coated.

Notes:
- In order to avoid risk of condensation, temperature of environment and/or steel surface must be minimum 3 ^{0}C higher than the dew point.

- The surface cleanliness and assessment of dust on steel surface shall be measured according to ISO 8502-3 and the maximum allowable level shall be class 1.

- The inspection requirements for surface preparation are defined in Table 5.

7.5 Chemical Pretreatment

Line pipes shall be subjected to chemical pretreatment using an approved Phosphoric acid solution. This treatment shall be executed after all surface preparation operations and just prior to heating for coating application.
The applicator shall provide the purchaser all documentation and certification including procedures, MSDS, product quality control test results and treatment materials to be approved.
The surface to be coated shall be heated to a temperature of 45 ^{0}C – 65 ^{0}C, and treated with a low pressure (0.5 – 2.0 bar) spray application of a maximum 10 ± 3% 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 ± 5 seconds and then rinsed with clean potable water, before it starts to dry out.

High-pressure water rinse at 700 – 1000 psi (50 – 70 bar) shall be used to remove any treatment residues. 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 <10 ppm chlorides, Sulfates <40 ppm, Nitrates <10 ppm and a conductivity of 10 μmhos/cm or less. The water shall not be reused. Acid concentration, pipe temperature, dwell time, rinse water conductivity and pipe surface pH shall be monitored twice per shift.
After chemical treatment and before application of the epoxy coating, soluble salts (Chloride contamination) on the steel surface shall be checked using an approved salt detector instrument measuring conductivity, SCM400, ISO 8502-6, ISO 8502-9 or equivalent. Soluble salt content shall not excess 2 micrograms/cm^2.

8. COATING APPLICATION

The coating applicator shall provide coating plant qualification records in accordance with Appendix B to be approved by purchaser.
When the relative humidity is less than or equal 85% blast-cleaned pipes shall be coated within 4 hours. Pipes delayed beyond this period, or pipes showing any visible rust stains, shall be blast cleaned again. When due to unforeseen circumstances, the relative humidity is more than 85%, the blast cleaned pipes shall be coated within one hour.
The coating of pipe fittings and bends shall be in accordance with Appendix C.

8.1 First FBE Layer of the Coating System

Prior to starting the fusion bonded epoxy powder application, the recovery systems shall be thoroughly cleaned to remove any unused powder from previous applications.
The pipe shall be uniformly preheated to a temperature within the powder manufacturer's specified range. The pipe metal temperature shall not exceed 270 ^{0}C and shall show no signs of spots, discoloration, or of oxides. Oxidation of the steel prior to coating in the form of 'blueing' or other apparent oxide formation is not acceptable. If any such oxidation occurs, the pipe shall be rejected and quarantined for purchaser's inspection. Any pipe heated above 270 ^{0}C shall be rejected and replaced at the expense of the applicator.
Pipe temperature shall be checked periodically by tempil sticks or a recording pyrometer in conjunction with tempil sticks. If a pyrometer is used, it shall be checked for error at least every four hours against a calibrated temperature-measuring instrument according to the procedural requirements of ISO 9001.
Rubber smears and other contaminants from the handling system shall be removed by re-blast cleaning if they occur. Frequent smears shall be the cause of a production stop and investigative action.
The coating shall be applied by electrostatic spray with the pipe at earth potential and the epoxy powder charged to high potential. Prior testing shall be conducted on applicator's test pipe(s) to establish the correct arrangement of spray guns to achieve the required coating parameters.
The FBE shall be applied to the thickness value tolerances specified.

Note:
Consideration should be given to strain ageing when specifying line-pipe for FBE coating.

8.2 Second FBE Layer of the Coating System

Prior to starting the fusion bonded epoxy powder application, the recovery systems shall be thoroughly cleaned to remove any unused powder from previous applications.
The second layer of FBE shall be applied by electrostatic spray with the pipe at earth potential and the epoxy powder charged to high potential.
The second layer shall be applied to the first layer after a sufficient dwell time, but in sufficient time to achieve the required bond and degree of cure for both layers.
The dual layer FBE shall be applied to the specified thickness value tolerances (including individual layer and combined total thickness, and layer to layer ratio) as specified in this standard specification.
The coating shall be cooled to below 80 ^{0}C before handling.

8.3 Powder Recycle

The use of recycled powder from the same batch may be permitted but it shall not exceed 20% of the total powder mix at any time. Recovery shall be automatic and continuous. This powder shall be processed through magnetic separators and sieves and then uniformly mixed with fresh powder. When recycled powder is used, the moisture content of the powder shall be checked at least once per day and shall be in accordance with A.5 of ISO 21809-2.
The use of recycled powder for both the first and second FBE layers are exclusively allowed when the first and second layer powders are departed in different compartments and collected by different apparatuses.

8.4 Coating Cut-Back

The coating shall be applied to the external surface of the full length of each pipe except for a cutback of 100 ± 7 mm for pipe diameter up to 20" and 150 ± 10 mm for equal or greater than 20" at each end. The cutback shall be measured from the bevel shoulder. Any coating applied to the cutback shall be removed.
There shall be no change in the cutback length without approval of the purchaser.

8.5. Coating Thickness

The thickness of the individual cured layers and total thickness shall be as follows:

First layer: 400 µm ± 50 µm;
Second layer: 400 µm ± 50 µm;
Total DFT: 800 µm ± 100 µm.

The thickness of the cured FBE coating applied on bends and fittings shall be not less than 400 µm and shall be not more than 1000 µm.
For pipes that are to be coated later with concrete weight coating DFT of the cured FBE shall be 725 µm ± 75 µm.

Table 5: Requirements for Inspection of Surface Preparation

Item	Properties	Test Method	Requirement	Frequency Qualification	Frequency Production
1	Surface condition before blasting	visual inspection	dry and free from contaminations (oil, grease, etc.) and surface defects	5 pipes	each pipe
2	Surface condition after blasting	conductive measurement, ISO 8502-9	salt content maximum 20 mg/m^2	5 pipes	5 pipes at start of production and 1 pipe per shift
3	Environmental conditions	calculation	as determined at time of measurement	once	every 2 h
4	Pipe temperature and relative humidity before blasting	thermocouple	minimum 3 ^0C above the dew point and for humidity refer to clause 7.3	once	every 2 h
5	shape and properties of abrasive	visual + certification ISO 11124 resp. ISO 11126	conformity to certificate, compliance to manufacturing/ working procedures	once	1 per shift
6	Water soluble contamination of abrasives	ASTM 4940	conductivity maximum 50 µS/cm	once	1 per shift
7	Surface roughness of blasted surface (Rz)	ISO 8503-4	60 µm to 100 µm	5 pipes	every 1 h
8	Visual inspection of blasted surface	ISO 8501 -1	grade Sa3	5 pipes	each pipe
9	Presence of dust after dust removal	ISO 8502-3	maximum class 1	5 pipes	every 1 h
10	Chemical pretreatment	clause 7.5	as required in clause 7.5	5 pipes	once per shift
11	Final surface condition	visual examination	free from surface defects	5 pipes	each pipe
12	Pipe condition prior to coating	monitoring	no rust, pipe temperature at least 3 ^0C above the dew point	continuously	continuously
13	Preheating temperature before coating	thermometer	compliance to as per manufacturer's recommendations	continuously	every 5^{th} pipe
14	Pipe temperature	monitoring	maximum 270 ^0C	continuously	startup and every 5^{th} pipe

9. INSPECTION AND TESTING

9.1 General

9.1.1 Inspector(s) shall have free access at all times to all work related to the coating application process, with the right to inspect work and materials furnished by applicator. All such work shall be subject to approval by Inspector(s). Failure of Inspector(s) to identify or reject defective work or materials shall not be construed as acceptance of such work or materials.

9.1.2. Inspector shall have the right and opportunity to witness any quality control tests and/or to perform such tests himself.

9.1.3 The applicator shall prepare a daily production summary containing the following information for each pipe coated:

A) Date and coating sequence number;
B) Manufacturer's pipe/heat number;
C) Pipe length;
D) Coating thickness readings;
E) Number of holidays;
F) Disposition (accepted, rejected for stripping and recoating or temporarily rejected – e.g., diverted for cut-off, rebeveling, coating repairs that cannot be made at time of final inspection).

9.2 Visual Inspection

Particular attention shall be given to the following external surface areas when carrying out visual inspection:

- Adjacent to the longitudinal welds;
- Adjacent to the cut-back at each end of pipe;
- Within the body of the pipe.

The coating shall be of natural color, uniform sheen, smooth, blemish free and with no dust or other particulate inclusions. The coating shall not show any defects such as wrinkles, sags, fish eyes, pin holes, blisters, cuts, swellings, excess material thickness, disbonded zones, air inclusions, tears, voids, etc.

9.3 Production Testing

9.3.1 Production testing shall not be commenced before PQT results reviewed and approved by the purchaser.

- The applicator shall have facilities available at the application plant for preparation, testing and evaluation of test rings of pipe samples for the test required in Table 4.

- Test rings shall be obtained from locations at least 300 mm from the end and shall be of sufficient size to provide the mandatory tests as described in Table 4.

- The minimum test frequency shall be one test ring per pipe diameter and specified wall thickness every working shift (to a maximum of 12 h).
Where specified in the purchase order, additional test rings shall be taken with only the corrosion coating, such test rings shall be obtained by turning off the overcoat powder application. The requirements of Table 4 shall be met.

The test frequency and retest procedure of coating system shall be in accordance with Table 4. In case any additional measures and tests are deemed necessary by the purchaser, they shall be specified in the purchase order or contract.

- For pipe that is stripped and recoated, at least one test ring of the stripped and recoated pipe shall be taken for each order item. Where specified in the purchase order, additional test rings shall be taken.

- For each test ring, the tests to be conducted, the number of test specimens to be used, the test method to be used, and the acceptance criteria shall be as specified in Table 4.
Gel time tests shall be conducted on each batch of epoxy powders prior to its use in accordance with the requirements of Table 1. Where the average gel time is failed, the gel test shall be repeated using two additional samples. Where both retests conform to the requirement, the powder batch shall be accepted. Where one or both retests fail to conform to the requirements, the powder batch shall be rejected.

9.3.2 The applicator shall conduct testing and evaluation of powders before its use for production coating in accordance with the requirements of Table1. The minimum testing frequency shall be one sample on every vehicle shipment of epoxy powders received. If any of tests is failed, that specific test shall be repeated same gel time test repeating procedure as mentioned in above paragraph. Any batch of powders stored outside the manufacturers specified storage conditions shall be retested as per Table 1.
Production testing shall be performed at the frequency given in Tables 4 and 5 and is applicable to normal production operations. This frequency may be increased initially, or after a change in normal operations, e.g. as a result of a material change or quality acceptance.

9.4 In Process Inspection/Measurement by Applicator

- The surface finish shall be monitored a minimum of every 1 hour during production.

- At least once every 1 hour of production, the external surface profile on two pipes shall be measured using a profile meter (stylus or replica tape) or purchaser-approved equivalent.

- After cleaning, each pipe shall be visually inspected for surface defects and surface imperfections that might cause holidays in the coating. Such surface imperfections shall be removed by grinding, provided that the remaining wall thickness is within specified limits (see IPS-M-PI-190(2)). Any treated surface with an area larger than 25 cm^2 shall be re-blasted to the cleanliness and roughness as specified above. Pipe containing defects shall be quarantined for further inspection and acceptance by the purchaser's representative.

- Pipes shall be inspected for surface cleanliness and chloride contamination. If contamination of the surface occurs the quality of the blasting material and process shall be examined. If the conductivity of the blasting material is greater than 50 µS/cm, the blasting material shall be replaced.

- The surface temperature of the pipe during the epoxy powders application shall be continuously monitored and recorded by means of suitable instruments, e.g. infrared sensors, contact thermometers of thermocouples. The instruments shall be calibrated daily and verified at least twice per shift with tempil sticks and controlled within the limits recommended by powder manufacturer. The temperature at start-up and the temperature of every fifth pipe shall be recorded.

- The thickness of the cooled coatings shall be checked using an approved magnetic or electro-magnetic thickness gauge that has been calibrated at least once every working shift (to a maximum of 12 hour) against a thickness standard that is within 10% of nominal coating thickness specified in 8.4.
Measurements shall be made at 12 points uniformly spaced over the length of pipe, that is, three each at the 12, 3, 6 and 9 o'clock positions with 12 o'clock being taken as the longitudinal weld. At least 3 points shall be measured on longitudinal welds.
For dual layer system, the thickness of each individual layer shall be measured either by progressive removal of layers and measuring the remaining thickness by means of a Tooke gauge, or by microscopic measurements of the cross-section of a representative sample near the end of a selected line pipe. Areas where the overcoat has been removed shall be repaired. For dual layer system, where the total or individual coating thickness is less than that specified minimum, additional measurements shall be carried out near each end. The average of such measured values for each line pipe shall be at least the minimum coating thickness specified, and no individual measured thickness value for the total coating thickness, as well as the individual coating thickness, shall not be less than 90% of the specified minimum thickness.
If the coated pipe does not meet the requirements of this clause, it shall be cause for the coated pipe length to be rejected. Such pipe may be quarantined for further inspection and acceptance by the purchaser's representative. Pipes having a coating of insufficient thickness shall not be repaired by over coating.

9.5 Holiday detection

Each pipe shall be inspected for holidays over 100 percent of its coated surface using a high voltage DC detector in accordance with NACE RP0490.
A conductive rubber, wire brush or rolling electrode shall be applied to the coated surface and moved at a rate not exceeding 300 mm/sec over the whole pipe length. The electrode shall directly contact the entire surface of the coating being inspected. There shall be no gaps between the electrode and the surface of the coating, including the surfaces and the toe on each side of the weld seam of the pipe.
All holidays indicated either by spark and/or equipment alarm shall be marked by the operator with a waterproof marker.
For automatic holiday detection systems, all holidays indicated by spark shall sound an equipment alarm and shall be marked by an automatic paint spray system. Such automatic equipment shall be monitored.
Copper, copper alloy and bronze contact electrodes shall not be permitted if their use is ineffective, or if their use is detrimental to the line pipe, or the FBE coating. Their use is subject to approval of the purchaser.
The applicator shall demonstrate to the purchaser's representative at the start and middle of a shift, before the holiday detector is shut off at the end of a shift, and after prolonged (not intermittent) holiday detector shut down, that the holiday testing equipment is capable of detecting deliberate holidays. These shall be in the coating on a calibration pipe, produced with a 0.8 mm drill. This pipe shall be retained for calibration purposes. Calibration runs shall be carried out at the travel speed to be used in at 300 mm per second.
The voltage used for all holiday detection shall be at least 5V per micron of coating film thickness based on nominal coating thickness. If the holiday tester is of the constant voltage type, testing shall be carried out only on a dry coating. The operating voltage between electrode and pipe shall be checked for each calibration run.
All holidays and other defects shall be marked clearly and indelibly for subsequent repair and retesting. On re-testing, no holidays shall be permitted in the final coating.
The pipe identification number and the number of holidays (if any) for each pipe length shall be recorded by the applicator.
The detector shall be calibrated at least twice every working shift (every 4 h). Inspection shall be performed when the temperature of the coating is less than 80 ^{0}C.
For dual layer FBE coating, for a 12 m nominal pipe length, the maximum number of allowable coating defects (holidays) (inclusive of damage caused by testing and handling), shall be as follows:

Outside Diameter of Pipe, nominal	Maximum Number of Coating Holidays Allowed per Pipe
up to 200 mm (8 inches) pipe diameter	4
200 mm (8 inches) up to 600 mm (24 inches) pipe diameter	6
600 mm (24 inches) pipe diameter and above	8

The maximum single area to be repaired shall be 25 cm^2 and the maximum total area per pipe that may be repaired is 40 cm^2.
Coated pipe having holidays in excess of those given above shall be stripped and recoated at no additional cost to the purchaser.
No holidays shall be permitted in finished coating. Coated pipe having holidays shall be repaired in accordance with clause 10.

Note:
Weak areas normally occur on pipe with slivers. If the sliver penetrates to within 25 μm to 50 μm of the surface, the holiday detector can burn through the coating.

10. COATING REPAIRES

Applicator shall submit detailed coating repair procedures for approval by purchaser. These shall detail minimum/maximum areas for which each type of repair is applicable. Only manufacturer's recommended two-part epoxy repair systems shall be used. No thermal patch stick repairs shall be allowed. Prepared areas for repair shall be tapered and the repair material applied according to manufacturer's recommendation and in a workmanlike manner.
No single defect shall exceed an area of 25 cm^2. Pipes with a total repaired area exceeding 40 cm^2 shall be cause for rejection.
Repairs shall provide a finished coating equal in effectiveness to that of the parent coating.
If the number of holidays per pipe exceeds the figures stated above, the coating shall be removed and the pipe shall be re-blasted and re-coated. If two consecutive pipes are rejected for this reason, the coating process shall be checked to determine the cause of the high holiday rate. If the cause is not resolved after further rejection of consecutive pipes, the complete process shall be stopped for full investigation.
Each repaired area shall be holiday tested in accordance with clause 9.5 of this standard specification.
Shrink sleeves are not considered an acceptable repair.

10.1 Test Failure

In the event that a production coated pipe fails to meet the acceptance criteria for a specified test, or if the number of holidays detected is excessive, or if the total area of holidays detected is excessive, the pipe shall be rejected and stripped unless approval is given by purchaser.
The pipe joint preceding and following a rejected pipe in the same production run shall be similarly tested. If both are acceptable, the remainder of the pipe in that batch shall be accepted. If either of the two pipes fails the same test, the applicator shall provide a re-test schedule for purchaser’s approval. The schedule shall determine what pipes are defective since the last acceptable test pipe.
The purchaser retains the right to reject any shift's or day's production if the reject rate of that production is more than 10% and/or if sample test results are found to be outside the specification in this standard specification.

10.2 Stripping of Failed Coated Line Pipe

Applicator shall submit a coating stripping procedure for rejected pipes to purchaser for review and approval. Stripped pipe shall not be allowed to oxidize prior to re-blasting and coating. Re-blasted pipe surface shall be checked with magnifying glass (X30) to confirm no residues of FBE remain in the anchor pattern valleys. All pipes to be recoated shall be subjected to all of the processes starting at incoming inspection rack.

11. DOCUMENTATION

The applicator shall furnish certificates of compliance stating that the coating has been applied, inspected, and tested in accordance with the requirements of this standard specification and any other requirements specified in the purchase order (if any), and the results of the coating tests and other required tests have been found to conform to such requirements.

The applicator shall submit to purchaser the following documentation prior to the delivery of coated pipe to purchaser:

- Mill certificates for line pipe received;
- Manufacturer's certificates for each batch of coating materials;
- Certification/calibration certificates for all testing and coating equipment;
- Inspection and test, records, results, and other documentation of all material and PQT and production coating tests.

All reports shall be signed by applicator to signify applicator compliance with the requirements of this standard specification.

12. MARKING

Unless otherwise specified by the purchaser, the following information shall be marked a minimum of 0.3 m clear of the ends of the pipe, on each length of coated pipe with a permanent weatherproof marking system:

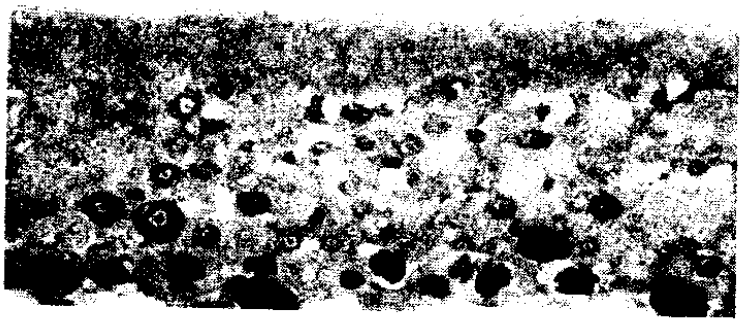
a) Date of coating (year, month, day);
b) Coating applicator's name or trademark;
c) Coating purchase order No.;
d) Coating sequence No.;
e) Nominal coating thickness, in micrometers;
f) Pipe specification and steel grade;
g) Pipe length, diameter and wall thickness;
h) Coating brand identification;
i) Pipe number (where applicable);

13. HANDLING AND STORAGE

Receipt, unloading, handling and storage of coated pipes shall be in accordance with Appendix A.

14. SAFETY

Applicator shall make all necessary provisions (with regard to materials, equipment, personnel, procedures and practices) to assure that work is done safely and that the working area is kept free of all health and safety hazards.
Applicator shall ensure that adequate health and safety precautions are observed during all storage, handling, application, and drying periods of materials. Applicator is specifically directed to consult the current Material Safety Data Sheet (MSDS) for each material, and to consult current OSHA and/or ANSI bulletins on safety requirements when using any product in a confined space or closed area.
Purchaser shall review all safety procedures and plant facilities of the applicator.
Applicator shall submit a Health and Safety Plan that conforms to purchaser Health and Safety Plan.
If the work cannot be performed safely and without health hazards, Inspector will shut down the job.



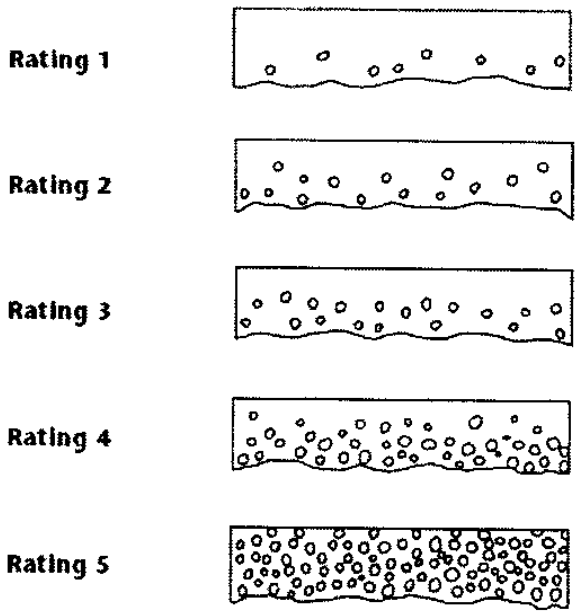
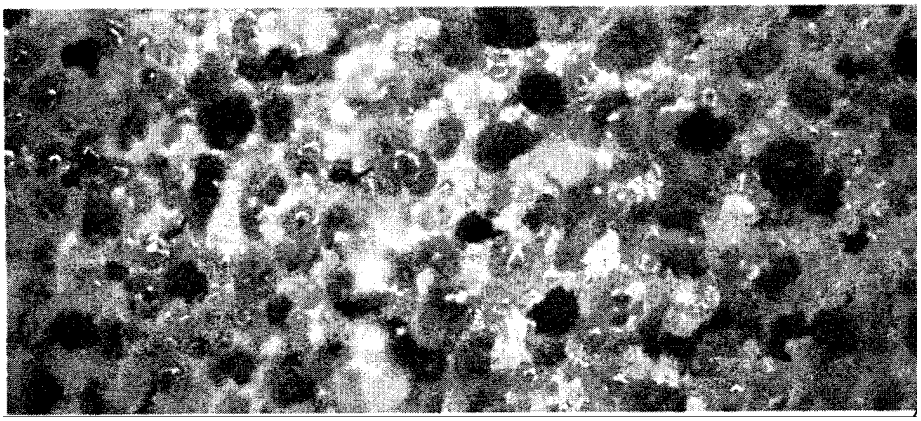


Figure 1- maximum allowable cross-section porosity



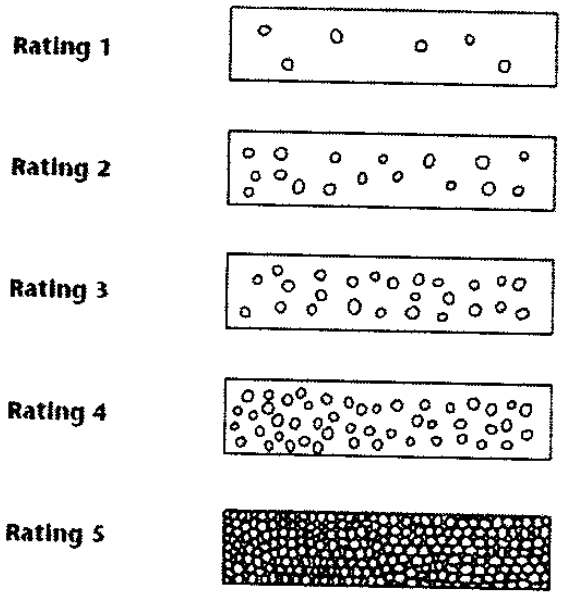


Figure 2- maximum allowable interface porosity

"APPENDIX A"
Receipt, Unloading, Handling and Storage of Materials

A.1 Acceptance of Pipe

Before the coating process starts, all pipes shall be inspected and checked carefully for surface condition. Pipe that fails this inspection shall be rejected and shall require rectification prior to re-inspection and acceptance.
Pipe furnished by the purchaser, or other pipe mill, and received by applicator shall be deemed to be in the custody of applicator from the time of receipt until returned to purchaser (as coated or rejected line pipe).
Applicator shall inspect and accept responsibility for each length of line pipe, and other purchaser supplied material, immediately upon receipt, with the exception of defective materials that cannot be detected until after blast cleaning.
All pipes shall be inspected for bevel damage, excessive weld seam height, dents, gouges, laminations, slivers, flat ends, corrosion and other damage.
Defects shall be recorded by applicator and verified by purchaser's representative. Inspection of bare pipe for laminations and other steel surface defects shall be performed before and after pipe blast cleaning.
Bevel protectors shall be removed before the pipe travels through the coating plant and be replaced with the same, or new, caps after the pipe is coated.
Bevel protectors shall be such that they do not damage adjacent coated pipes when they are stacked.
Damage caused to the pipe while in the custody of applicator shall be reported to purchaser and repaired by applicator to the satisfaction of purchaser’s representative. The cost of such repair work and the replacement cost of any material lost or spoilt shall be borne by applicator.
No repair work, other than cosmetic grinding, shall proceed until a written repair procedure has been approved by purchaser.
Identification marks stenciled on the pipe, shall be recorded by applicator before commencement of surface preparation. Applicator shall mark a unique reference number on the inside of the pipe for tracking during coating operations. Certification documents accompanying the pipes shall be preserved by applicator.
All pipes shall be visually examined for external and internal contamination for items such as oil, grease, temporary coatings, chlorides or other substances which may affect the blast cleaning, FBE coating adhesion and process plant.

A.2 Pipe Handling

All pipe handling equipment, lifting gear and procedures shall be subject to purchaser review and approval prior to use. Vacuum lifting is acceptable.
Pipe shall be handled in a manner that prevents damage to the pipe and its coated surfaces.

End hooks, suitably radiused and lined with plastic or similar approved material, or a fork lift with suitably padded forks, shall be used to lift the pipe. A spreader bar shall be used between lifting lines. During handling the pipe shall be representative. Wire ropes shall not be used in direct contact to lift bare or coated protected from impact.
Purchaser's representative shall be advised of any pipe suffering impact and this pipe shall be placed in quarantine until it is inspected and accepted by the purchaser pipes. Copper and copper alloy materials shall not be in contact with line pipe, or used for lifting devices.

A.3 Pipe Stacking and Transportation

Pipe shall be stacked in such a manner so as to prevent damage to the pipe or coating. Applicator shall submit his proposed stacking arrangements, including supporting calculations, stacking heights, separators and supports for purchaser review and approval prior to stacking pipe.
Pipe in a given stack shall be of the same diameter, wall thickness and grade of steel and shall be clearly marked. For safety reasons and to limit damage, the maximum stacking height for bare and coated pipe shall not exceed the following:

Outside Diameter of Pipe (inches), nominal	Maximum Number of Layers
8 and below	10
10 to 12	7
14 to 20	5
24 and above	4

All pipes shall be stacked on level ground, but at a slight slope to allow drainage.
The ground shall be free from foreign materials, stones and vegetation and on supports of a proven load bearing capacity. Pipes shall be suitably spaced from the soil (minimum 150 mm) to prevent any contact with the ground and to prevent surface water from entering the pipe during the entire storage period.
Pipe shall also be protected from exposure to wind-borne salts and salt spray.
Pipe stored outdoors shall be rotated at least every 60 days.
The bottom layer of pipe in any stack shall be supported on wooden bearers, or windrows with suitable plastic sheeting. Timber bearers shall be nominally 200 mm wide and placed within 1.5 m of each pipe end and at intervals not greater than 5.5 m along the pipe length. Pipes supported on windrows shall be placed nominally within 2.5 m of each end of the pipe. For pipes of length in excess of 12 m nominal, additional windrows shall be used. The ends of each pipe row shall be secured to prevent movement of the pipe in the stack. The second and subsequent layers of bare pipe may be nested on top of the previous layers.

Separation between coated pipe joints in a stack shall be provided by use of PE/PE rope separators securely attached to the pipe. The rope separators shall be placed nominally at 1.5 m for each pipe end and at nominally 3 m spacing along the pipe length. The diameter of the rope separator shall not be less than 19 mm for pipe of diameter up to and including 324 mm (12 inches) nominal and 25 mm for larger diameter pipe.
Pipes shall be secured to the transport vehicle using non-metallic slings or straps in a manner that prevents movement of the pipes during transport. Where pipe is in contact with supports or bolsters and securing devices, the pipe coating shall be protected from damage. All supports or bolsters shall be a minimum 150 mm wide. A minimum of 3 bolsters shall be used for 12 m lengths and 4 bolsters for 18 m lengths. Individual pipes shall be separated during transport by utilizing the rope separators that were applied after coating.

A.4 Damage to Pipe Ends

All major damage to pipe ends/bevels, including dents or gouges, shall be repaired by machine removal of damaged pipe material and re-beveling. No welding on the pipe surface shall be allowed.
Minor damage to pipe ends/bevels may be repaired by grinding. Minor damage shall mean damage that is less than 1 mm in depth. The purchaser's representative shall be consulted for damage deeper than 1 mm. The decision to repair or reject shall be made by the purchaser.
Repair by grinding on the outer surface of pipe ends/bevels shall not reduce the wall thickness to less than 95 percent of the nominal pipe wall thickness, or as specified on the relevant standard, when measured using ultrasonic thickness measurement equipment and provided the hardness does not exceed specified limits. The requirements of IPS-M-PI-190(2) shall be maintained.
Pipe identification numbers shall be preserved during repair and due allowance for cut-off ends shall be made in the tally of pipe lengths returned to purchaser.
Re-prepared ends shall be inspected for geometric conformance with the line pipe Data Sheet. Any information stamped onto the cut-off bevel shall be transferred to the re-prepared pipe end using low stress round nosed stamps.
Any reduction in pipe lengths shall be notified to the purchaser in order that the data can be entered into the purchaser’s pipe tracking system.

A.5 Material Control Records

Applicator shall record the receipt, issue return or disposal of all materials supplied by purchaser and shall permit inspection of those records by purchaser at all reasonable times. In particular, the records shall include the unique pipe number of each pipe.
Applicator shall submit details of material control recording procedure to purchaser for review and approval prior to commencement of the works.
Applicator shall submit details of his traceability procedure for purchaser's review and approval prior to commencement of the work. All details marked on pipe joints when received shall be preserved for each pipe joint during and after the coating process.

A.6 Handling and Storage of Coating Materials

Material used for coating provided by applicator shall be clearly marked with the following details:

- Name of manufacturer;
- Material identification;
- Batch number;
- Date and place of manufacture;
- Quantity;
- Expiry date;
- Manufacturing standard.

Materials shall be handled and stored in accordance with applicable safety regulations and the material manufacturer's recommendations. The materials shall be used sequentially according to the manufacturer's batch sequence instructions.
The containers or packages of materials shall be properly handled in order to avoid damage and stored in a manor to prevent deterioration contamination of raw materials.
Storage temperatures and conditions for coating materials shall be as specified by the manufacturer.

A.7 Storage of Coated Pipes

Coated pipes shall be stored a minimum of 150 mm clear of the ground in such a manner as to minimize corrosion to the uncoated parts of the pipe and prevent damage to the pipe and the coating. No uncoated section of pipe shall be in contact with the soil.
When pipes are supported on timbers, the pipe supports shall be placed nominally within 1.5 m of each end of the pipe and at intervals not greater than 5.5 m measured along the pipe.
The bottom layer of pipe in any stack shall be supported on wooden bearers or wind-rows. Timber bearers shall be nominally 200 mm wide padded with rubber, felt or similar material, and the ends of each row shall be securely chocked to prevent movement of the pipes in the stack. When pipes are supported on wind-rows covered with suitable plastic sheeting, the pipe supports shall be placed nominally within 2.5 m of each end of the pipe. For pipes in excess of 12 m length, additional wind-rows may be required. Pipe separators shall be used to prevent contact between the coated pipes. A minimum of three separators shall be used for double random pipes, and 5 separators shall be used for triple random lengths.

"APPENDIX B"
Applicator's Coating Plant Qualification

The following equipment requirements are prerequisites for the application of coatings. Failure to comply with any portion of this section is potential cause for cessation of coating operations or non-award of a bid. However, these plant qualification for application of FBE to purchaser pipe and fittings do not imply that a coating plant is automatically acceptable to purchaser solely on the basis of meeting these requirements.
Applicator shall have a detailed Quality Control Plan (QCP) documented and available to purchaser.
Applicator shall obtain from the coating manufacturer certification for each batch of material used to coat line pipe and fittings. A batch shall be defined by the coating manufacturer, but cannot exceed the quantity produced by the coating manufacturer in an eight-hour period from one production line.
Certification shall include a statement from the coating manufacturer that no changes have been made in the formulation, raw materials, origin, or manufacturing procedure since the product was last tested and/or approved by purchaser. When advised of any such changes, purchaser shall promptly review and/or test the product for re-approval.
All plant equipment shall be in a safe operating mode and in good working condition, and staffed by knowledgeable personnel.
The plant shall have an operational preheater system to remove moisture from the surface of pipe or fittings. Preheating shall be sufficient to ensure that the pipe temperature is at least 3 ^{0}C above the dew point temperature during abrasive blast cleaning and inspection.
Any air lines supplying air knives, lances or other air impingement implements shall have operative condensate traps to assure that no moisture, oil, or other contaminants are deposited on the pipe or fitting. Applicator shall blow the trap twice per shift.
The powders system shall have a source of clean, dry air, and the dew point temperature must be no higher than -29 ^{0}C. The air dryer shall have instrumentation to monitor dryness, or applicator shall arrange proof testing of air dryness by a testing purchaser at his/her expense.
Fluidized beds shall have magnets adequate to remove iron and steel shaving contamination from the virgin and recycled powder.
The powders system shall have an operational automatic fire suppressant system.
The plant shall have the means, such as a water truck, to suppress dust in the yard.
Applicator shall have a laboratory or testing facility at the plant site for performing all production quality-control tests. Laboratory shall have the following test equipment for such tests:

A. Equipment for preparing test rings and a power saw for cutting straps from the test rings;
B. Refrigeration equipment that can achieve -23 ^{0}C;
C. A strap-bending apparatus of either a four-point or mandrel style;
D. Microscope of at least 30X or greater power;

E. Equipment for cathodic disbondment testing in accordance with the applicable section(s) of ISO 21809-2;
F. Equipment for measuring coating thickness, temperature, and anchor pattern profile;
G. A full set of coating thickness calibration standards for twice-daily calibration of coating thickness gauges. The calibration standards shall be free from corrosion, nicks, and scratches, which may create false readings;
H. Ultrasonic thickness gauge, with steel calibration block approximating the thickness of the pipe or fitting to be coated;
I. Holiday detector with both visual and audible alarms and a visual voltage output meter;
J. Visual standards for contamination, voids, and matching curves for bending;
K. Stainless steel gel plate.

The powders shall be delivered to the plant in a refrigerated container.
The plant shall have a powders storage room capable of storing the coating materials per coating manufacturer's recommendations.
The plant shall have an internal blowout and debris collection system to remove loose scale, dirt, and abrasive from the pipe interior. Abrasive materials shall not be recycled unless automatic reclamation equipment is used.
Powders system shall be automated, and have the means to filter virgin and recycled powder through a 70-mesh screen. Reworked powder shall not be used.
Spider grinders or facing machines shall be available at the plant site for refacing of cutoffs or damaged bevels, with purchaser approval.

"APPENDIX C"
Coating of Pipe Fittings and Bends

This Appendix shall apply only for buried fittings, including bends and valve bodies that are coated in the shop with the dual layer FBE system. Manual methods shall be used and this will place practical size limitations on what components can successfully be coated with this process.
A detailed field coating repair procedure for fittings shall be provided for purchaser review and approval. This procedure shall be demonstrated as part of the PQT.
For the dual layer FBE coating, the coating shall be applied in 2 layers with the ratio of 1st layer = 1/3 rd of total thickness and 2nd layer = 2/3 rd of the required thickness.
The total coating thickness shall be not less than 400 µm and shall be not more than 1000 µm.

C.1 Coating Procedure Qualification Test (PQT) for Fittings

The applicator shall provide a detailed written procedure covering all aspects of the coating process for fittings for review and acceptance by purchaser before proceeding with the PQT. This procedure shall include details of how repairs to coatings are to be controlled and performed.
The test regime given in Table 2 shall be used as the basis of the PQT procedure.
For induction bends, actual drop pieces from the bend mother material shall be used for the PQT and production tests. Drop pieces may be welded together to obtain a length sufficient enough to simulate the actual coating process. The weld must be ground smooth prior to surface preparation.
All aspects of the procedure qualification shall require witness by purchaser representative. All results shall be acceptable for the procedure to be qualified. The PQT shall be subject to the following tests as a minimum.

C.1.A Visual inspection
Prior to coating, each fitting shall be clean with correct surface finish and profile, there shall be no surface contamination.
The coated surface shall be smooth, free of detrimental defects, imperfections, dust, grit or other harmful impurities.

C.1.B Coating thickness
The coating thickness shall be measured using an approved magnetic or electromagnetic thickness gauge. Measurement shall be made around the complete circumference and shall fairly sample the entire coated area. At least 12 measurements shall be made for each fitting.

C.1.C Holiday inspection
The coating of each fitting shall be 100 percent tested for “holidays” using a high voltage DC holiday detector. Detector can be either a constant or a pulsed voltage type. The operating voltage between the electrode and pipe shall be maintained at a minimum of 5 volts per micron of nominal coating thickness.
There shall be no holidays.

C.1.D Cure

Cure shall be checked by DSC testing. Representative samples shall be taken by removing chippings or curls of applied coating and the samples shall be packed into bags and sealed to prevent water pick up. The samples shall be sent for laboratory testing witnessed by purchaser.

Acceptance of the coating shall be based on the DSC test result.

The applicator shall provide his procedure for proving full cure of coatings.

C.2 Coating of Fittings

Fittings shall be coated in the shop after completion of welding and NDE activities.

The environment for preparation of the area and application of the coating shall be controlled to prevent contamination and inconsistency of the finished coating.

The applicator shall provide a detailed written procedure covering all aspects of the production coating process for fittings for review and acceptance by purchaser before proceeding with the work.

This procedure shall include details of how repairs to coatings are to be controlled and performed. The test regime given in Table 4 shall be used as the basis of the production testing procedure.

C.2.A Surface preparation of welded area

All weld slag and spatter in area to be coated shall be removed by mechanical means.

Area for coating shall be cleaned of all surface contaminants using a solvent cleaner.

The use of sand as a blasting media is NOT permitted.

The surfaces of the area to be coated shall be blasted until a finish of ISO 8501-1 Sa3 is attained.

No blast cleaning shall take place when the prevailing relative humidity is greater than 85 percent unless the fitting is preheated to at least 3 ^{0}C above the dew point or 25 ^{0}C whichever is greater.

The surface cleanliness of all fittings shall be visually inspected. The surface profile (anchor pattern) of a representative number of fittings shall be measured and shall be between 60 and 100 microns, (measured peak to trough). Surface profile shall be measured using suitable equipment such as replica tape or Rugosity meter. The Applicator preferred technique shall be demonstrated as suitable and subject to purchaser acceptance.

The blast cleaned surface shall not be contaminated with dirt, dust, metal particles, hydrocarbons, water, chlorides, sulfates or any other foreign matter which would be detrimental to the coating and its application. Prior to the coating application, the exterior surface shall be thoroughly inspected under adequate lighting. All surface imperfections such as slivers, scabs, burrs, gouges, or sharp edge defects, shall be removed by grinding and the area re-blast shall be cleaned.

C.2.B Heating

To permit coating cure, the fitting shall be uniformly preheated using suitable ovens, induction, resistance or radiant heaters. The temperature of the fitting shall be 232 ^{0}C to 253 ^{0}C, or as otherwise specified by the powder manufacturer data sheet, for coating application. Full coating details shall be submitted as part of the coating procedure to purchaser for review and approval.

The fitting metal temperature shall not be sufficient to promote the formation of oxides. The powders shall be applied by hand flocking. Care shall be exercised at all times to avoid over thick coatings and the applicator shall provide his procedure indicating control of maximum coating thickness for purchaser approval.
The use of recycled powders shall not be permitted.

C.2.C Visual inspection
Coated fittings shall be 100% visual inspected by a qualified coating Inspector.
The coated surface shall be smooth, free of detrimental defects, imperfections, dust, grit or other harmful impurities.

C.2.D Coating thickness
The coating thickness shall be measured using an approved magnetic or electromagnetic thickness gauge. Measurement shall be made around the complete circumference and shall fairly sample the entire coated area. Thickness shall be measured at 8 points on each fitting.

C.2.E Holiday Inspection
The coated area of each fitting shall be 100 percent tested for “holidays” using a high voltage DC holiday detector. Detector can be either a constant or a pulsed voltage type. The operating voltage between electrode and item shall be maintained at a minimum of 5 volts per micron based on the nominal coating thickness. Travel speed shall be no less than 300 mm per minute and the holiday tester shall not be repeatedly passed over the coating such that burn through occurs.
There shall be no holidays.

C.2.F Cure
Cure shall be checked by DSC testing. Representative samples shall be taken by removing chippings or curls of applied coating and the samples shall be packed into bags and sealed to prevent water pick up. The samples shall be sent for laboratory testing witnessed by purchaser as soon as possible. A solvent wipe test may be used for a quick production cure check only.
Acceptance of the coating shall be based on the DSC test result.
The applicator shall provide his procedure for proving full cure of coatings.

C.2.G Repairs
Any unacceptable defects or imperfections that are detected shall be repaired in accordance with the approved repair procedure, and re inspected using the method that detected the defect and also with holiday detection. Details including dimensions and locations of repairs shall be recorded in the pipeline construction records.
All repairs shall be inspected as per the original coating, visual inspection, coating thickness measurement and holiday detection shall be performed. All results shall meet the same requirements as those specified for the original coating.

"APPENDIX D"
Dry Adhesion Test

D.1 Equipment

The following equipment is required
a) Utility knife, (see A.2.1 (h) ISO 21809-2).

D.2 Test Specimens

Test can be carried out in site on pipe or on laboratory sample/test ring.

D.3 Procedures

D.3.A Inscribe a V-cut with two 20 mm lines intersecting at approximately 5 mm from their ends at 30^0 to 45^0.

D.3.B Insert the blade of the knife at the point of the V-cut, 45^0 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 V at least 4 times to confirm the integrity of the coating.

D.3.C When tested, the adhesion of the coating system shall be such that any attempt to remove the coating shall result in a cohesive break in the coating material and not in an adhesive failure of the coating/substrate interface.

An adhesive breakaway from the point of interaction of more than 2 mm, or a brittle breakaway of flakes of more than 2 mm constitutes a failure.

Absence of peeling, or a cohesive break less than 2 mm long entirely within the coating, constitutes a pass.

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

For qualification testing, the adhesion of coating system shall also be tested by the dolly pull off method. The pull-off adhesion strength shall be more than 10 N/mm^2 and the failure mode shall be cohesive for more than 75% of surface area.

D.4 Results

The following information shall be recorded:

a) epoxy powders batch number;
b) date of testing;
c) adhesion rating.

Testing of production coating requires pipe number or identification.

"APPENDIX E"
Gouge Resistance of Coating

E.1 Equipment

The equipment shall consist of the following:

(a) A shear-scratch test apparatus with the following features:

(i) A variable-speed crosshead-style materials test instrument or variable-speed control drive apparatus;
(ii) An adjustable loading mechanism for the test beam or carbide tool, capable of applying a 50 kg load;
(iii) A smooth carbide tip (i.e., SL-1) or a carbide burr (i.e., R-33); and
(iv) Steel shims in various thicknesses.

(b) A coating thickness gauge; and
(c) A gouge-depth dial gauge.

E.2 Test Specimens

Laboratory-coated test specimens shall measure approximately 76 ×102 mm (or be sized to suit the test apparatus). Specimens from test rings shall be of the same dimensions as the laboratory-coated samples.

E.3 Procedure

- Visually inspect each specimen for imperfections and ensure that the temperature of the sample is 20 ± 3 ^{0}C prior to conducting the test. Perform two tests on each specimen.
- Use a calibrated coating thickness gauge to take at least six measurements on the surface of the test panel (ideally in the regions of the panel to be gouge tested) and report the average thickness.
- Place the test specimen (coating side facing the gouge tip) on the fixture cart. Secure the specimen with the longitudinal direction parallel to the cart track movement direction. If necessary, use steel shims to level the specimen on the cart.
- Install the appropriate test bit on the bit-holder of the fixture beam. Position the beam and test bit over the coating surface at a sufficient distance to allow a minimum gouge travel length of 75 mm. Ensure that the test beam is parallel to the coating surface and that the gouge bit is perpendicular to the surface to be tested.
- Perform the following steps:

(a) Adjust the materials test machine or drive mechanism to produce a travel speed of 25.4 cm/min;
(b) Perform the gouge test on the coating at the first test location;
(c) Remove or reposition the test sample to perform additional tests.

- Mark each gouge approximately 10 mm from the start of the scratch. Draw a line across all of the scratches, ensuring that the line is always at least 10 mm from the starting point of the scratches. Using this first line as a reference point, draw two more parallel lines 2.54 cm apart across the width of the specimen. The last line drawn should also be at least 10 mm away from the finish of the gouges. These three lines, which cross the width of the gouge, shall act as measurement reference points.
- Place the dial gauge over the undamaged area of the test panel and zero the dial reading. Position the dial gauge over the gouge, ensuring that the contact point drops into the bottom of the scratch. The gauge base should not rest on the gouges or the adjacent deformed coating; instead, it should rest on either side of this area. Record the depth of the scratches at the area where the scratches are intersected by the marked lines.

E.4 Report

The following information shall be reported to the purchaser by the applicator:

(a) The epoxy/overcoat coating and identification and batch numbers;
(b) The date of testing;
(c) The total and individual coating thickness of applied powders;
(d) The load used for testing (50 kg);
(e) The type of carbide tip used;
(f) Recorded gouge depths.