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Fusion Bonded Epoxy Coating on Internal Surface of Line Pipe, Girth Weld Joints and Fittings

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Fusion Bonded Epoxy Coating on Internal Surface of Line Pipe, Girth Weld Joints and Fittings

Foreword

This AMPP standard practice provides guidelines for determining requirements for the internal lining of pipes, field girth weld joints, custom-made pipe spools, and fittings with fusion bonded epoxy (FBE). FBE is a thermosetting resin coating that is applied to the internal surface of steel pipes using a specialized coating process. FBE coatings are highly effective in protecting pipes from corrosion and other forms of degradation. FBE-lined pipelines are generally used for handling various kinds of fluid found in the Oil and Gas sector, viz. effluent water, oily water with traces of hydrocarbon gases, treated water, brackish water, and well injection water.

This standard is intended for use by corrosion control personnel, design engineers, specifiers, construction engineers and managers, pipeline contractors, and coating applicators (shop and onsite). The use of this standard in concurrence with the FBE manufacturer's recommendations will reduce the likelihood of improper application and optimize the long-term corrosion protection performance of the FBE lining system.

The coating system outlined in this standard is designed to offer a substantial level of protection against corrosion. However, it is crucial to acknowledge that the effectiveness of the coating may be influenced by various factors, including the specific operating conditions and the chemical composition of the material being transported. Consequently, the utilization of supplementary anti-corrosion measures, based on the operation and service fluid dynamics, such as inhibitors, may be necessary under certain circumstances.

FBE internal coating offers multiple benefits, including increased flow performance through reduced friction, reduced scale adhesion, and acting as a corrosion barrier. Ensuring the quality of FBE coatings, primarily used for corrosion control, is essential for maintaining their effectiveness and longevity. This standard aims to provide manufacturers, suppliers, and operators with the minimum requirements to ensure FBE acts as a corrosion barrier. The purchaser may adapt these requirements as necessary when FBE is used for purposes other than corrosion control.

Rationale

FBE is a widely recognized and effective coating system for protecting steel pipes from internal corrosion in oil and gas pipelines. Currently, there are no definite standards that provide the requirements for a pipeline internal lining with FBE. This standard aims to establish a uniform approach to FBE application and ensure that the resulting coatings meet the necessary performance standards.

Referenced Standards and Other Consensus Documents

Unless specifically dated, the latest edition, revision, or amendment of the documents listed in the table below shall apply.

AMPP/NACE/SSPC, www.ampp.org:	
NACE SP0188	Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates
NACE SP0287	Field Measurement of Surface Profile of Abrasive Blast-Cleaned Steel Surfaces Using a Replica Tape
NACE SP0394	Application, Performance, and Quality Control of Plant-Applied Single-Layer Fusion-Bonded Epoxy External Pipe Coating
NACE TM0185	Evaluation of Internal Plastic Coatings for Corrosion Control of Tubular Goods by Autoclave Testing
SSPC-AB 1	Mineral and Slag Abrasive
SSPC-AB 2	Cleanliness of Recycled Ferrous Metallic Abrasive
SSPC-AB 3	Ferrous Metallic Abrasive
SSPC-Guide 12	Guide for Illumination of Industrial Coating Projects
SSPC-PA 2	Procedure for Determining Conformance to Dry Coating Thickness Requirements

SSPC-SP 1	Solvent Cleaning
SSPC-SP 5/NACE No. 1	White Metal Blast Cleaning
SSPC-SP 10/NACE No. 2	Near-White Metal Blast Cleaning
SSPC-VIS 1	Guide and Reference Photographs for Steel Surfaces Prepared by Dry Abrasive Blast Cleaning
ASTM International, www.astm.org:	
ASTM D4060	Standard Test Method for Abrasion Resistance of Organic Coatings by the Taber Abraser
ASTM D4285	Standard Test Method for Indicating Oil or Water in Compressed Air
ASTM D4417	Standard Test Method for Field Measurement of Surface Profile of Blast Cleaned Steel
ASTM D4940	Standard Test Method for Conductimetric Analysis of Water Soluble Ionic Contamination of Blast Cleaning Abrasive
ASTM D6943	Standard Practice for Immersion Testing of Industrial Protective Coatings and Linings
ASTM G6	Standard Test Method for Abrasion Resistance of Pipeline Coatings
ASTM G73	Standard Test Method for Liquid Impingement Erosion Using Rotating Apparatus
American Petroleum Institute (API), www.api.org:	
API RP 5L1	Recommended Practice for Railroad Transportation of Line Pipe
API RP 5LW	Recommended Practice for Transportation of Line Pipe on Barges and Marine Vessels
Canadian Standards Association (CSA), www.csagroup.org:	
CSA Z245.20	Plant-applied external coatings of steel pipe
International Organization for Standardization (ISO), www.iso.org:	
ISO 8501-1	Preparation of Steel Substrates Before Application of Paints and Related Products – Part 1: Visual assessment of surface cleanliness
ISO 8502-3	Preparation of steel substrates before application of paints and related products – Tests for the assessment of surface cleanliness – Part 3: Assessment of dust on steel surfaces prepared for painting (pressure-sensitive tape method)
ISO 8502-6	Preparation of steel substrates before application of paints and related products – Tests for the assessment of surface cleanliness – Part 6: Extraction of soluble contaminants for analysis – The Bresle method
ISO 8502-9	Preparation of steel substrates before application of paints and related products – Tests for the assessment of surface cleanliness – Part 9: Field method for the conductometric determination of water-soluble salts
ISO 8503-4	Preparation of steel substrates before application of paints and related products. Surface roughness characteristics of blast-cleaned steel substrates. Method for the calibration of ISO surface profile comparators and for the determination of surface profile – Part 4: Stylus instrument procedure
ISO 8503-5	Preparation of steel substrates before application of paints and related products – Surface roughness characteristics of blast-cleaned steel substrates – Part 5: Replica tape method for the determination of the surface profile
ISO 11124	Preparation of steel substrates before application of paints and related products – Specifications for metallic blast-cleaning abrasives
ISO 16773	Electrochemical impedance spectroscopy (EIS) on coated and uncoated metallic specimens
ISO 21809-2	Petroleum and natural gas industries – External coating for buried or submerged pipelines used in pipeline transportation systems – Part 2: Single layer fusion-bonded epoxy coatings

In AMPP standards, the terms *shall* and *must* are used to state requirements and are considered mandatory. The term *should* is used to state something that is recommended, but is not considered mandatory. The term *may* is used to state something considered optional.

Section 1: Scope

1.1 This standard outlines the minimum requirements for FBE material qualification, surface preparation, application procedures (automatic & manual), inspection, quality control, repair, and documentation to ensure the integrity and performance of the FBE lining system for corrosion protection of steel pipes, custom-made pipe spools, field girth weld joints, and fittings in the Oil and Gas sector.

1.2 For quality execution and adherence to this standard, the work shall be executed by experienced and trained applicators for the project. Additionally, a qualified and certified coating inspector, such as an AMPP-certified coating inspector or an individual with equivalent training and expertise, shall be employed to ensure the quality of the applied coating throughout the process.

1.3 To ensure compliance with the approved specification. The purchaser's coating inspector shall be granted unrestricted access to both the production and testing areas throughout the project duration. This access allows the inspector to monitor progress and actively verify that the work performed aligns with the agreed-upon specifications.

1.4 This standard is not intended to restrict innovative approaches or discourage the development of alternative equipment or engineering solutions for individual applications. Applicators are encouraged to offer, and purchasers are not precluded from accepting, such alternatives, particularly when they involve novel or evolving technologies. However, details of the same shall be provided to the purchaser for approval.

1.5 While the supplier may provide technical recommendations and considerations, the purchaser shall make the final determination regarding the acceptability of any coating material.

1.6 It is the sole responsibility of users adopting this standard to define and implement appropriate safety, health, and environmental practices. These practices must demonstrably comply with all relevant regulations, including those pertaining to insurance requirements and directives.

Section 2: Definitions

Applicator: The organization that carries out fusion bonded epoxy coating application in accordance with this standard.

Application Procedure Specification (APS): Applicator-controlled document describing procedures, methods, equipment, and tools used for application of fusion bonded epoxy.

Coating Material: Fusion Bonded Epoxy (FBE) powder and phenolic-based liquid primer.

Cutback: Area of each section of line pipe that was left uncoated at the coating mill/plant to facilitate welding of adjacent pipe joints.

Field Girth Weld Joint Area: The area of pipe over which the coating is applied in the field after welding of adjacent pipes.

Fusion Bonded Epoxy (FBE) Powder: Single-part thermo-setting resin.

Holiday: A discontinuity in a protective coating that exposes unprotected surface to the environment.

Procedure Qualification Trial (PQT): Application of field joint coating and subsequent inspection/testing of its properties. T the APS results in an application of acceptable quality.

Purchaser/client/end user: Company owner or the authorized agency that has the authority over the pipe to which the coating is to be applied.

Repair Area: Area of the original coating system that has been damaged and is being repaired using the coating materials.

Service Temperature: Temperature range within which a material or component operates optimally without compromising performance or integrity.

Shelf Life: The maximum length of time packaged materials (for example, coating materials) can be stored, at specified conditions, and remain in usable condition.

Supplier: The manufacturer and/or distributor of the coating material and its authorized technician.

Test Ring: Sample taken from the pipe coated during production or a sample piece of similar material and dimension attached to the production pipe.

Working Shift: A designated work period, with a maximum duration of twelve hours, occurs within the company's operational facilities.

Section 3: Coating System

3.1 Selection of the coating system shall be based on the service fluid. The complete coating system shall be tested in accordance with Table 2 of this standard.

a) For sour service fluids: Primer coat and an FBE topcoat.
b) For non-sour service fluids: One coat of FBE. (Use of a primer coat is optional. However, if the purchaser requires a primer and top coat, their specification takes precedence).

3.2 Primers are typically phenolic-based liquid requiring a baking cycle. However, the FBE applicator may use an alternative primer with approval from the coating manufacturer and end user.

3.3 The application of a primer coat for field girth weld joints, in both sour and non-sour service environments, is contingent upon the recommendations of the FBE coating manufacturer. The supplier shall furnish all pertinent documentation for applicator and purchaser endorsement before project initiation. Nevertheless, the field girth weld joint coating system shall meet the requirements mentioned in Table 2 of this standard.

Section 4: Coating Material

4.1 The FBE coating material shall be a homogeneous, pre-combined, powdered compound comprised exclusively of epoxy resins, curing agents, pigments, fillers, catalytic additives, and flow modifiers. Upon application to a preheated substrate, this material will undergo fusion, flow, and subsequent curing to form a coating complying with the requirements of this standard.

4.2 Upon request, the coating material supplier shall furnish the following information in writing to the purchaser and/or applicator:

4.2.1 Product data sheets including operating temperature and pressure limits of the product,

4.2.2 Safety data sheets (SDS),

4.2.3 Batch certificate in accordance with Table 1 of this standard,

4.2.4 Product qualification test in accordance with Table 2 of this standard,

4.2.5 Instructions for handling and storing the coating material, including environmental conditions.

4.3 Labels of supplied epoxy powder boxes shall contain the following information:

4.3.1 Epoxy powder manufacturer's name,

4.3.2 Product description,

4.3.3 Product code/number,

4.3.4 Batch number,

4.3.5 Manufacturing location,

4.3.6 Manufacturing date and expiration date,

4.3.7 Temperature requirements for transportation and storage.

4.4 Batch certificate: Each batch of epoxy powder shall be provided with a test certificate in accordance with the requirements specified in Table 1. Along with the material manufacturer shall provide a batch certificate to the applicator.

4.5 The purchasing entity or applicator has the discretion to conduct any or all of the tests listed in Table 1, however, it shall be documented within the Application Procedure Specification (APS) and Inspection and Test Plan (ITP).

Table 1
Minimum Properties of the Epoxy Powder Provided in the Batch Certificate from the Supplier

Properties	Value Limits	Test Method
Density / Specific gravity	Within supplier's specification	NACE SP0394 or CSA Z245.20 or ISO 21809-2
Cure time	Capable of cure at temperatures and time specified by the supplier	According to supplier's specification
Gel time	Within supplier's specification or within 20% of the published value	NACE SP0394 or CSA Z245.20 or ISO 21809-2
Particle size	Max. retained on 150 µm (100 mesh) sieve; max. retained on 250 µm (60 mesh) sieve within the manufacturer's recommendation	NACE SP0394 or CSA Z245.20 or ISO 21809-2
Moisture content[(A)]	Max. 0.5%	NACE SP0394 or CSA Z245.20 or ISO 21809-2
Total volatile content[(A)]	Max. 0.6%	NACE SP0394 or CSA Z245.20 or ISO 21809-2
Thermal characteristics	Within supplier's specification	NACE SP0394 or CSA Z245.20 or ISO 21809-2

[(A)] Moisture content and total volatile content may be determined at the supplier's discretion.

4.6 Product Qualification Test

4.6.1 The requirement for product qualification testing shall be established based on the product's performance history. An FBE coating system shall be considered an established system if it has:

a) Successfully demonstrated its corrosion protection performance in the intended service or environment for a minimum period of five years.
b) All available test certificates demonstrating the performance.
c) No changes to the formulation since the successful demonstration.

4.6.2 An established FBE coating system, when used in the service or environment for which it was established, shall not require additional qualification testing if sufficient details of prior service use are provided and accepted by all parties.

4.6.3 An established FBE coating system intended for use in a new service or environment shall require qualification testing as per Table 2 of this standard.

4.6.4 A new FBE coating system with no prior service history shall be required to undergo qualification testing as per Table 2 of this standard.

4.6.5 The coating supplier shall provide a product qualification test certificate in accordance with Table 2. Laboratory tests shall be carried out at an independent, accredited laboratory.

4.6.6 The test specimens shall be either laboratory-prepared coupons in accordance with this standard or test rings/coupons collected from pipe coated at the factory. A minimum of three test specimens shall be tested unless otherwise specified in each test requirement.

4.6.7 Coating products intended for operation at a service temperature up to 95 °C shall undergo qualification testing by the supplier, as per the applicable test listed in Table 2, at the designated service temperature.

4.6.8 For coatings intended for service temperatures exceeding 95 °C, the tests outlined in Table 2 shall be carried out using samples preconditioned in an oven at a temperature 5 °C below their glass transition temperature (T_g) for a minimum of 30 days. Subsequently, the samples shall be conditioned at ambient temperature for 24 hours prior to testing. The test temperature shall be at a minimum equivalent to the service operating temperature. The supplier and the purchaser, prior to the start of the test, shall mutually agree upon testing parameters and acceptance criteria for the test procedures. Coating products shall be tested at the maximum service temperature.

4.6.9 The product qualification test shall be repeated if the epoxy powder formulation, composition, or manufacturing location changes.

4.6.10 The FBE repair material supplier and the purchaser shall mutually define the technical specifications, performance requirements, and quality control procedures for the FBE repair materials, ensuring their compatibility and effectiveness for the intended application.

4.6.11 The abrasion and erosion test shall b fluid is anticipated to abrade or erode the FBE coating during operation. The purchaser is required to provide comprehensive details of the service fluid to the supplier to ensure a suitable FBE coating is proposed. These de-tails shall include, but not be limited to, the chemical composition, pH level, temperature, viscosity,total suspended solids, particle size and type, flow rate, pressure, and corrosive properties.

Table 2
FBE Qualification Test Requirements

Test	Acceptance Criteria	Number of Test Specimens	Test Method
Glass Transition Temperature	Coating T_g value shall be at least 5 °C above the pipeline design temperature or in accordance with the supplier's specification.	1	NACE SP0394 or ISO 21809-2
Degree of conversion	≥ 95%	1	NACE SP0394 or ISO 21809-2
Cross-section porosity	Rating of 1 to 2, inclusive	3	NACE SP0394 or CSA Z245.20 or ISO 21809-2
Interface porosity	Rating of 1 to 2, inclusive	3	NACE SP0394 or CSA Z245.20 or ISO 21809-2
Chemical resistance[A]	Absence of blister, cracks, delamination, softening, and loss of adhesion.	1	ASTM D6943
Abrasion Resistance	In accordance with supplier's specification	3	ASTM D4060
Slurry Resistance	In accordance with supplier's specification	3	ASTM G6
Impingement Erosion Resistance In accordance with supplier's specification[3]			ASTM G73
24 h, Hot water adhesion 95 ± 3 °C	Rating of 1 to 2, inclusive	3	NACE SP0394 or CSA Z245.20 or ISO 21809-2
28 d, Hot water adhesion 95 ± 3 °C	Rating of 1 to 3, inclusive	3	NACE SP0394 or CSA Z245.20 or ISO 21809-2
Flexibility: 3.0° /PD permanent strain at 0 °C, -18 °C, or -30 °C	No cracking	3	NACE SP0394 or CSA Z245.20 or ISO 21809-2
Electrochemical Impedance Spectroscopy (EIS)	Greater than 10^8 ohms·cm^2 at 0.1 Hz	3	ISO 16773
Autoclave Testing: Mixture of Gas, Water and Crude Oil [B] [C]	No coating defects (blisters, cracks, delamination) exposing the steel substrate.	1	NACE TM0185

[A] Test fluid may be a mixture of hydrocarbon oil and gas, H_2S, CO_2, and water, or a test fluid equivalent to the purchaser's service requirement.
[B] Temperature, pressure, and test duration shall be mutually agreed upon by the supplier and the purchaser. At a minimum, the test temperature and pressure shall be equivalent to the service conditions.
[C] Test fluid shall be a combination of water, salt, hydrocarbon oil, and hydrocarbon gas (including H_2S and CO_2), equivalent to actual service fluid or laboratory crude oil mixture.

4.7 Preparation of Laboratory Test Specimen

4.7.1 The test specimen shall be hot-rolled carbon steel and have dimensions in accordance with the test method specified in Table 2.

4.7.2 All the test panels shall be abrasive blast cleaned using an acceptable steel grit to achieve surface cleanliness of SSPC-SP 5/NACE No. 1. The surface profile when measured in accordance with NACE SP0287 shall be 50 to 100 µm (2.0 to 4.0 mil).

4.7.3 The application and curing of the completed coating system shall strictly adhere to the written recommendations of the FBE supplier. The maximum allowable temperature during the entire application and curing process shall not exceed 260 °C (500 °F).

4.7.4 The thickness of the FBE coating system on the completed test specimen shall be at a minimum DFT of the supplier's specification when measured with a calibrated magnetic pull-off thickness gauge in accordance with SSPC-PA 2 Level 2.

4.7.5 The test specimen shall be holiday tested in accordance with NACE SP0188. There shall be no holidays. In case of holidays, the sample shall be rejected and reprocessed.

4.8 Preparation of Test Ring

4.8.1 The test ring shall be a sample piece of similar material and wall thickness to that of the production pipe. Unless otherwise specified by the purchaser, the test ring shall not be greater than 500 mm in length.

4.8.2 The test ring may be a separate sample piece attached to the production pipe or a sample piece obtained from the production pipe. This requirement shall be as per mutual agreement between the applicator and the purchaser.

4.8.3 The test ring shall undergo all the steps (from surface preparation to coating curing) similar to those of the production pipe as per the purchaser's specification.

4.8.4 Test samples shall be cold cut from the test ring as per the dimensions specified in the test method in Table 2.

4.8.5 The final inspection and coating thickness requirement shall be within the purchaser's specification.

4.8.6 Sample piece may require the purchaser's coating inspector's authentication before cutting and testing the test piece.

4.8.7 The test specimen shall be holiday tested prior to cutting in accordance with NACE SP0188. There shall be no holidays. In case of holidays, the sample shall be rejected and reprocessed.

Section 5: Applicator Procedure Specification (APS)

5.1 The applicator shall prepare and obtain written approval of the Applicator Procedure Specification (APS) from both the purchaser and supplier before production commences or any agreed-upon Procedure Qualification Testing (PQT) and/or Pre-Production Trial (PPT) occurs. All parties' roles and responsibilities shall be clearly defined in the APS. Once approved, any changes or revisions to the APS shall require written authorization from all parties.

5.2 The Application Procedure Specification (APS) shall cover, as a minimum, all listed items and any mutually agreed upon amendments between the purchaser and applicator.

5.2.1 Abrasive and coating material (including repair materials): datasheets, receipt, inspection, handling, and storage.

5.2.2 List of inspection and quality control tools.

5.2.3 Surface preparation methodology shall include:

a) Type of equipment (manual, automated, spin head, etc.),
b) Removal of pipe surface and weld defects (grinding, scraping, etc.),
c) Pre-cleaning activities for removal of contaminations (oil, grease, debris, etc.),
d) Abrasive addition and recycling during blast-cleaning activities, including inspection requirements for recycled abrasive,
e) Ambient conditions requirements and monitoring, including inspection of compressed air quality,
f) Storage and covering requirements for abrasive blast-cleaned items.

5.2.4 Coating application procedure shall include:

a) Coating system (with/without primer)
b) Type of equipment for application of liquid primer (Conventional spray, pressure pot, airless spray, etc.) and/or FBE powder (Manual, automated, etc.),
c) Number of coats or passes required to obtain the specified thickness value,
d) Coating WFT (for primer) and DFT limits,
e) Coating thickness measurement locations and number of readings,
f) Overlap (with DFT tolerance) of field joint coating over plant coating,
g) Coating material storage and reuse (for single-component primer).

5.2.5 Heating procedure shall include:

a) Type of equipment (oven, induction coils, etc.),
b) Heating duration, including recording and verification (for gas-fired oven with temperature leads connected on the steel surface),
c) Type for equipment and location for temperature verification,
d) Temperature measuring techniques and allowable variability,
e) Determine procedure, mechanical, or environmental changes that would constitute the need for re-qualifying the heating process.

5.2.6 Inspection procedure shall include:

a) Quality control equipment and calibration/verification certificate,
b) Inspection methodology for inspection on the internal surface of various pipe dimensions, including field girth weld joints,
c) Procedure for inspection and verification of quality control tools attached to automated systems,
d) Methods of testing of the applied coating (on the field, in the plant, and in the laboratory),
e) The purchaser and applicator shall agree upon the method and frequency for remediation and inspection of salt contamination.

5.2.7 For automated systems, the applicator may necessitate a sample pipe joint for initial setup and subsequent restarts after production interruptions. This sample facilitates the configuration of equipment and tools for abrasive blast cleaning, coating application, and inspection. Any such requirements shall be clearly documented in the APS.

5.2.8 The applicator shall prepare an Inspection and Test Plan (ITP) as agreed upon by the purchaser and applicator.

5.2.9 Method for stripping defective coating.Repair materials, method of repair.The applicator shall

5.2.10 prepare a daily log to record quality control data.Marking, traceability, handling, and storage.

5.2.11 Special conditions for coated pipe dispatch (including end protection).

5.2.12 Documentation (sample format of inspection reports).

5.2.13 APS may detail any limitations associated with the manual coating of custom-made piping spools, both with and without fittings. Graphical or drawing representations can be included in the APS to

5.2.14 illustrate these limitations.

5.2.15 If required by the purchaser for quality assurance, APS may include details of the company, applicator, and coating inspector qualification program certificates (e.g., AMPP QP programs, CIP certification, etc., or equivalent).

5.2.16

Section 6: Procedure Qualification Trial (PQT) and Pre-Production Trial (PPT)

6.1 The APS shall be verified by a Procedure Qualification Trial (PQT) conducted by the applicator, if requested by the purchaser.

6.2 Test methods for PQT are defined in Table 3 below.

Table 3
PQT Testing Requirements

Test	Acceptance Criteria	Number of Test Specimens	Test Method
Glass Transition Temperature	Coating T_g value shall be at least 5 °C above the pipeline design temperature or in accordance with the supplier's specification.	1	NACE SP0394 or ISO 21809-2
Degree of conversion	≥ 95%	1	NACE SP0394 or ISO 21809-2
Cross-section porosity	Rating of 1 to 3, inclusive	1	NACE SP0394 or CSA Z345.20 or ISO 21809-2
Interface porosity	Rating of 1 to 3, inclusive	1	NACE SP0394 or CSA Z245.20 or ISO 21809-2
24 h, Hot water adhesion 95 ± 3 °C	Rating of 1 to 2, inclusive	1	NACE SP0394 or CSA Z245.20 or ISO 21809-2
Flexibility: 2.50° /PD permanent strain at 0 °C[(A)]	No cracking	2	NACE SP0394 or CSA Z245.20 or ISO 21809-2

[(A)] Field-recorded minimum ambient temperatures may necessitate adjustment of the testing temperature by the purchaser.

6.3 The purchaser may require a PPT before production to establish working parameters and ensure the procedure, materials, and final coating meet APS specifications.

6.4 All Inspection and Testing procedures outlined in the ITP are mandatory during PQT and PPT. A single failed test shall require retesting with no further failures allowed.

6.5 The applicator may request manufacturer support during PQT and PPT to ensure proper material use and applicator training.

6.6 All PQT tools and equipment (heating, blasting, coating application, inspection) shall match those used in the actual coating production job.

6.7 For field girth weld joint coating, the following shall apply:

6.7.1 Unless otherwise specified, a minimum of three test zones shall be coated for field girth weld joints.

6.7.2 Tests shall be conducted on a pipe segment with the actual plant-applied coating, matching the length of the field joint coating. The length of the test zones shall be equivalent to the field joint coating length.

6.7.3 If APS specifies heating the overlap area, PQT must demonstrate no visual detriment (blistering, disbondment) to the plant-applied coating.

6.7.4 PQT coating application time should reflect the estimated field joint coating time. Significant environmental differences (work stations, lifting equipment) between PQT and production should be considered.

6.7.5 The PPT shall be performed on the first joints to be coated or, with agreement, on a sample pipe of similar dimensions.

6.8 Coating repairs and removal of defective coatings shall be included in PQT upon agreement between the purchaser and applicator.

6.9 PQT and PPT results shall be documented in a report, including process parameters, referenced APS, and coating material certificates. The report shall highlight any recommended revisions to the APS for production implementation.

Section 7: Surface Preparation

7.1 This section underlines the critical importance of meticulous surface preparation and treatment for the internal pipe surface and field girth weld joints. The performance and longevity of the Fusion Bonded Epoxy (FBE) coating are directly dependent upon the condition of the underlying pipe surface.

7.2 Pre-cleaning

7.2.1 Incoming steel pipe material shall be thoroughly examined for any irregularities and surface defects (e.g., laminations, slivers, and gouges) that could adversely affect FBE coating performance. Any such defects shall be removed in accordance with the APS.

7.2.2 Steel pipe defect removal by grinding, if necessary, must ensure the remaining wall thickness meets the minimum specified requirement.

7.2.3 The internal pipe surface shall also be inspected for extraneous materials like mud, sand, dirt, oil, grease, salts, mill lacquer/varnish, and deleterious matter. Any such deposits found must be removed from the pipe surface using suitable methods or in accordance with SSPC-SP 1 requirements. Only solvents that do not leave a residue shall be used for cleaning.

7.2.4 Optionally, an oven burn-off may be employed if the applicator deems it the only satisfactory method to ensure the steel is free of mill lacquer/varnish and oily contaminants. However, the applicator shall ensure that the oven burn-off temperature remains within safe limits to prevent changes to the steel pipe's properties and must not exceed the steel's tempering temperature limit.

7.2.5 For field girth weld joints, fittings, and custom-made pipe spools, the purchaser shall ensure optimal weld penetration (not greater than 1.5 mm) using the most appropriate welding methods. Purchaser shall also ensure the removal of all weld spatters, rough welds, and sharp edges prior to applicator handover. Should these anomalies significantly influence the internal surface area of the pipe welds and fittings, hindering the coating process, the applicator shall report to the purchaser for further instruction.

7.2.6 Prior to pipe welding, abrasive blast cleaning with a pipe bung may be employed for pre-cleaning the cutback area. This process removes damaged or loose factory-applied coatings from the bare steel, achieving a tapered edge. Additionally, it facilitates feathering or brush blasting for a minimum of 50 mm (2 in) of the internal FBE coating to create a key for subsequent internal girth weld coating overlap.

7.2.7 Any remaining rough edges or disbonded mill-applied coating revealed by blast cleaning shall be removed until a sound substrate is achieved. The exposed areas shall then be re-cleaned.

7.2.8 Furthermore, the cutback area shall be tested (prior to or following abrasive blasting) for the presence of water-soluble contaminants (such as chlorides, nitrates, and sulfates).

7.2.8.1 The purchaser and applicator shall mutually determine the frequency and testing method employed for soluble salt identification, considering the contamination type and severity.

7.2.8.2 Soluble salt levels shall not exceed 20 mg/m^2.

7.2.8.3 In case of excessive chloride levels, the applicator and purchaser shall mutually agree on a surface pre-treatment cleaning process to achieve a contaminant level below 20 mg/m^2.

7.3 Preheating

7.3.1 Prior to blast cleaning, the pipe shall be uniformly preheated to remove any moisture from the surface. The preheat shall be sufficient to ensure the pipe temperature is at least 3 °C (5 °F) above the dew point temperature during abrasive blast cleaning and inspection.

7.4 Abrasive Blast Cleaning

7.4.1 Abrasive blast cleaning equipment and abrasive material shall be capable of providing the required surface cleanliness and profile, as specified within this standard. Verification of their proficiency shall be done during the PQT.

7.4.2 Abrasive material (including recycled materials) shall comply with the requirements specified in SSPC-AB 1, SSPC-AB 2, SSPC-AB 3, and ISO 11124 (all parts). To minimize contamination and ensure a clean finish, abrasives that resist shattering and embedding in the steel surface are optimal.

7.4.3 Abrasive material shall be clean, dry, and free from contaminants. Abrasive material shall be tested according to ASTM D4940 for the presence of ionic contaminants to prevent substrate contamination.

7.4.4 Abrasive material shall contain less than 100 ppm sulfates, less than 100 ppm chloride, and less than 1% calcium carbonate by weight. Chemical analysis reports for the supplied abrasives shall be provided to the purchaser's inspection personnel prior to use.

7.4.5 Compressed air used for blast cleaning must be free of water and oil contamination. The compressed air system shall incorporate suitable separators, filters, or traps for moisture and oil removal. During periods of high humidity, a dehumidifier can be installed downstream of the compressor to further enhance moisture elimination from the air stream. Air cleanliness shall be verified according to ASTM D4285.

7.4.6 After the pre-cleaning activity, the internal pipe surface, field weld joints, and fittings shall be abrasive blast cleaned to a minimum requirement of SSPC-SP 10/NACE No. 2 or ISO 8501-1 (Sa2½).

7.4.7 The abrasive blast-cleaned surface shall have an angular profile of 64 to 115 microns (2.5 to 4.5 mil) from peak to valley when measured in accordance with NACE SP0287, ASTM D4417, ISO 8503-4, or ISO 8503-5.

7.4.8 Blast cleaning media shall be completely removed from the pipe's internal surface using appropriate equipment. The surface to be coated shall be clean, dry, and exhibit a dust level of no greater than 2 (for both rating and class) as per ISO 8502-3.

7.4.9 Following abrasive blast cleaning, the pipe's internal surface shall be tested for the presence of water-soluble contaminants like chlorides, nitrates, and sulfates.

7.4.9.1 Permissible levels of soluble salt shall not exceed 20 mg/m^2 in accordance with ISO 8502-6 and ISO 8502-9.

7.4.9.2 The applicator and purchaser shall mutually agree upon the specific testing frequency, methodology, and any necessary surface treatments required in the event of excessive soluble salt levels. The same shall be documented within the APS.

7.4.10 In cases where direct visual examination of pipes, field girth weld joints, and fittings is impractical, an internal digital camera inspection shall be mandated to verify the adequacy of surface preparation before lining procedures commence.

Section 8: Coating Application

8.1 Primer Application

8.1.1 The selection and application of primer shall comply with the coating manufacturer's recommendations for the specific fluid service and coating system specified in Section 3 of this standard.

8.1.2 Primer shall be applied to the pipe surface within 4 hours of blasting. If any flash rusting appears on the pipe surface during this timeframe, coating activities shall not proceed. Re-blast any pipe that exceeds the 4-hour limit or develops rust before coating application.

8.1.3 The applied primer film thickness shall be 13-25 microns (0.5-1.0 mils), uniformly applied to lightly coat the blasted surface while maintaining the peaks of the surface profile exposed. This ensures optimal adhesion for the subsequent FBE coating. Due to the low thickness, conventional DFT gauges are unsuitable for measurement. Therefore, the applicator, in coordination with the coating manufacturer, shall document within the APS their specific method for achieving the required primer thickness, inspection, and acceptance criteria.

8.1.4 To prevent contamination of the primed surface by dust or harmful materials, both ends of the pipe shall be capped using polyethylene sheets or end caps. The pipes shall be directly transferred to the heating area of the FBE coating plant. Any contact between the internal surface and any lifting or movement equipment during this transfer shall be avoided. End caps shall not be installed until the solvent vapors have evaporated.

8.2 Pre-heating of Pipes, Custom-made Pipe Spools, and Fittings

8.2.1 The pipe temperature during FBE coating application shall adhere to the coating manufacturer's recommended minimum and maximum values. Heating methods, such as furnaces, soaking ovens, or induction coils, shall possess adequate controls to prevent exceeding the maximum allowable pipe temperature.

8.2.2 The pipe preheating temperature shall be continuously monitored and documented at a minimum of three locations: the leading end, midpoint, and trailing end.

8.2.3 If optical pyrometers or infrared thermometers are employed for temperature measurement, the purchaser inspector may request a temperature log or graph for verification purposes. To ensure measurement accuracy, the optical pyrometer shall undergo verification checks at intervals not exceeding 4 hours of continuous applicator operation.

8.2.4 The pipe temperature shall not exceed 274 °C (525 °F) during the preheating process. Higher temperatures may alter the physical and toughness properties of the steel. Any pipe temperature exceeding 274 °C (525 °F) requires immediate notification to the purchaser. The heating process shall not cause oxidation (bluing) of the steel surface.

8.3 Pre-heating of Field Girth Weld Joints

8.3.1 For field weld joints, high-frequency induction heating coils shall be used to uniformly heat the designated coating area to a target temperature within ±8 °C (±15 °F) as recommended by the coating manufacturer.

8.3.2 Prior to heating, minimize the exposure of blasted surfaces to environmental factors (e.g., direct sunlight, strong winds) that could cause uneven temperatures around the pipe's circumference.

8.3.3 Requalification of the heating process might be necessary due to seasonal variations. The purchaser and applicator shall mutually agree upon limitations for environmental conditions during requalification and document them in the APS.

8.3.4 The acceptable duration of the heating process shall be determined during the PQT and documented in the APS.

8.3.5 The purchaser shall approve the heating equipment, which shall be sized to ensure the entire coated area reaches the required temperature. The temperature measurement method shall be documented in the APS and agreed upon by the purchaser.

8.3.6 Rapid heating to the application temperature can cause blistering of the applied coating. Therefore, heating the weld should be done carefully to avoid this issue.

8.3.7 The heating process shall be verified to ensure uniform heat distribution across the weld and around the pipe's circumference. This verification process, documented in the APS, shall confirm that the heating method does not damage the existing plant-applied coating.

8.4 FBE Application

8.4.1 The FBE powder shall be in a fluidized state (achieved by airflow in a fluidized bed) before being applied to the heated component. Powder shall be applied by flocking, electrostatic spray, or air spray immediately after removing the part from the heat source. The purchaser shall specify the requirements for application on flange faces or other appurtenances.

8.4.2 The dew point of the air shall be monitored at the beginning of the shift and at regular intervals to verify dryness. Coating activities shall not proceed if the dew point exceeds the supplier's maximum allowable dew point specification. The dew point of the air in the fluidized bed and powder feed lines shall be maintained below -20 °F (-29 °C).

8.4.3 FBE powder application requires the pipe surface temperature to be within the manufacturer's specified range. Pipes falling below the minimum recommended temperature shall be rejected for coating.

8.4.4 Primed surfaces shall be coated within the time specified by the coating manufacturer. If the next coating step cannot be completed within this timeframe, the primed components shall be re-blasted and re-coated.

8.4.5 Application of the Fusion Bonded Epoxy (FBE) powder shall achieve a uniform coating across the entire blast-cleaned and pre-heated surface. This shall be accomplished using automated or manual equipment. The minimum dry film thickness (DFT) requirement shall be met.

8.4.6 During manual application, the applicator shall ensure that each pass of the coating adheres to the material manufacturer's recommended gel time.

8.4.7 To ensure consistent quality and prevent equipment damage, a closed-loop system is required for utilizing recycled powder in the coating process. The system must continuously circulate the recycled powder through a properly sized sieve, eliminating oversized particles and clumps before reintroduction. This allows for seamless blending of the recycled material with a minimum of 80% virgin powder within the delivery system. Reintroduction of reclaimed powder, such as overspray or floor spills, shall not be accepted. These guidelines shall be clearly outlined within the APS.

8.4.8 Field girth weld joint coating with semi-automated or automated equipment:

a) Equipment tuning and setup shall be performed on a sample pipe joint before production begins or restarts after an interruption.
b) Equipment shall be capable of uniformly applying a single coat of the specified thickness on the cutback, weld joint, and overlap of the factory-applied coating.

c) All the necessary parameters identified during the PQT shall be followed during the production. If the applicator necessitates any change to the set parameters, then the purchaser may request to redo the PQT with the new changes.
d) PPT shall be carried out on a sample split pipe to verify the working parameters and ensure the procedure, materials, and final coating meet APS specifications. The sample split pipe shall be of similar material and wall thickness to that of the production pipe.
e) The purchaser may require the removal of excess FBE powder from the pipe interior after coating. The equipment shall be capable of performing this using a vacuum or any other suitable method.
f) During field weld joint coating application and line travel, the applicator shall ensure that the equipment does not damage the existing factory-applied internal pipe lining. To verify this, the purchaser may request additional holiday testing on the factory coating.
g) The FBE overlap onto the factory-applied lining shall be a minimum of 50 mm (2 in).

8.4.9 The spray system shall not:
a) Contact the applied coating.
b) Contaminate the steel surface or coating with foreign matter that would compromise the quality and performance of the applied coating.

8.4.10 Coating thickness requirements:
a) The purchaser, in coordination with the coating manufacturer, shall specify the minimum, average, and maximum acceptable thickness of the coating on pipes, field girth welds, and fittings.
b) In the absence of a purchaser-specified minimum thickness, individual coating thickness measurements taken at any point of the coated pipe surface shall not be less than the minimum DFT specified by the supplier.
c) If any individual thickness measurement falls outside this requirement, additional measurements shall be taken along the affected pipe at intervals no greater than 2 meters. The average of these additional measurements shall be within the DFT range specified by the supplier and the minimum DFT specified by the supplier, and no single measurement shall be less than the minimum DFT specified by the supplier.
d) For custom-made pipe spools, field girth weld joints, and fittings, the coating thickness shall be within the DFT range specified by the supplier. Individual coating thickness shall not be less than the minimum DFT specified by the supplier. The supplier shall also specify the maximum acceptable thickness on the overlap of factory-applied coatings.
e) In the absence of a specified minimum thickness from either the supplier or the purchaser, the minimum DFT may be considered as 350 microns (14 mil).
f) DFT measurement and verification of the gauge shall be in accordance with SSPC-PA 2 Level – 2.

8.5 The curing process of the applied FBE coating shall adhere to the specific time and temperature guidelines set forth by the coating manufacturer. When applying the coating in field conditions, it is crucial to account for environmental factors that may lead to uneven curing around the pipe's circumference.

Section 9: Coating Inspection and Testing

9.1 The purchaser has the right to inspect the entire epoxy application process, from surface preparation to completion, as detailed in this standard. To facilitate these inspections, the purchaser's designated inspector shall be granted full access to both production and testing areas. However, this right to inspection does not relieve the applicator of their obligation to provide materials and complete the work in accordance with this standard.

9.2 The applicator shall provide the inspector with all reasonable facilities, free of charge, to verify that the coating application complies with this Standard. Inspections shall be conducted at the application site prior to shipment, unless otherwise specified by the purchaser, and must not unduly disrupt plant operations.

9.3 When a purchaser's inspector intends to witness the coating application or testing, as specified in the purchase order, the applicator shall provide the purchaser with reasonable notice of the production schedule. This notice shall include the specific times when the coating application and tests are to be conducted.

9.4 All coating inspection and testing activities shall be conducted as per the ITP, as agreed between the purchaser and applicator. ITP may include, but not be limited to, the requirements mentioned in Table 4.

9.5 All testing equipment situated at the applicator's facility must be meticulously maintained and undergo calibration at predetermined intervals. The aforementioned equipment shall possess a current calibration certificate, issued by a reputable and independent third-party testing organization.

Table 4
Production Inspection and Testing Requirement

Inspection Activity	Acceptance Criteria	Frequency[B]	Test Method[C]
Primer and FBE powder material[A]	As per manufacturer's recommendation	Each batch	Visual and conformity to certificates
Abrasive material	As per manufacturer's recommendation	Each batch	Visual and conformity to certificates (SSPC-AB 1, SSPC-AB 2, SSPC-AB 3, and ISO 11124)
Incoming pipe surface condition before blasting	Free of any irregularities and surface defects	Each item	Visual inspection with suitable illumination and inspection tools
Ambient conditions	As determined at time of measurement	Start of shift and every 2 hrs	Monitoring equipment and calculations
Surface temperature before blasting	Surface temperature is at least 3 °C (5 °F) above the dew point temperature	Start of shift and every 2 hrs	Temperature gauge
Compressed air quality test	Free of water and oil contamination	Start of shift and mid shift	ASTM D4285
Water-soluble ionic contamination of abrasive	Conductivity max 60 µS/cm	Once per shift	ASTM D4940
Cleanliness of abrasive blast-cleaned surface	Minimum SSPC-SP 10/NACE No. 2/ISO 8501-1 (Sa 2½)	Each item	Visual inspection with suitable illumination and reference photographs (SSPC-VIS 1)
Surface profile of abrasive blast-cleaned surface	64 to 115 microns (2.5 to 4.5 mil)	Two times per shift	NACE SP0287, ASTM D4417, ISO 8503-4, or ISO 8503-5
Soluble salt level on abrasive blast-cleaned surface	20 mg/m^2	Two times per shift	ISO 8502-6 and ISO 8502-9
Level of dust on abrasive blast-cleaned surface	≤ 2 (for both rating & class)	Two times per shift	ISO 8502-3
Primer coat application, if applied	Compliance with APS	Each item	Visual inspection with suitable illumination
Preheating temperature prior to FBE coating	As per manufacturer's recommendation and APS	Each item	Optical pyrometers or infrared thermometers
FBE application	Compliance with APS	Each item	Visual inspection with suitable illumination and inspection tools
Post curing	As per manufacturer's recommendation and APS	Each item	Optical pyrometers or infrared thermometers
Visual inspection of applied FBE coating	Free from all anomalies such as blisters, runs, sags, and fish-eyes	Each item	Visual inspection with suitable illumination and inspection tools
Thickness measurement of applied FBE coating	As per Section 8	Each item	SSPC-PA 2 Level – 2
Holiday inspection of applied FBE coating	No holidays	Each item	NACE SP0188

[A] To ensure compliance with the acceptance requirements outlined in Table 1, the applicator may conduct tests to verify the properties of the supplied epoxy powder material.
[B] The term "item" refers to material presented for inspection. This includes pipes, field girth weld joints, pipe fittings, and custom-made pipe spools.
[C] The illumination at each point of inspection shall be a minimum of 538 lux (50 foot-candles), in accordance with SSPC Guide 12.

9.6 Production/Laboratory Tests

9.6.1 The applicator shall be responsible for ensuring that the plant has personnel with the appropriate training and suitable equipment for the preparation and testing of test specimens. Personnel involved in these activities may be a qualified and certified coating inspector, such as those certified by AMPP, or individuals with equivalent training and expertise. Production tests of pipes, custom-made spools, field girth weld joints, and fittings shall be conducted as outlined in Table 5.

9.6.2 For pipes, a production test shall be conducted on at least one test ring that is obtained at least 300 mm from the pipe end or a pup piece matching the exact specifications of the pipe to be coated, for each pipe diameter and wall thickness combination.

9.6.3 For custom-made pipe spools and fittings, a test shall be conducted on a sample plate of similar wall thickness.

9.6.4 For field weld joints, a test shall be conducted on a sample field weld joint of similar pipe diameter and wall thickness.

9.6.5 The frequency of testing and the specific requirements for test specimens may be determined based on the volume and/or duration of the work, change in process parameters, change in a batch of epoxy powder material, and interruption of work. However, both the purchaser and the applicator shall mutually agree upon these details. Once agreed upon, it shall be formally documented within the APS and ITP.

Table 5
Production Testing Requirements

Test	Test Type	Acceptance Criteria	Number of Test Specimens	Test Method
Flexibility[A]: 5.50°/PD permanent strain at 25 ± 3 °C, 3.50°/PD at 10 ± 3 °C or 3°/PD at 5 ± 3 °C.	A	No cracking	3	NACE SP0394 or CSA Z245.20 or ISO 21809-2
24 h, Hot water adhesion 95 ± 3 °C	A	Rating of 1 to 2, inclusive	1	NACE SP0394 or CSA Z245.20 or ISO 21809-2
Adhesion to steel surface at ambient temperature	A	Minimum rating 8	1	ASTM D6677
Glass Transition Temperature	B	Compliance with APS	1	NACE SP0394 or ISO 21809-2
Degree of conversion	B	≥ 95%	1	NACE SP0394 or ISO 21809-2
Cross-section porosity	B	Rating of 1 to 3, inclusive	1	NACE SP0394 or CSA Z245.20 or ISO 21809-2
Interface porosity	B	Rating of 1 to 3, inclusive	1	NACE SP0394 or CSA Z245.20 or ISO 21809-2

[A] Flexibility test is not required for field weld joints and custom-made pipe spools.

9.7 Reanalysis of Failed Samples

9.7.1 In the event that a laboratory Type A test fails to meet the requirements specified in Table 5:

a) All pipe sections coated subsequent to the last successful test and preceding the current failed test shall be stripped of their coating and re-coated, or

b) The failed test shall be repeated utilizing two additional test samples obtained from the originally tested end of the affected pipe section.

9.7.2 If both retests yield results that comply with the specified requirements, the coated pipe shall be considered acceptable. However, if one or both retests fail, further corrective actions will be necessary:

a) All pipe sections coated after the last successful test and preceding the current failed test shall be stripped of their coating and re-coated, or
b) Subject to the purchaser's approval, additional retesting may be conducted to identify acceptable pipe sections from those coated after the last successful test. Any sections deemed unacceptable through this retesting process shall be stripped of their coating and re-coated.

9.7.3 In the event that a laboratory Type B test fails to meet the requirements specified in Table 5, the application process parameters may require adjustments. Additionally, if requested by the purchaser, the applicator may hold the application process until the cause is rectified.

Section 10: Coating Repair

10.1 All holidays, imperfections, and defects detected by electrical inspection or visually in the applied FBE powder coating shall be rectified using materials compatible with and adherent to the original coating.

10.2 To ensure compatibility and effectiveness for the intended use, the repair material supplier and applicator of FBE repair material shall establish formal technical specifications, performance requirements, and quality control procedures.

10.3 Repaired areas must extend a minimum of 25 mm (1 in) beyond the perimeter of the original defect to ensure sufficient coverage. Prior to the application of the repair material, the surface must be appropriately prepared to optimize adhesion.

10.4 The minimum thickness of the repaired coating shall comply with the recommendations set forth by the manufacturer of the coating material.

10.5 Repaired areas shall be holiday tested in accordance with NACE SP0188.

10.6 In instances where the damaged coating cannot be repaired to meet acceptance criteria, or where repair itself is not feasible due to the location of the holiday, the affected pipe sections shall undergo a complete removal and reapplication of FBE coating.

10.7 Stripping of coating: The existing coating shall be removed by heating it to a temperature no higher than 275 °C, sufficient to induce softening or charring. This thermal treatment shall be followed by abrasive blasting to ensure complete removal of the coating prior to the commencement of standard surface preparation and coating procedures outlined in this standard. The identity of each stripped and recoated pipe shall be documented.

Section 11: Documentation and Marking

11.1 In the absence of a waiver clause for test reports within the purchase order, the applicator shall provide the purchaser with documentation of the tests outlined within this standard.

11.2 The applicator shall furnish reports that demonstrably verify the following:

11.2.1 The coating material, application, inspection, and testing were conducted in accordance with the stipulations of this standard and/or any additional requirements outlined in the purchase order.

11.2.2 The report shall confirm that the outcomes of the coating tests and all other mandated tests comply with the requirements specified within this standard and/or the purchase order.

11.3 All coated pipes and fittings shall be clearly marked on the exterior or interior surface with the following information, applied using a stencil:

11.3.1 Applicator's name or logo

11.3.2 Coating material identification

11.3.3 Purchase order number for the pipe or custom-made spool or fittings

11.3.4 Markings required by the applicable pipe specification or standard (Pipe size & length, pipe grade, heat number, etc.)

11.3.5 Date of coating application

11.4 Custom-made spools and fittings that cannot be stenciled as specified above shall be marked in accordance with the purchaser's written instructions.

Section 12: Handling, Storage, and Shipping

12.1 Handling of Coated Pipe: All coated pipe must be handled with care to prevent damage to the pipe itself, its ends, and the FBE coating. If the purchase order specifies, the applicator shall provide a detailed handling procedure for approval.

12.2 Equipment for Handling and Storing Coated Pipe: All equipment used for handling or storing coated pipe, such as booms, hooks, forks, supports, and skids, shall be designed and maintained to ensure no damage occurs to the pipe or its coating.

12.3 Storage Procedures for Coated Pipe: Until delivery, all coated pipes shall be stored on sand berms covered with polyethylene sheathing. Custom-made spools and fittings shall be stored on pallets or padded elevated racks, with the specific method determined by their size, shape, and weight.

12.4 Cleaning and Protection of Internally Coated Pipes: Prior to final shipment or loading, all internally coated pipes shall be thoroughly cleaned. Additionally, end caps or plastic sheets must be reinstalled on the pipe ends to prevent contamination of the internal surface.

12.5 Preparation for Storage and Transportation: Coated pipes shall be prepared for storage or transport in accordance with the relevant standard, either API RP 5L1 or API RP 5LW. During transportation, the pipes shall be stacked and secured to prevent movement. Wooden wedges or other suitable materials should be used to separate individual pipes within a stack.

12.6 All requirements outlined in Section 12 shall be considered applicable to pipes, custom pipes/spools, and fittings that have received the application of FBE coating at an applicator facility.