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شرکت ملی گاز ایران
مدیریت پژوهش و فناوری
امور تدوین استانداردها

IGS

دستورالعمل

اپوکسی مایع برای تعویض و تعمیر پوشش خارجی خطوط لوله مدفون ،
سرجوش ها ، شیر آلات ، اتصالات و سایر اجزاء لوله کشی

Liquid Epoxy for Rehabilitation and Repair of External coating of
Buried Steel Pipelines, Field joints, valves, fittings and other
piping components



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شرکت ملی گاز ایران



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ابلاغ مصوبه هیأت مدیره

مدیر محترم پژوهش و فناوری

باسلام،

به استحضار می‌رساند در جلسه ۲۰۴۸ مورخ ۱۴۰۲/۱۲/۰۸ هیأت مدیره، نامه شماره ۲۰۵۳۴۷ مورخ ۱۴۰۲/۱۱/۱۱ مدیر پژوهش و فناوری در مورد تصویب نهایی مقررات فنی شرکت ملی گاز ایران به شرح زیر مطرح و مورد تصویب قرار گرفت.

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Foreword

This standard specification is intended to be mainly used by N.I.G.C. and contractors, and has been prepared base on interpretation of recognized standards and technical documents, as well as knowledge, backgrounds and experiences in gas industries at national and international levels.

Iranian Gas Specification (IGS) are prepared, reviewed and amended by technical standard committees within NIGC standardization division of research and technology management and submitted to "the standards council of NIGC" for approval.

IGSs are subjected to revision, amendment or withdrawal, if required, and thus the latest edition of IGS shall be checked / inquired by NIGC'S users.

This standard must not be modified or altered by NIGC employees or its contractors. Any deviation or conflicts between this specification and other applicable standards, codes, procedure or well-known manufacturer's specifications must be resolved in writing by the user or its representative through Manager, Engineering Department or standardization division of NIGC.

The technical standard committee welcomes comments and feedbacks from concerned or interested corporate and individuals about this standard, and may revise this document accordingly based on the received feedbacks.

General Definitions

Throughout this standard the following definitions, where applicable, should be followed:

- 1- "STANDARDIZATION DIV." is organized to deal with all aspects of industry standards in NIGC. Therefore, all enquiries for clarification or amendments are requested to be directed to mentioned division.
- 2- "COMPANY": refers to National Iranian Gas Company (NIGC).
- 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 covers the minimum requirements for material, surface preparation, application, quality assurance and inspection of liquid epoxy to be used for preventing external corrosion of buried steel pipeline systems. The coating system shall be used at maximum design temperature of the pipeline limited to 80 °C (T_{max}) for applications as follow:

- Rehabilitation of buried pipelines and piping's coatings.
- Field joints and repair of buried pipelines and piping, valves, fittings and other pipeline and piping components coated with FBE or liquid epoxy or liquid polyurethane coating systems.
- New coating of buried piping, valves, fittings and other piping components.
- The epoxy shall be of the type that can be applied by using either plural component spray equipment or brushes and rollers for brush grades.

Note 1: This standard specification does not cover factory coating of line pipes.

Note 2: If the design temperature is more than 40 °C or for field joints or pipe sizes with O.D. 30" and larger, the minimum dry film thickness of coating shall be 1500 μm . For smaller sizes or lower temperatures, the minimum dry film thickness of coating shall be 800 μm .

Note 3: Manual / hand application is acceptable only for repair.

Note4: For higher design temperature(>80°C) only epoxy-Novolac coating shall be used.

Note5: This standard withdraws and replaces IGS-M-TP-027 (1).

2. REFERENCES

Throughout this standard the following dated and undated standards/codes are referred to. This referenced documents shall, to the extent specified herein, from a part of this standard. For dated references, the edition cited applies. For undated references, the latest edition of the referenced documents applies.

2.1 Normative references

ASTM D 1640 (2022) "Standard Test Methods for Drying, Curing, or Film Formation of Organic Coatings at Room Temperature"

ASTM D 4285 (2018) "Standard Test Method for Indicating Oil or Water in Compressed Air"

ASTM D 4940 (2020) "Standard Test Method for Conduct Metric Analysis of Water Soluble Ionic Contamination of Blasting Abrasives"

EN 10289 (2002) "Steel Tubes and Fittings for Onshore and Offshore Pipelines – External Liquid Applied Epoxy and Epoxy-Modified Coatings"

ISO 4624 (2023) "Paints and Varnishes – Pull-Off Test for Adhesion"

ISO 868 (2003) "Plastics and Ebonite – Determination of Indentation Hardness by Means of a Durometer (Shore Hardness)"

ISO 8502-3 (2017) "Preparation of Steel Substrates before Application of Paints and Related Products – Test for Assessment of Surface Cleanliness – Part 3: Assessment of Dust on Steel Surface Prepared for Painting (Pressure Sensitive Tape Method)"

ISO 8502-6 (2020) "Preparation of Steel Substrates before Application of Paints and Related Products – Test for Assessment of Surface Cleanliness – Part 6: Extraction of Soluble Contaminants for Analysis – The Bresle Method"

ISO 8502-9 (2020) "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 8503-2 (2012) "Preparation of Steel Substrates before Application of Paints and Related Products –Surface Roughness Characteristics of Blast-Cleaned Steel Substrates – Part2: Method for the Grading of Surface Profile of Abrasive Blast-Cleaned Steel – Comparator Procedure"

ISO 11124 (all parts) (2018) "Preparation of Steel Substrates before Application of Paints and Related Products –Specifications for Metallic Blast-Cleaning Abrasives"

ISO 11126 (all parts) (2018) "Preparation of Steel Substrates before Application of Paints and Related Products –Specifications for Non-metallic Blast-Cleaning Abrasives"

ISO 8501-1(2007) "Preparation of Steel Substrates before Application of Paints and Related Products – Group A. Visual Assessment of Surface Cleanliness – Part A1. Specification for Rust Grades and Preparation Grades of Uncoated Steel Substrates and of Steel Substrates after Overall Removal of Previous Coatings"

ISO 8503-5(2017) "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 21809-3(2020) "Petroleum and Natural Gas Industries – External Coatings for Buried or Submerged Pipelines Used in Pipeline Transportation Systems – Part 3: Field Joint Coating"

IGS-M-PL-001-2"SMLS/HFW/SAWL/SAWH Carbon Steel Pipes, Grades B to X80, Sizes: 6 to 56 inch".

IGS-O-TP-001 "Maintenance and Rehabilitation of Coating of Gas Pipeline Under Operation"

SHELL 31403038(2005) "Liquid Rehabilitation Coating of Onshore Pipelines"

SHELL 31403037(2008) "External Field Joint and Rehabilitation Coating Systems for Line Pipe"

2.2 Informative references

EN 10204(2006) "Metallic Products-Types of Inspection Documents"

NACE RP0105(2005) "Standard Recommended Practice for Liquid-Epoxy Coating for External Repair, Rehabilitation, and Weld Joints on Buried Steel Pipelines"

3. DEFINITIONS

Applicator

The company that applies the liquid epoxy coating system in the field.

Backfill

Material placed in a hole to fill the space around the buried pipes.

Backfill Time

Time required for the coating to dry hard enough to resist mechanical damage by the backfill soil.

Batch

Amount of materials produced within one uninterrupted production run of maximum 8 hours under constant production conditions.

Dry-to-Touch Time

Time taken by the coating to dry until it becomes tack-free

Epoxy

Thermosetting resin capable of forming tight cross-linked polymer structures characterized by toughness, strong adhesion, and low shrinkage, used especially in surface coatings and adhesives

Epoxy Novolac

Class of epoxy resin containing more than two functional groups to react with cross linking agents to generate a high degree of cross linking, generally for high temperature application

Field Joint Area (weld zone)

Uncoated area that results when two pipe sections or a pipe section and a fitting with coating cutbacks are assembled, by welding, in the field

Holiday

Discontinuity in a protective coating that exposes the unprotected surface to the environment, or a thin coating spot that cannot provide good barrier to the environment, normally detected by a low or high voltage holiday detector

Manufacturer/Supplier

The company that manufactures or supplies coating material

Maximum design temperature (T_{max})

temperature which is specified by the Principal as the maximum design temperature of the pipeline

Overlap

Length of the field joint coating over the plant-applied coating including the coating bevel ends

Plural Component Spray

Application method that automatically proportions and mixes two or more components of a coating material in the process of delivering them to the spray gun. Plural component spray equipment is used to apply coatings with a pot life that is too short to permit mixing and application by conventional air and airless spray equipment

Pot Life

Time within which a coating can be effectively applied after all components of the coating have been thoroughly mixed

Purchaser

The owner company that has the authority for the pipeline or piping systems to which the coating is to be applied

Principal

the party which initiates the project and ultimately pays for its design and construction. The Principal will generally specify the technical requirements. The Principal may also include an agent or consultant authorised to act for, and on behalf of, the Principal

Room Temperature (RT)

Indoor temperature generally between 20 °C and 25 °C

Shelf Life

The maximum allowed storage time for a coating material prior to its use

Third Party Inspection (TPI)

Third party inspection authorities approved by purchaser (NIGC)

4. REQUIREMENTS

4.1 The two-pack coating material is generally composed of a base (epoxy resin) and a curing agent. The base and curing agent should have different colors allowing the verification of the correct mixing and checking the uniformity of the color of the mixed product.

4.2 Normally, the liquid pipeline coatings shall be two-component, 100% solids, solvent free coating to form a thick film of smooth appearance without drips, running, sags, pinholes or fisheyes.

4.3 No primers shall be required by the epoxy coating to achieve proper performance.

4.4 Thinners shall not be used for diluting.

4.5 The epoxy material shall have sufficient pot life to ensure convenient application in site condition.

4.6 Only qualified brands supported by manufacturer test certificates in accordance with the specified standard test methods in Table 2 of this specification shall be selected by the applicator and approved by the purchaser.

4.7 The dry-to-touch time shall be no longer than 3 hours at room temperature when tested in accordance with ASTM D 1640.

4.8 The backfill time shall be as short as possible, particularly for pipeline rehabilitation. The backfill time for plural component sprayed coatings shall be less than 6 hours and for airless sprayed coatings shall be less than 8 hours at room. The backfill time is that taken for the film to attain the hardness of 65 Shore "D" as per ISO 868 standard.

4.9 The specific application procedure shall be described by the manufacturer and furnished to the purchaser with each batch of product.

Table 1-Contents of Data Sheets and Certificates

Elements	Technical data	Test certificate
Date of issue	x	x
Name of manufacturer	x	x
Name, use and type of product	x	x
Type of base (epoxy resin) and extender modification	x	x
Type of curing agent	x	x
Factory of origin		x
Batch or production lot number	a	x
Date of manufacture and use by date	a	x
Color	a	x
Physical state of the delivered product	a	x
Methods of application	x	
Solids by volume	x	
Solids by weight	x	x
Theoretical coverage per m ² for nominal thickness	x	
Size of container	a	x
Shelf life	a	x
Storage conditions	x	
Pot-life	x	
Surface preparation	x	
Recommended instructions for application	x	
Recommended repair material(s)	x	

Table 1 – Contents of Data Sheets and Certificates(cont.)

Elements	Technical data	Test certificate
Mixing instructions	x	
Recommended dry film thickness	x	
Typical thickness applicable in one layer	x	
Minimum and maximum over coating time	x	
Range of pipe service temperature	x	
Range of application temperature (ambient, pipe and product) and humidity	x	
Specific curing – Requirements	x	
Shore "D" hardness at 23 ± 2°C	x	
Time at 23 ± 2°C to achieve Shore "D" hardness at curing	x	
Time at 23 ± 2°C at Shore "D" hardness before handling	x	
Viscosity ^b	x	x
Density	x ^b	x ^a
Adhesion test, resistance to removal at 23 ± 2 °C	x	
Adhesion test, pull off method at 20 ± 2 °C	x	
Cathodic disbondment at 23 ± 2 °C	x	
Cathodic disbondment at 80 ± 2 °C (95 ± 3°C for epoxy-Novolac)	x	
Cathodic disbondment at 48 h at 65 °C	x	
Impact resistance	x	
Indentation resistance at 10 N/mm ²	x	
Hot-water immersion test	x	
Specific electrical insulation resistance	x	
Thermal ageing	x	
Time to backfill-ready at 10 °C, 24 °C, 35 °C and 65 °C	x	
Moisture permeation	x	
Cure time at 24 °C, 35 °C and 65 °C	x	
Test methods described in the present standard shall be used. In any case test methods used shall be mentioned for any tests. The acceptable limits shall be mentioned in the test certificate.		
^a Required for the base (epoxy resin) and curing agents.		
^b Required for the base (epoxy resin), curing agent and for the mixed product.		

Table 2-Qualification Requirements

Item	Property	Test temp.	Unit	Acceptance criteria	Test method
1	Minimum thickness (minimum individual reading)	-	µm	-1500 µm: If the design temperature is more than 40 °C or for field joints or pipe sizes with O.D. 30" and larger -800 µm: For smaller sizes or lower temperatures	ISO 21809-3/Annex B
2	Visual inspection	-	-	Continuous and uniform film free of sags runs and color striations	-
3	Holiday detection at 5 kV/mm at a maximum of 25 kV	-	-	no holiday	ISO 21809-3 Annex C
4	Impact resistance (holiday detection at 5 kV/mm)	23 °C -5 °C	J/mm	≥3 ≥1.5	ISO 21809-3 Annex D
5	Indentation resistance at 10 N/mm ² (indentation depth)	Tmax (limited to 80 °C ± 2 °C and 95 ± 3 °C for epoxy-Novolac)	% DFT	≤30	ISO 21809-3 Annex E
6	Cathodic disbondment at 28 days	23 °C Tmax (limited to 80 ± 2 °C and 95 ± 3 °C for epoxy-Novolac)	mm	≤5 ≤15	ISO 21809-3 Annex G
7	Cathodic disbondment at 48 h	65 °C	mm	≤5	ISO 21809-3 Annex G
8	Adhesion, to plant coating and pipe surface, resistance to removal	23 ± 2 °C	-	rating 1	ISO 21809-3 Annex Q
9	Hardness (Shore D) Min.	23 °C	-	70	ISO 868
10	Adhesion to pipe surface Min.	23 °C	MPa	≥10,0 ^a	ISO 4624
11	Adhesion to FBE, liquid applied epoxy or PU plant coatings Min.	23 °C	MPa	≥10,0 ^a	ISO 4624

Table 2 – Qualification Requirements (cont.)

Item	Property	Test temp.	Unit	Acceptance criteria	Test method
12	Adhesion to pipe surface after 28-day hot-water immersion test at Tmax as per Annex I(limited to 80 ± 2 °C and 95 ± 3 °C for epoxy-Novolac)	23 °C	MPa	$\geq 7,0$	ISO21809-3Annex I Plus ISO 4624
13	Adhesion to FBE, liquid applied epoxy or PU plant coatings after test 28-day hot-water immersion Annex I(80 at Tmax limited as per ± 2 °C and 95 ± 3 °C for epoxy-Novolac)	23 °C	MPa	$\geq 3,0$	ISO 21809-3 Annex I plus ISO 4624
14	Specific electrical insulation resistance (RS100)	23 °C	$\Omega \cdot m^2$	$\geq 10^6$	ISO 21809-3 Annex F
15	RS100/RS70	-	-	$\geq 0,80^b$	-
16	Thermal ageing 100 days to pipe surface to plant coating	Tmax (limited to 80 ± 2 °C and 95 ± 3 °C for epoxy-Novolac)	MPa	^c No defect, No holiday ≥ 7 MPa and \leq rating 2 ≥ 3 MPa and \leq rating 2	Annex J EN10289
17	Max. residual chloride level	-	mg/m ²	20	ISO 8502-6 OR Elcometer 130/ SCM 400
18	Dry-to-touch time	RT	hour	No longer than 3	ASTM D 1640
19	Backfill time	RT	hour	(4.8)	ISO 868

a Figures applicable for PQT and PPT. For production testing, results of 70 % of these figures may be accepted by agreement due to a possible lack of curing of the glue during the allowable duration of testing, provided that the failure occurs within the glue.

b It is necessary that this requirement ($RS100/RS70 \geq 0,8$) be fulfilled only if the specific electrical insulation resistance after 70 days is less than 10 times the requirement of the specific electrical insulation resistance after 100 days.

c at the discretion of the purchaser, the qualification tests may be waived, provided that the certificates and the results of tests carried out at a reputable third-party test laboratory, not exceeding two years from the date of tests, submitted by the manufacturer/supplier and approved by the purchaser.

5. DOCUMENTS

5.1 Documents to be submitted by the manufacturer

The following documents shall be provided to the purchaser by the applicator from the coating material manufacturer/supplier:

- a. Technical specification and material data sheets as detailed in Table 1;
- b. Test reports as detailed in Table 2 (The test methods shall be specified for any tests);
- c. Origin batch certificate;
- d. Application procedure of the coating material;(Tack free (dry to touch) time curve or table/ Dust free time curve or table/Back fill ready time curve or table / Full cure time curve or table;(at 10°C, 24°C, 35°C, and 65°C) in accordance with ASTM D 1640.
- e. Directions for handling and storage;
- f. Material safety data sheet (MSDS).

5.2 Documents to be submitted by the applicator

The following documents shall be prepared by the applicator and submitted to the purchaser for review and approval:

- a. Quality control plan (QCP) for application of the coating in the field;
- b. Repair procedure.

6. PACKAGING

Each part of liquid epoxy coating material shall be packed in hermetically sealed metallic containers.

Pallets shall be strapped on all sides to be suitable for long-distance shipment and additionally shrink wrapped to be weather-proof. Each pallet of coating material shall contain an application instruction.

7. MARKING

7.1 CONTAINERS

Each container shall be marked with the following information:

- a. Product manufacturer's name;
- b. Name of material;
- c. Application method;
- d. Batch number;
- e. Production and expiration date (shelf life);
- f. Recommended storage conditions;
- g. Color of the materials (base, hardener and mixed);
- h. Health and safety warnings.
- i. Storage in closed and dry place, must be marked with a red "double roof" symbol.

7.2 PALLETS

Each pallet container shall be plainly marked with the following information:

- a. Name and trademark of the manufacturer
- b. Product designation
- c. Quantity
- d. Batch No.
- e. Date of manufacture
- f. Manufacturer's name and address

8. QUALITY ASSURANCE

8.1 The product supplier shall guarantee the consistent quality of the products and maintain for the properties listed in Table 1. The purchaser or applicator may also perform any or all of the specified tests in Table 1 as part of a quality assurance program.

8.2 The applicator's operators shall be trained and certified by the coating material manufacturer/supplier. The applicator's equipment shall be approved by the coating manufacturer. The applicator shall submit to the purchaser, all documents that prove satisfactory training and certification from the manufacturer for review and approval.

8.3 The applicator shall be responsible for all HSE aspects, regulations and rules.

8.4 Manufacturer shall operate an effective, documented quality system based on the last version of relevant part of the ISO 9001 and maintain records identifying the product, date of manufacturing, batch numbers and all results of inspection and testing.

9. APPLICATION OF COATING

9.1 Qualification

9.1.1 Qualification of coating applicator

Coating applicator shall be qualified in the presence of the purchaser as follows:

A piece of steel pipe shall be blasted and coated to the specified coating thickness identical to production coating in the field. It shall be inspected and tested for surface condition before and after cleaning. After the coating has hardened, it shall be inspected and tested for DFT, appearance and continuity, holiday detection, hardness Shore "D" and adhesion. The acceptance criteria are listed in Table 2.

9.1.2 Coating system qualification

9.1.2.1 The coating system shall be qualified by the applicator prior to coating application. The tests specified in Table 2 shall be conducted on each batch of material used for repair, rehabilitation and field joint coating and meet the acceptance criteria. The batch of material to be tested shall be selected by the purchaser's representative.

9.1.2.2 Coating system qualification test results shall be approved by the purchaser. Coating system qualification shall be carried out by a third-party test laboratory approved by the purchaser. The tests shall be witnessed by TPI or the purchaser's representative. The applicator shall inform the purchaser prior to any qualification tests.

9.1.2.3 The coating manufacturers shall submit the certificates and test results of each batch of coating materials which complies with the requirements of Table 2.

Note 1: Coating application shall not be commenced before the results of coating system qualification tests are reviewed and approved by the purchaser.

Note 2: At the discretion of the purchaser, the qualification Type tests (items 13 and 15 of Table 2) may be waived, provided that the certificates and the results of tests carried out at a reputable

third-party test laboratory, not exceeding two years from the date of tests, submitted by the manufacturer/supplier and approved by the purchaser.

Note 3: The coating system shall be requalified in case of any changes in the material formulation, manufacturer and changes in the production process which influence the material processing behavior and change in production facility.

9.1.3 Qualification testing steel panels

9.1.3.1 Test panels shall be of carbon steel and shall be abrasive blast cleaned to SA 2 ½ degree to a surface profile of 60 to 100 µm.

9.1.3.2 Coating application, curing procedure and coating thickness shall be in accordance with the manufacturer's recommendations and identical to the field application procedure.

9.1.3.3 The coating system shall be considered qualified when the results of test panels meet the acceptance criteria for each test as specified in Table 2.

9.2 Surface preparation

9.2.1 Prior to blast cleaning, the steel surface shall be dry and free from surface defects (such as slivers and laminations), contamination (such as oil, grease, hydrocarbons and temporary corrosion protection), previously applied coatings and deleterious materials. The preblasting surface preparation processes may be used such as chemical treatment, solvent cleaning, water jetting and use of hand or power tools. These processes shall be approved by purchaser. After blast cleaning the degree of cleanliness shall be SA 2 ½ or better in accordance with ISO 8501-1 and the roughness R_z shall be between 60 and 100 µm as measured in accordance with ISO 8503-5 or ISO 8503-2.

9.2.2 Abrasive materials shall comply with the requirements of ISO 11124(all parts) or ISO 11126(all parts). They shall be free from contamination and contain less than 100 mg/kg chlorides and less than 0.3% copper. If the conductivity of the blasting material is greater than 50 µS/cm (in accordance with ASTM D 4940), the blasting material shall be replaced.

9.2.3 Compressed air for surface preparation shall be free of oil and condensed water. These shall be determined daily with a blotter test in accordance with ASTM D4285. If necessary, after-coolers shall be provided to reduce the water content to an acceptable level. Traps, filters and separators shall be regularly emptied and cleaned.

9.2.4 Nozzles for blast cleaning equipment shall be of venturi design and shall be discarded when wear reaches 30% of the original bore.

9.2.5 The pipe surface shall be maintained at least 3 °C above the dew point temperature and humidity shall not exceed 85% during cleaning and prior to coating.

9.2.6 The maximum residual chloride level on the blast-cleaned surface shall be 20 mg/m² in accordance with ISO 8502-6 or ISO 8502-9 or using Elcometer 130/SCM400 or any other method approved by purchaser.

9.2.7 Contaminants (e.g. residual abrasive dust and grit) shall be removed from all blasted surfaces prior to coating application. Dust contamination shall be a maximum of class 2,

in accordance with ISO 8502-3. A tape test shall be conducted to verify that the surface is free of contaminants.

9.2.8 Prepared surface shall be visually inspected for surface defects and surface imperfections that may cause holidays in the coating.

9.2.9 After blast cleaning, the surface of the pipe shall be inspected. All slivers, laminations, weld spatters and other surface imperfections made visible by the blast cleaning process shall be removed. After removal of these defects, the residual thickness of pipe shall satisfy the minimum requirements specified by IGS-M-PL-001-2 standard. The treated areas greater than 10 cm² shall be ground flash to a smooth contour profile.

9.2.10 If pipe heating is used to meet required environmental conditions, the pipe must be heated with caution to prevent damage to parent coating or lining.

9.2.11 Blast-cleaned pipe surfaces shall be protected from condensation, moisture, rainfall, frost and snow. Blast-cleaned surfaces shall also be protected from other contaminants including sand, grit and dirt. The blasted pipe surface shall not be allowed to flash rust or exhibit deterioration before coating.

9.3 Application procedure

9.3.1 The applicator shall follow the coating manufacturer's procedures and recommendations, which are subject to approval by the purchaser. The epoxy shall be of the type that can be applied by using either plural component spray equipment, airless spray equipment or brushes and rollers, with all necessary ancillary equipment in accordance with the coating manufacturer's recommendations.

9.3.2 The contents of base (epoxy resin) and curing agent shall be stirred or agitated and thoroughly mixed in separate containers in accordance with manufacturer's recommended practice.

9.3.3 The coating shall be a single coat and may be applied in multiple passes to build the required film thickness in accordance with the manufacturer's recommended practice.

9.3.4 No thinner shall be used to dilute or change the consistency of the coating material.

9.3.5 If the coating is to be applied in the field, coating shall not be applied during rain, fog, mist or when there is free moisture on the prepared surface or rust flashed.

9.3.6 The coating operation shall be suspended when the metal temperature falls to within 3 °C of the dew point, or is less than 5 °C and/or when the relative humidity is higher than 85%.

9.3.7 If the surface to be coated is below 10 °C, preheating of the substrate is recommended. Pipe temperature shall not exceed 70 °C as a result of preheat.

9.3.8 The maximum time between surface preparation and start of coating application shall be no longer than 4 hours for relative humidity up to 70% and 2 hours for relative humidity between 70% to 85%.

9.3.9 The finished coating shall be uniform and free of application defects such as pinholes, fish eyes, sags, drips, icicles, etc.

9.3.10 During the coating application, the wet-film thickness (WFT) of the applied coating shall be measured using a wet-film gauge and the wet-film gauge marks shall be brushed out. Wet-film measurements shall be made on every joint, elbow, tee, etc., being coated. If low areas are detected, additional coating shall be applied before a tack-free condition occurs.

9.3.11 For twin feed airless application, appropriate monitoring equipment shall be used to ensure correct metering of the two pack materials specified by the manufacturer.

9.3.12 The curing temperature, the time interval between application and backfill and the methods used to determine whether the coating is backfill-ready such as hardness test shall be conducted to be within the limits recommended by the coating manufacturer.

9.3.13 The coating is considered cured when it has attained the hardness recommended by the coating manufacturer.

Note: It is recommended that the coated pipe be buried as soon as the full curing time of the coating is elapsed so that no color change occurs in the coating.

10. INSPECTION AND TESTING

10.1 INSPECTION FOR QUALIFICATION

10.1.1 Inspection operations shall be carried out as per Table 2 by the applicator and according to item 9 (Qualification). The results of inspection shall be recorded by the applicator and made available to the purchaser's inspector

10.1.2 The purchaser's appointed inspector shall have free access to the workshops, storage yards and laboratory of the coating applicator. Inspector shall have the right and opportunity to witness any quality control tests and/or to perform such tests himself. The applicator shall furnish the purchaser's inspector with all tools and equipment necessary for inspection at the application site.

10.1.3 Purchaser's inspector shall have free access at all times to all work related to the coating application process, with the right to inspect work and materials. All such work and materials shall be subject to approval by inspector. Failure of inspector to identify or reject defective work or materials shall not be construed as acceptance of such work or materials.

10.1.4 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, pinholes, blisters, cuts, swellings, excess material thickness, dis bonded zones, air inclusions, tears, voids, etc.

10.2 INSPECTION FOR BATCH CERTIFICATE

To guarantee the quality of the products to be delivered, the inspection is carried out at the manufacturer's site prior to shipment.

Based on the results of material tests during the inspection and on the provided quality control data (process control, in-house and external tests) an inspection report shall be filled-out and signed by the inspector according to inspection type 3.1 of standard EN 10204. This inspection and Testing Procedure regulates the steps that be performed during the inspection process.

The Inspector's works and duties consist of the following activities, but not limited to:

1. Checking of Documents

- a. Checking the raw material quality control test results and Certificates for all items and verifying the results versus the manufacturer's data sheets.
- b. Checking the manufacturer's daily production quality control test reports showing the amounts of produced material & results of the relevant tests and verify the results versus the manufacturer's data sheets.
- c. Check the calibration certificates of the testing and inspection instruments.
- d. Check the test report for all items (long terms and short terms) of qualification properties according to related standard IGS, not exceeding two years from issuance date.

2. Visual inspection of the produced goods:

- a. Visual inspection of the marking and packaging (number and weight of container, batch number of components, etc.) according to this standard.
Requirement: purchase order
- b. Crosscheck of purchase order quantities with stock

3. Selection of samples for material tests

Selection of one container per each batch of all material to prepare samples from coating system running for each item according to related test methods.

4. Batch certificate tests:

All short test which are done throughout 7 days shall be carried out according to table 2 of this standards.

5. Inspection report:

Inspection report shall be including of the following items, but not limited to:

- a. List of inspection materials, quantities and batch numbers
- b. Report of document check (according to section 1)
- c. Report of visual inspection (according to section 2), plus photos of activities
- d. Description of sample selection and preparation of specimens, plus photos of activities
- e. Report of calibration certificates of the testing and inspection instruments
- f. Date of presence in factory, preparation of specimens and start test
- g. Tests report include of tests result and graphs (if that to exist)
- h. Third party inspection agency approves

Note: All in-house tests shall be performed in witness of inspector.

5.1 For external tests of one produced batch exemplary for the whole shipment, to be carried out by an internationally well-known independent laboratory and all of documents shall be accepted by inspector.

5.2 Details of all inspection and testing shall be fully documented by the manufacturer and certified by inspector.

5.3 The results of all mentioned tests shall be checked and complied by criteria which are remarked in related standard.

5.4 In the case of any failure to comply with any of the NIGC's requirements mentioned in related standard IGS, new samples according to above mentioned table shall be selected by inspector and all of required tests shall be carried out accordingly. If any failure occurred again, it shall be effect of rejection for each batch presented.

5.5 At least one photo of inspector next to the goods is required. The photos of the all parts (include of storage, batch number of drum, preparation of test specimens, test instruments and etc.), plus the image of the inspector's photo attached to the certificate on the inspection report (via CD/DVD) is required.

5.6 Third party inspector shall issue release note to supplier and purchaser (two copies) after enquiry items acceptance

5.7 Third party inspection agency shall issue inspection certificate after release note has been issued.

10.3 INSPECTION FOR FIELD

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

- a. Date and pipe section number;
- b. Coating thickness readings;
- c. Number of holidays;
- d. Disposition (accepted, repair needed, rejected).
- e. Particular attention shall be given to the following external surface areas when carrying out visual inspection:
- f. Adjacent to the longitudinal welds;
- g. Adjacent to the cut-back at each end of pipe;
- h. Within the body of the pipe.

The nature and frequency of inspection operations shall be as per purchaser's ITP.

Table 3-Field Tests and Control

Item	Property	Acceptance Criteria	Test Method	Test Frequency
1	Surface condition before blast cleaning	dry, free from contamination, previously applied coating and deleterious materials	visual	all surface (each pipe)
2	Compressed air	no water, no oil contamination	ASTM D 4285	once per day
3	Blast abrasives	no oil contamination conductivity < 50 $\mu\text{S}/\text{cm}$	ASTM D 4940	once per batch
4	Checking of the blast cleaning process	section 9.2	ISO 8503-5	every 4 working hours
5	Condition of prepared surface	section 9.2	Visual ISO 8501-1	all surface
	Anchor and surface profile	60 μm to 100 μm	ISO 8503-2 ISO 8503-5	min 2 per shift
	Chloride	< 20 mg/m^2	ISO 8502-6 ISO 8502-9	min 1 per 24 h
	Dust	maximum of class 2	ISO 8502-3	min 1 per 24 h
6	Ambient conditions	humidity less than 85%, the surface temperature more than 5 $^{\circ}\text{C}$ and at least 3 $^{\circ}\text{C}$ above the dew point	-----	monitored and the values recorded at least one per hour
7	Dry thickness of the coating system (minimum individual reading)	-1500 μm : If design temperature is more than 40 $^{\circ}\text{C}$ or for field joints or pipe sizes with O.D. 30" and larger -800 μm : For smaller sizes or lower temperatures	ISO 21809-3 /Annex B	every 100 m^2
8	Hardness Shore "D" at 23 ± 2 $^{\circ}\text{C}$, min	70	ISO 868	on the fully cured coating
9	Appearance and continuity	uniform color, free of holidays, blister and other defects	visual	all surface
10	Holiday detection test	no holidays (min 5 $\text{V}/\mu\text{m}$) (max 25 kV)	ISO 21809-3/ Annex C	all surface
11	Adhesion test, pipe surface plant coating at 23 ± 2 $^{\circ}\text{C}$ Min.	10 MP	ISO 4624	every 8 working hours

12. REPAIR

Any repair operation shall be carried out in accordance with the repair procedure approved by the purchaser. All coating defects and those resulting from destructive tests shall be repaired. This procedure shall contain:

- a. Repair of surface damages;
- b. Repair of holidays and small damages;
- c. Repair of damages due to site quality check;
- d. Testing to prove the efficiency of the repairs.

12.1 The compatibility of repair material with the previously applied coating shall be approved by the manufacturer.

12.2 The repair material and the application conditions shall be those defined in the manufacturer's technical specification and data sheets.

12.3 The repair material and the application conditions shall be in accordance with IGS-O-TP-001

12.4 All damaged areas shall be thoroughly abraded and roughened by using wire brush, surface grinders and/or 80-grit sandpapers to ensure adhesion of the repair material. The coating around the area to be repaired shall be lightly abraded for at least 25 mm from the perimeter of this exposed substrate.

12.5 Edges of the existing coating shall be roughened by power brushing or by sweep blasting but not removed or contaminated by abrasive dust. The coating shall overlap the existing coating for a minimum of 75 mm. Existing coatings on the pipeline that are not being repaired shall be protected from blasting and brushing damages. At least 25 mm of roughened existing coating shall remain uncoated at the overlap.

12.6 Where the metal substrate is visible, it shall be cleaned in accordance with ISO 8501-1, SA 2 ½ degree.

12.7 The surface shall be clean and dry during application of the repair material.

12.8 The completed repair shall satisfy the values specified in the manufacturer's data sheets. After curing all repaired areas shall be holiday detected.

12.9 The coating DFT after repair shall meet the minimum DFT requirements as the original pipe coating.

13. HEALTH, SAFETY AND ENVIRONMENT

The applicator shall comply with the requirements of the purchaser's HSE Management System, the product's MSDS and other requirements such as site regulations, safety rules, etc. The applicator shall ensure that updated MSDS are obtained from the manufacturer. The applicator shall provide all painters with approved protective clothing including safety

glasses, safety shoes, hard hats, goggles, respirators, earplugs, fresh-air-fed hood and any other necessary safety equipment. All the safety equipment shall be maintained in a good working condition. The applicator shall be required to test work areas for flammable vapors, with an appropriate vapor tester, prior to and throughout abrasive blasting and coating operations. The applicator shall post appropriate warning signs and erect appropriate barriers in the work area. The waste produced during operation, repairing and maintenance shall be managed and disposed under waste management laws and related regulations (MOP-HSED-301 to 306).

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