



شرکت ملی گاز ایران

مدیریت پژوهش و فناوری

امور تدوین استانداردها

# IGS

## مشخصات فنی خرید

پوشش پلی یورتان مایع برای تعویض و تعمیر پوشش سطوح خارجی خطوط لوله فولادی مدفون، پوشش سرجوش ها ، لوله کشی تاسیسات مدفون ، پوشش دهی جدید شیرآلات ، اتصالات و سایر اجزاء لوله کشی

External Liquid Polyurethane Coating for Rehabilitation and Repair of Buried Steel Pipelines , coating of Field joints , Buried Steel pipings and new Coating of valves , Fittings and other piping components



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شرکت ملی گاز ایران



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## ابلاغ مصوبه هیات مدیره



مدیر محترم پژوهش و فناوری

باسلام،

به استحضار می‌رساند در جلسه ۱۶۷۴ مورخ ۱۲ / ۲۴ / ۱۳۹۴ هیات مدیره، نامه شماره ۹۰۰۰۲۰۰۱۸۵ مورخ ۱۹ / ۱۲ / ۹۴ مدیر پژوهش و فناوری در مورد تصویب نهایی استاندارد تحت عنوان پوشش پلی یورتان مایع برای تعویض و تعمیر "پوشش سطح خارجی خطوط لوله فولادی مدفون" به شماره استاندارد (2) IGS-M-TP-020 مطرح و مورد تصویب قرار گرفت.

این مصوبه در حکم مصوبه مجمع عمومی شرکت های تابعه محسوب و برای کلیه شرکت های تابعه لازم الاجرا می‌باشد.

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## FOREWORD

This standard is intended to be mainly used by NIGC and contractors, and has been prepared based on interpretation of recognized standards, technical documents, knowledge, backgrounds and experiences in natural gas industry at national and international levels.

Iranian Gas Standards (IGS) are prepared, reviewed and amended by technical standard committees within NIGC Standardization division and submitted to the NIGC's "STANDARDS COUNCIL" for approval.

IGS Standards are subject to revision, amendment or withdrawal, if required. Thus the latest edition of IGS shall be checked/inquired by NIGC employees and contractors.

This standard must not be modified or altered by NIGC employees or its contractors. Any deviation from normative references and / or well-known manufacturer's specifications must be reported to Standardization division.

The technical standard committee welcomes comments and feedbacks 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 NIGC 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 polyurethane to be used for preventing external corrosion of underground steel pipeline systems. The coating system may be used at operating temperatures up to 80 °C ( $T_{max}$ ) for applications as follow:

- Rehabilitation of buried pipelines and pipings coatings.
- Field joints and repair of buried pipelines and pipings, valves, fittings and other pipeline and piping components coated with dual layer FBE or liquid epoxy or liquid polyurethane coating systems.
- New coating of buried pipings, valves, fittings and other piping components.

The liquid polyurethane shall be a two-component, 100% solid and solvent free coating. The polyurethane 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 shop or factory coating of line pipes.

**Note 2:** If the operating temperature is more than 60 °C or for field joints and pipe sizes with O.D. 30" and larger, the minimum thickness of coating shall be 1500 µm. For smaller sizes and lower temperatures, the minimum thickness of coating shall be 1000 µm.

**Note 3:** Manual / hand application is acceptable for repair and where spraying is not feasible / practical or for small areas.

**Note 4:** This standard withdraws and replaces IGS-M-TP-14-1(0) and IGS-M-TP-20-1(1) standards.

## 2. REFERENCES

Throughout this standard specification, the following standards and codes are referred to, the edition of them, that are in effect at the time of issue of this standard specification (2015) shall, to the extent specified herein, form part of this standard specification. The applicability of changes in standards and codes that occur after the date of standards that referred shall be mutually agreed upon by the purchaser and manufacturer or supplier.

### 2.1 Normative references

**ASTM D 543 (2006)** "Standard Practices for Evaluating the Resistance of Plastics to Chemical Reagents"

**ASTM D 570 – 98 (2010)** "Standard Test Method for Water Absorption of Plastics"

**ASTM D 1640 – 03 (2009)** "Standard Test Methods for Drying, Curing, or Film Formation of Organic Coatings at Room Temperature"

**ASTM D 4060 (2001)** "Standard Test Method for Abrasion Resistance of Organic Coatings by the Taber Abraser"

**ASTM D 4285 (1999)** "Standard Test Method for Indicating Oil or Water in Compressed Air"

**ASTM D 4940 (2010)** "Standard Test Method for Conductimetric Analysis of Water Soluble Ionic Contamination of Blasting Abrasives"

**BS EN 10290 (2002)** "Steel Tubes and Fittings for Onshore and Offshore Pipelines – External Liquid Applied Polyurethane and Polyurethane-Modified Coatings"

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

**BS EN ISO 4624 (2003)** "Paints and Varnishes – Pull-Off Test for Adhesion"

**BS EN ISO 8502-3 (2000)** "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)"

**BS EN ISO 8502-6 (2000)** "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"

**BS EN ISO 8502-9 (2001)** "Preparation of Steel Substrates before Application of Paints and Related Products – Test for the Assessment of Surface Cleanliness – Part 9: Field Method for the Conduct Metric Determination of Water-Soluble Salts"

**BS EN ISO 8503-2 (1995)** "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"

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

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

**IGS-M-PL-001-2(0) (2013)** "SMLS/HFW/SAWH Carbon Steel Pipes, Grades B to X80, Sizes 6 to 56 inch."

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

**ISO 8503-5 (2003)** "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 (2008)** "Petroleum and Natural Gas Industries – External Coatings for Buried or Submerged Pipelines Used in Pipeline Transportation Systems – Part 3: Field Joint Coating"

**SSPC PA-2 (2012)** "Procedure for Determining Conformance to Dry Coating Thickness Requirements"

## **2.2 Informative references**

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

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

## **3. DEFINITIONS**

### **Applicator**

The company that applies the liquid polyurethane coating system.

### **Backfill**

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

### **Backfill-ready**

The stage or degree of cure, which may not be full chemical cure, that the coating has attained that provides resistance to moisture absorption and toughness to handle mechanical stresses including abrasion and backfill.

### **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.

### **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.

### **Liquid Polyurethane**

Liquid polyurethane coatings are two-pack coating systems composed of polyol and isocyanate. This type of coating has a fast cross linking reaction between the isocyanate and polyol monomer, and limited pot-life after the two components are mixed.

### **Manufacturer/Supplier**

The company that manufactures or supplies coating material.

**Maximum continuous operating temperature ( $T_{max}$ )**

Maximum continuous temperature of the medium transported through the buried or immersed coated 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.

**Room Temperature (RT)**

Indoor temperature generally between 20 °C and 25 °C.

**Shelf Life**

Amount of time a coating or other material remains in useable condition.

**Third Party Inspection (TPI)**

Third party inspection authorities approved by purchaser (NIGC).

**4. COATING MATERIAL****4.1 General**

- The two-component liquid coating is generally composed of a polyol and an isocyanate. The polyol and isocyanate should have different colors allowing the verification of the correct mixing and checking the uniformity of the color of the mixed product. The mixed coating shall not be black.
- Normally, the liquid pipeline coatings shall be high-solid coatings to form a thick film of smooth appearance without drips, running, sags, pinholes or fisheyes.
- No primer shall be required for the polyurethane coating to achieve proper performance.
- The polyurethane material shall have sufficient pot life to ensure convenient application in site condition.
- 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.



**4.2** The dry-to-touch time shall be no longer than 2 hours at room temperature when tested in accordance with ASTM D 1640.

**Note:** For rehabilitation purposes, due to unforeseen conditions in site such as climate change etc. the dry-to-touch time may be reduced down to 15 minutes.

**4.3** The backfill time shall be no longer than 6 hours at room temperature. The backfill time is that taken for the film to attain the hardness of 70 Shore "D" as per BS EN ISO 868 standard.

#### **4.4 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. Batch certificates;
- d. Application procedure of the coating material;
- e. Dry-to-touch time curve;
- f. Directions for handling and storage;
- g. Material safety data sheets (MSDS).

#### **4.5 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;
- b. Repair procedure.

#### **4.6 Packaging**

Each part of polyurethane coating material shall be packed in hermetically sealed metallic containers and suitably marked giving as a minimum, the following details:

- Product manufacturer's name;
- Name of material;
- Application method;
- Batch number;
- Date of manufacture and expiry date (shelf life);
- Recommended storage conditions;
- Color of the materials;
- Health and safety warnings.

**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 polyol and isocyanate	x	x
Factory of origin		x
Batch or production lot number	<sup>a</sup>	x
Date of manufacture and use by date	<sup>a</sup>	x
Color	<sup>b</sup>	
Physical state of the delivered product	<sup>a</sup>	
Methods of application	x	
Solids by volume	x	
Solids by weight	x	
Theoretical coverage per m <sup>2</sup> for nominal thickness	x	
Size of container	<sup>a</sup>	
Shelf life	<sup>a</sup>	
Storage conditions	x	
Pot-life	x	x
Surface preparation	x	
Recommended instructions for application	x	
Recommended repair material(s)	x	
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	<sup>a</sup>	x
Fineness of grind	x	x
Density	x <sup>b</sup>	x <sup>a</sup>
Gel time	x	x
Sag resistance	x	x
Adhesion test, resistance to removal at 23 ± 2 °C	x	
Adhesion test, pull off method at 23 ± 2 °C	x	
Cathodic disbondment at 23 ± 2 °C	x	
Cathodic disbondment at 80 ± 2 °C	x	
Impact resistance	x	
Indentation resistance at 10 N/mm <sup>2</sup>	x	
Specific electrical insulation resistance	x	
Flexibility	x	
Thermal ageing	x	
Hot water immersion test	x	
Water absorption	x	
Chemical resistance	x	
Abrasion resistance	x	
Cure time before handling	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.		
<sup>a</sup> Required for the polyol and isocyanate.		
<sup>b</sup> Required for the polyol, isocyanate and for the mixed product.		

**Table 2 – Qualification Requirements**

Item	Property	Acceptance criteria	Test method
1	Dry thickness of the coating System (minimum individual reading)	- 1500 µm: If the operating temperature is more than 60 °C or for field joints and pipe sizes with O.D. 30" and larger - 1000 µm: For smaller sizes and lower temperatures	ISO 21809-3 Annex A / SSPC PA2
2	Hardness Shore "D" at 23 ± 2 °C, min	70	BS EN ISO 868
3	Appearance and continuity	uniform color, smooth appearance and free from defects	visually
4	Holiday detection test	no holidays (min 5 V/µm)	ISO 21809-3 Annex B
5	Adhesion test, to pipe surface, resistance to removal at 23 ± 2 °C	rating 1	ISO 21809-3 Annex C
6	Adhesion test, pull off method, at 23 ± 2 °C, min - to pipe surface - to plant coating(FBE and liquid epoxy) - to plant coating for other coatings	10 MPa 7MPa (agreement by user and manufacturer)	BS EN ISO 4624
7	Cathodic disbondment, max radius, 28 days at 23 ± 2 °C	6 mm*	BS EN 10290 Annex E
8	Cathodic disbondment, max radius, 2 days at 80 ± 2 °C	8 mm*	BS EN 10290 Annex E
9	Impact resistance, min - at 23 ± 2 °C - at -5 ± 2 °C	5J ×k**×mm 3J ×k**×mm (mm of coating thickness)	ISO 21809-3 Annex G
10	Indentation resistance at 10 N/mm <sup>2</sup> (holiday detection at 5 V/µm), max - at 23 ± 2 °C - at 80 ± 2 °C	0.20 mm 30% initial thickness	BS EN 10290 Clause 7.13, Annex H
11	***Specific electrical insulation resistance, min after 100 days at 23 ± 2 °C	For 1000 µm coating: 10 <sup>6</sup> Ω.m <sup>2</sup> For 1500 µm coating: 10 <sup>7</sup> Ω.m <sup>2</sup> R <sub>S100</sub> / R <sub>S70</sub> ≥ 0.80	BS EN 10290 Clause 7.11, Annex F
	Specific electrical insulation resistance, min after 30 days at 80 ± 2 °C	10 <sup>4</sup> Ω.m <sup>2</sup>	
12	Flexibility - at 23 ± 2 °C - at 0 ± 2 °C	Pass Pass	BS EN 10290 Annex K
13	***Thermal ageing 100 days at 100 ± 2 °C, to pipe surface	no blistering (less than 10% of the test area) no holidays after flexibility test > 7 MPa and ≤ rating 2	Annex A
14	Adhesion test after immersion in tap water	≤ rating 2	BS EN 10290 Annex G
15	Water absorption, max 24 hours at 23 °C	2.0%	ASTM D 570
16	Chemical resistance, change in mass, length and width after 30 days immersion, max (10% H <sub>2</sub> SO <sub>4</sub> , 30% NaCl, 30% NaOH and #2 diesel fuel)	5%	ASTM D 543

\* The specimen surface shall also be examined for any pinhole formation, blistering, cracking, and discoloration. The pinhole shall be examined by means of a wet sponge holiday detector and confirmed with a 30x stereo microscope. For acceptance, the coating shall exhibit no defects.

**\*\*k: Correction factor**

Pipe Diameter, mm	k
D > 219.1	1.00
76.1 < D ≤ 219.1	0.85
D ≤ 76.1	0.70

\*\*\* 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.

\*\*\*An infra-red scan spectrogram performed on polyol, isocyanate and cured product with a KBr standard disk obtained from the original manufacturer shall be supplied by the applicator. This spectrogram should subsequently be used for comparison with reference scan.

## 5. QUALITY ASSURANCE

**5.1** 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.

**5.2** 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.

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

## 6. QUALIFICATION

### 6.1 Qualification of coating applicator

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

– A piece of steel pipe shall be blast cleaned and coated to the specified coating thickness identical to production coating. 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 and test methods are listed in Table 2.

### 6.2 Coating system qualification

The coating system shall be qualified by the applicator prior to coating application. The tests specified in Table 2 shall be conducted on one batch of material and meet the acceptance criteria. The batch of material to be tested shall be selected by the purchaser's representative.

Coating system qualification test results shall be approved by the purchaser. Coating system qualification shall be carried out at 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 well in advance prior to any qualification tests.

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 11 and 13 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.

### 6.3 Qualification testing steel panels

- Test panels shall be of carbon steel and shall be abrasive blast cleaned to SA 2½ degree and a surface profile of 60 µm to 100 µm.
- Coating application and curing procedure shall be in accordance with the manufacturer's recommendations and identical to the application procedure.
- The coating system shall be considered qualified when the results of test panels meet the acceptance criteria for all tests as specified in Table 2.

## 7. APPLICATION OF THE COATING

### 7.1 Surface preparation

- 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 2½ 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.
- Abrasive materials shall comply with the requirements of BS EN ISO 11124(all parts) or BS EN 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.
- 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 D 4285. 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.
- Nozzles for blast cleaning equipment shall be of Venturi design and shall be discarded when wear reaches 30% of the original bore.

- 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.
- 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.
  
- 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.
  
- The maximum residual chloride level on the blast-cleaned surface shall be 20 mg/m<sup>2</sup> in accordance with BS EN ISO 8502-6 or BS EN ISO 8502-9 or using Elcometer 130-SCM400 or any other method approved by purchaser.
  
- Contaminants (e.g. residual abrasive dust and dirt) shall be removed from all blasted surfaces prior to coating application. Dust contamination shall be a maximum of class 2, in accordance with BS EN ISO 8502-3. A tape test shall be conducted to verify that the surface is free of contaminants.
  
- Prepared surface shall be visually inspected for surface defects and surface imperfections that may cause holidays in the coating.
  
- 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(0). The treated areas greater than 10 cm<sup>2</sup> shall be ground flash to a smooth contour profile.

## **7.2 Application procedure**

- The applicator shall follow the coating manufacturer's procedures and recommendations, which are subject to approval by the purchaser. The polyurethane shall be of the type that can be applied by using either plural component spray equipment or brushes and rollers for brush grades, with all necessary ancillary equipment in accordance with the coating manufacturer's recommendations.
  
- For twin feed airless application, appropriate monitoring equipment shall be used to ensure correct metering of the two pack materials specified by the manufacturer.
  
- Polyol and isocyanate shall be stirred or agitated and thoroughly mixed in separate containers in accordance with manufacturer's recommended practice.
  
- 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.
  
- No thinner shall be used to dilute or change the consistency of the coating material.
  
- Coating shall not be applied during rain, fog, mist or when there is free moisture on the prepared surface or rust flashed.

- 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%.
- 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.
  
- The maximum time between surface preparation and start of the coating application shall be no longer than 4 hours for relative humidity up to 70% and 2 hours for relative humidity between 70% and 85%.
  
- 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.
  
- The coating is considered cured when it has attained the hardness recommended by the coating manufacturer.
  
- The finished coating shall be uniform and free of application defects such as pinholes, fish eyes, sags, drips, icicles, etc.

**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.

## 8. INSPECTION AND TESTING

- Inspection operations shall be carried out by the applicator. The results of inspection shall be recorded by the applicator and made available to the purchaser's inspector. The nature and frequency of inspection operations shall be as per Table 3.
  
- 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.
  
- 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.
  
- 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, disbonded zones, air inclusions, tears, voids, etc.
  
- The applicator shall prepare a daily production summary containing the following information for each pipe section coated:
  - Date and pipe section number;
  - Coating thickness readings;

- Number of holidays;
  - Disposition (accepted, repair needed, rejected).
- Particular attention shall be given to the following external surface areas when carrying out visual inspection:
- Adjacent to the longitudinal welds;
  - Adjacent to the cut-back at each end of pipe;
  - Within the body of the pipe.

**Table 3 – Nature and Frequency of Testing and Control**

Item	Property	Acceptance Criteria	Min. Test Frequency	Test Method
1	Surface condition before blast cleaning	dry, free from contamination, previously applied coating and deleterious materials	all surface	visual
2	Compressed air	no water, no oil contamination	every 4 hour	ASTM D 4285
3	Blast abrasives	no oil contamination conductivity < 50 $\mu\text{S}/\text{cm}$	once per batch	ASTM D 4940
4	Checking of the blast cleaning process	section 7.1	every 4 hour	ISO 8503-5
5	Condition of prepared surface	section 7.1	all surface	Visual ISO 8501-1
	Anchor and surface profile	60 $\mu\text{m}$ to 100 $\mu\text{m}$	every 4 hour	BS EN ISO 8503-2 ISO 8503-5
	Chloride	< 20 $\text{mg}/\text{m}^2$	every 8 hour	BS EN ISO 8502-6 BS EN ISO 8502-9
	Dust	maximum of class 2	every 8 hour	BS EN ISO 8502-3
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	once per day and at any weather change	-----
7	Dry thickness of the coating system (minimum individual reading)	- 1500 $\mu\text{m}$ : If the operating temperature is more than 60 $^{\circ}\text{C}$ or for field joints and pipe sizes with O.D. 30" and larger - 1000 $\mu\text{m}$ : For smaller sizes and lower temperatures	every 10 $\text{m}^2$	ISO 21809-3 Annex A / SSPC PA2
8	Hardness Shore "D" at 23 $\pm$ 2 $^{\circ}\text{C}$ , min	70	every 2 hour	BS EN ISO 868
9	Appearance and continuity	uniform color, free of holidays, blister and other defects	all surface	visual
10	Holiday detection test	no holidays (min 5 $\text{V}/\mu\text{m}$ )	all surface	ISO 21809-3 Annex B
11	Adhesion test, to pipe surface, at 23 $\pm$ 2 $^{\circ}\text{C}$ - resistance to removal - pull off method, min	rating 1 10 MP	every 2 hour	ISO 21809-3 Annex C BS EN ISO 4624

**Note:** for rehabilitation purpose, the test frequency shall be specified by the user.



## 9. 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:
  - Repair of surface damages;
  - Repair of holidays and small damages;
  - Repair of damages due to site quality check;
  - Testing to prove the efficiency of the repairs.
- The compatibility of repair material with the previously applied coating shall be approved by the manufacturer.
- The repair material and the application conditions shall be those defined in the manufacturer's technical specification and data sheets.
- 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 the exposed substrate.
- 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.
- Where the metal substrate is visible, it shall be cleaned in accordance with ISO 8501-1, Sa 2½ degree.
- The surface shall be clean and dry during application of the repair material.
- The completed repair shall satisfy the values specified in the manufacturer's data sheets. After curing all repaired areas shall be holiday detected.
- The coating DFT after repair shall meet the minimum DFT requirements as the original pipe coating.

## 10. 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.

## **"Annex A"**

### **Thermal Ageing Test**

A rectangular shaped sample, length 200 mm x width 100 mm, machined from a ring section, cut from the coated pipe shall be exposed to air in an oven at the test temperature. The sample shall consist of the coating applied on steel and overlap with existing line pipe coating. The bare edges of the sample shall be coated to prevent delamination of the coating. When agreed by the purchaser, other sized coated samples may be used.

The exposure time shall be 100 days.

Immediately after the exposure, the coated sample shall be removed from the oven and allowed to cool to ambient temperature.

The coating shall then be examined visually and the adhesion shall be tested and judged in accordance with BS EN 10290 (Annex D) and BS EN ISO 4624.

Adhesion tests shall be performed on the coating over the steel substrate and the major failure made (>75% of surface area) shall be cohesive.

The flexibility of the coating after exposure shall be such that holidays do not appear when it is tested in accordance with the procedure in BS EN 10290 (Annex K) at  $23 \pm 2$  °C.