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دستورالعمل اجرائی

پوشش اپوکسی درون لوله های خطوط انتقال گاز طبیعی

Internal Epoxy Coating of Line Pipe for Sweet Gas Transmission Services



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شرکت ملی گاز ایران



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باسلام،

به استحضار می‌رساند در جلسه ۱۷۴۳ مورخ ۱۳۹۶/۵/۲۲ هیأت مدیره، نامه شماره گ. ۶۳۲۷۳/۰۰۰/۹ مورخ ۹۶/۵/۱۷ مدیر پژوهش و فناوری در مورد تصویب نهایی استانداردها به شرح زیر مطرح و مورد تصویب قرار گرفت.

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این تصمیم به منزله مصوبه مجمع عمومی شرکت‌های تابعه محسوب می‌شود.

الهام ملکی

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FOREWORD

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

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

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

This standard must not be modified or altered by the end users within NIGC and her contractors.

Any deviation from normative references and / or well-known manufacturer's specifications must be reported to Standardization division.

Any comments from concerned parties on NIGC distributed IGS are welcome to technical standards committees and will receive serious attention and consideration should a revision to standards is recommended .

GENERAL DEFINITIONS:

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

1-"STANDARDIZATION DIV." has been organized to deal with all aspects of industrial standards in NIGC. Therefore, all queries for clarification or amendments are requested to be directed to mentioned div.

2- "COMPANY": refers to national Iranian gas company.

3- "SUPPLIER": refers to a firm who will supply the service, equipment or material to IGS specification whether as the prime producer or manufacturer or a trading firm.

4-"SHALL": is used where a provision is mandatory.

5- "SHOULD": is used where a provision is advised only.

6- "MAY": is used where a provision is completely discretionary.

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1. INTRODUCTION

1.1 Scope

This standard specification specifies the NIGC's requirements and recommendations for the factory application of liquid epoxy as internal coating for non-corrosive service (flow coat) to externally coated line pipes for use in single phase gas transmission pipelines with the objective of reducing surface roughness and pressure losses. The internal coating shall be applied by airless spray or other suitable spraying techniques. Brush application shall only be used for small repair jobs. It specifies the requirements for coating materials, coating application, inspection and testing and gives procedures for the qualification of coating materials and coating applicators.

Note : the use of this standard to apply in pipelines by taking all the necessary items, especially economic and technical considerations is allowed.

1.2 Information to be submitted by the purchaser

For a project qualification, the purchaser shall supply technical information to the contractor or applicator regarding the project, in particular the installation and operating conditions.

This information shall contain as a minimum:

- project name;
- the type and thickness of coating required;
- the maximum and minimum operating temperature of the pipeline;
- description of steel pipe;
- the applicable line pipe specification;
- the geographical area;
- expected ambient temperatures during installation;
- installation method;
- length of coating cut back;
- whether temporary protection of bare pipe ends is required;
- internal pipe marking requirements.

1.3 Information to be submitted by the contractor or applicator

The contractor shall submit information to the purchaser on the coating system to be used.

This information shall contain as a minimum:

- Coating manufacturer's product data sheet;
- Coating system qualification information;
- Coating application procedures;
- Name(s) of the proposed coating applicator(s);
- Applicator's qualification information;
- Quality control plan.

The contractor shall confirm that the coating system is suitable for use under the specified conditions.

1.4 Quality assurance system

The applicator and the coating manufacturer shall implement a quality management system in accordance with ISO/TS 29001.

1.5 Retention of records

Contract records shall be retained by the applicator and made available to the purchaser upon completion of the project.

1.6 Measuring devices

The applicator shall control measuring devices in accordance with ISO 10012.

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

API RP 5L1 (2002) "Recommended Practice for Railroad Transportation of Line Pipe"

API RP 5LW (1996) "Recommended Practice for Transportation of Line Pipe on Barges and Marine Vessels"

ASTM D4285 (2012) "Standard Test Method for Indicating Oil or Water in Compressed Air"

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

IGS-C-PL-001(0) (2014) "Loading, Handling and Storage of Externally Coated Pipes"

ISO 10005 (2005) "Quality Management Systems – Guidelines for Quality Plans"

ISO 10012 (2003) "Measurement Management Systems–Requirements for Measurement Processes and Measuring"

ISO 11124-1 (1997) "Preparation of Steel Substrates before Application of Paints and Related Products –Specifications for Metallic Blast-Cleaning Abrasives – Part 1: General Introduction and Classification"

ISO 11124-2 (1997) "Preparation of Steel Substrates before Application of Paints and Related Products –Specifications for Metallic Blast-Cleaning Abrasives – Part 2: Chilled-Iron Grit"

ISO 11124-3 (1997) "Preparation of Steel Substrates before Application of Paints and Related Products –Specifications for Metallic Blast-Cleaning Abrasives – Part 3: High-Carbon Cast-Steel Shot and Grit"

ISO 11124-4 (1997) "Preparation of Steel Substrates before Application of Paints and Related Products –Specifications for Metallic Blast-Cleaning Abrasives – Part 4: Low-Carbon Cast-Steel Shot"

ISO 11126-1:1997/Cor 1&2:1997 "Preparation of Steel Substrates before Application of Paints and Related Products –Specifications for Non-metallic Blast-Cleaning Abrasives – Part 1: General Introduction and Classification"

ISO 11126-3 (1998) "Preparation of Steel Substrates before Application of Paints and Related Products –Specifications for Non-metallic Blast-Cleaning Abrasives – Part 3: Copper Refinery Slag"

ISO 11126-4 (1998) "Preparation of Steel Substrates before Application of Paints and Related Products –Specifications for Non-metallic Blast-Cleaning Abrasives – Part 4: Coal Furnace Slag"

ISO 11126-5 (1998) "Preparation of Steel Substrates before Application of Paints and Related Products –Specifications for Non-metallic Blast-Cleaning Abrasives – Part 5: Nickel Refinery Slag"

ISO 11126-6 (1998) "Preparation of Steel Substrates before Application of Paints and Related Products –Specifications for Non-metallic Blast-Cleaning Abrasives – Part 6: Iron Furnace Slag"

ISO 11126-7:2001/Cor 1:1999 "Preparation of Steel Substrates before Application of Paints and Related Products –Specifications for Non-metallic Blast-Cleaning Abrasives – Part 7: Fused Aluminium Oxide"

ISO 11126-8 (1998) "Preparation of Steel Substrates before Application of Paints and Related Products –Specifications for Non-metallic Blast-Cleaning Abrasives – Part 8: Olivine Sand"

ISO 11126-9 (1999) "Preparation of Steel Substrates before Application of Paints and Related Products –Specifications for Non-metallic Blast-Cleaning Abrasives – Part 9: Staurolite"

ISO 11126-10 (2000) "Preparation of Steel Substrates before Application of Paints and Related Products –Specifications for Non-metallic Blast-Cleaning Abrasives – Part 10: Almandite garnet"

ISO 1524 (2013) "Paints, Varnishes and Printing Inks – Determination of Fineness of Grind"

ISO 15741 (2001) "Paints and Varnishes – Friction-Reduction Coatings for the Interior of On-and Offshore Steel Pipelines for Non-Corrosive Gases"

ISO 2409 (2013) "Paints and Varnishes – Cross-Cut Test"

ISO 2431 (2011) "Paints and Varnishes –Determination of Flow Time by Use of Flow Cups"

ISO 2808 (2007) "Paints and Varnishes – Determination of Film Thickness"

ISO 2811-1 (2011) "Paints and Varnishes – Determination of Density– Part 1: Pycnometer method"

ISO 2811-2 (2011) "Paints and Varnishes – Determination of Density– Part 2: Immersion Body (Plummet) method"

ISO 2811-3 (2011) "Paints and Varnishes – Determination of Density– Part 3: Oscillation method"

ISO 2811-4 (2011) "Paints and Varnishes – Determination of Density– Part 4: Pressure Cup method"

ISO 2812-1 (2007) "Paints and Varnishes – Determination of Resistance to Liquids – Part 1: Immersion in Liquids Other than Water"

ISO 2812-2 (2007) "Paints and Varnishes – Determination of Resistance to Liquids – Part 2: Water Immersion Method"

ISO 2815 (2003) "Paints and Varnishes – Buchholz Indentation Test"

ISO 3233-1 (2013) "Paints and Varnishes – Determination of the Percentage Volume of Non-Volatile Matter– Part 1: Method Using a Coated Test Panel to Determine Non-Volatile Matter and to Determine Dry Film Density by the Archimedes Principle"

ISO 3233-2 (2014) "Paints and Varnishes – Determination of the Percentage Volume of Non-Volatile Matter – Part 2: Method Using the Determination of Non-Volatile-Matter Content in Accordance with ISO 3251 and Determination of Dry Film Density on Coated Test Panels by the Archimedes Principle"

ISO 3233-3 (2015) "Paints and Varnishes – Determination of the Percentage Volume of Non-Volatile Matter – Part 3: Determination by Calculation from the Non-Volatile-Matter Content Determined in Accordance with ISO 3251, the Density of the Coating Material and the Density of the Solvent in the Coating Material"

ISO 3251 (2008) "Paints, Varnishes and Plastics –Determination of Non-Volatile-Matter Content"

ISO 4287:1997/Amd 1: 2009 "Geometrical Product Specifications (GPS) – Surface Texture: Profile Method – Terms, Definitions and Surface Texture Parameters"

ISO 4628-1 (2003) "Paints and Varnishes–Evaluation of Degradation of Coatings – Designation of Quantity and Size of Defects, and of Intensity of Uniform Changes in Appearance –Part 1: General Introduction and Designation System"

ISO 4628-2 (2003) "Paints and Varnishes–Evaluation of Degradation of Coatings – Designation of Quantity and Size of Defects, and of Intensity of Uniform Changes in Appearance –Part 2: Assessment of Degree of Blistering"

ISO 6743-4 (2015) "Lubricants, Industrial Oils and Related Products (Class L) – Classification –Part 4: Family H (Hydraulic Systems)"

ISO 6860 (2006) "Paints and Varnishes–Bend Test (Conical Mandrel)"

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 8502-2 (2005) "Preparation of Steel Substrates before Application of Paints and Related Products –Tests for the Assessment of Surface Cleanliness– Part 2:Laboratory Determination of Chloride on Cleaned Surfaces"

ISO 8502-3 (1992) "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 8502-4 (1993) "Preparation of Steel Substrates before Application of Paints and Related Products –Tests for the Assessment of Surface Cleanliness– Part 4:Guidance on the Estimation of the Probability of Condensation Prior to Paint Application"

ISO 8502-6 (2006) "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 8503-2 (2012) "Preparation of Steel Substrates before Application of Paints and Related Products – Surface Roughness Characteristics of Blast-Cleaned Steel Substrates – Part 2: Method for the Grading of Surface Profile of Abrasive Blast-Cleaned Steel – Comparator Procedure"

ISO 8503-4 (2012) "Preparation of Steel Substrates before Application of Paints and Related Products – Surface Roughness Characteristics of Blast-Cleaned Steel Substrates – Part 4: Method for the Calibration of ISO Surface Profile Comparators and for the Determination of Surface Profile – Stylus Instrument Procedure"

ISO 8504-2 (2000) "Preparation of Steel Substrates before Application of Paints and Related Products –Surface Preparation Methods– Part 2:Abrasive Blast-Cleaning"

ISO 9001 (2015) "Quality Management Systems–Requirements"

ISO 9227 (2012) "Corrosion Tests in Artificial Atmospheres–Salt Spray Tests"

ISO/TS 29001 (2010) "Petroleum, Petrochemical and Natural Gas Industries – Sector-Specific Quality Management Systems – Requirements for Product and Service Supply Organizations"

2.2 Informative references

API RP 5L2 (2002) "Recommended Practice for Internal Coating of Line Pipe for Non - Corrosive Gas Transmission Service"

SHELL DEP 31.40.30.35-Gen. (2005) "Internal Coating of Line Pipe for Non-corrosive Gas Transmission Service"

3. DEFINITIONS

Applicator

The party which applies the flow coating system in the coating plant

Batch

The quantity of coating material manufactured at one time in a single vessel and identified by a unique batch number.

Coating contractor

The party which is ultimately responsible for the coating operation which may include supply of coating materials, application of the coating and transport of uncoated and coated line pipe as specified in the relevant contract. The coating contractor may be the applicator, the coating manufacturer, the line pipe manufacturer or the pipeline construction contractor.

Coating manufacturer/supplier

The party which manufactures the coating materials, supplied to the applicator.

Dry Film Thickness (DFT)

The thickness of a coating remaining on the surface when the coating has hardened.

Pot life

The maximum time during which a coating material supplied as separate components should be used after they have been mixed together.

Purchaser

The organization or individual that buys the coated pipes and fittings.

Shift

A production run of which the beginning and end coincide with a change in personnel. In the context of the quality control procedures of this standard specification, the maximum duration of a shift is 8 h.

4. COATING AND APPLICATOR QUALIFICATION

4.1 General

- The coating material shall be a two – pack epoxy and contain no substances, which could be released from the coating after it has cured.
- The coating material shall be qualified in accordance with clauses 4.2 and 4.3 per each order.
- The manufacturer of the coating material shall provide on request infrared spectrograms of the base component and the curing agent component (see 4.2.8).
- The manufacturer shall provide a product data sheet (see 4.6), a health and safety data sheet and a certificate stating the test results obtained in accordance with 4.2 and 4.3 respectively.
- The applied coating shall provide corrosion protection of the internal surfaces of the line pipes during storage and transport for a minimum period of one year without significant breakdown of the coating.
- The typical operating-temperature range for this type of coating is between -20 °C and 110 °C.
- Any material which has exceeded its pot life shall be rejected.
- Before a coating system may be applied in a production run, the contractor shall submit all the data specified in (4.6) and (4.7) and shall ensure that both the coating system and the applicator have been qualified in accordance with the procedures in (4.3) and (4.9).

4.1.1 Coating material qualification

Qualification shall be carried out according to the following procedures.

The contractor or the coating manufacturer shall show that samples of the coating system applied on panels of the specified material have been successfully subjected to the tests as specified in Table 4. The tests shall be carried out by an independent and certified test laboratory or, if approved by the purchaser, by the coating manufacturer. The purchaser shall witness the application and the tests.

The number of panels to be tested and the test procedures are also given in Table 4.

4.2 Particular requirements for qualification of the coating material

4.2.1 General

The following clauses describe the laboratory test methods and requirements for qualification of the individual coating components.

4.2.2 Non-volatile matter (by mass)

When determined in accordance with ISO 3251, the non-volatile matter (by mass) of the coating material shall comply with the value specified by the coating material manufacturer in the qualification certificate (Table 2).

4.2.3 Non-volatile matter (by volume)

When determined in accordance with ISO 3233, the non-volatile matter (by volume) of the coating material shall comply with the value specified by the coating material manufacturer in the product data sheet (Table 1).

4.2.4 Viscosity

When determined by the method specified by the manufacturer, the viscosity of the ready-mixed coating material shall comply with the value specified by the coating material manufacturer in the qualification certificate (Table 2).

4.2.5 Density

When determined in accordance with one of the parts of ISO 2811, the density of the coating material shall comply with the value specified by the coating material manufacturer in the product data sheet (Table 1).

4.2.6 Ash (residue on ignition)

When determined in accordance with the method described in Annex A of ISO 15741 standard, the ash (residue on ignition) of the coating material shall comply with the value specified by the coating material manufacturer in the qualification certificate (Table 2).

4.2.7 Pot life

The pot life is considered to be the time taken by the ready-mixed coating material to reach a condition at which it can no longer be applied satisfactorily. The pot life shall be specified in the product data sheet (see 4.6).

4.2.8 Infrared spectrograms

Infrared spectrograms of the base component and the curing agent component shall be submitted.

4.3 Particular requirements for qualification of the applied coating system

4.3.1 Preparation of test panels

Perform the tests specified in 4.3.3 to 4.3.12 on coatings applied to the required film thickness specified in 4.3.3 by spraying onto the steel test panels.

The steel panels shall be grit-blasted to achieve a preparation grade meeting ISO 8501-1 SA 2.5. The surface profile shall be measured in accordance with ISO 8503-2 or ISO 8503-4 and shall be within 25 and 50 μm . Both the preparation grade and the surface profile of the test panels shall be included in the qualification test report.

The coating shall be applied in accordance with the instructions of the coating material manufacturer.

The number of test panels to be tested are given in Table 4.

4.3.2 Conditioning of test panels

All testing shall be performed on test panels conditioned as follows:

The test panels shall be air dried for 10 days at 25 °C, followed by 24 h drying in a circulating-air oven at 50 °C. Relative humidity during the drying shall not exceed 80 %.

After completing the schedule of conditioning outlined above, panels may be stored at room temperature until needed for testing, but not longer than 90 days.

4.3.3 Film thickness

– The dry film thickness (DFT) for the coating, applied on a steel panel shall be between 60 μm and 100 μm .

– The DFT shall be measured in accordance with ISO 2808, Method No. 10 for blast-cleaned steel, following the procedure given in Annex B of ISO 15741 standard.

– The Wet film thickness (WFT) shall be as specified by the coating manufacturer's data sheet for the material, either directly or from calculation to achieve the specified DFT. WFT measurement shall be made in accordance with ISO 2808.

4.3.4 Adhesion

When determined in accordance with ISO 2409, the cross-cut classification of the coating applied on steel panels and conditioned using clause 4.3.2 shall be equal to or lower than 1.

4.3.5 Buchholz hardness

When determined in accordance with ISO 2815, the Buchholz hardness of the coating applied on steel panels and conditioned using clause 4.3.2 shall have a value of 94 or more.

4.3.6 Resistance to neutral salt spray

The coating applied on steel panels with a dry film thickness of 60 µm to 100 µm and with an X-cut down to the substrate located at least 20 mm from any edge, shall be tested in accordance with ISO 9227 for 480 h.

After the test, allow the test panels to dry for at least 30 min at 18 °C to 25 °C and ≤ 80 % relative humidity.

The coating shall be free from any signs of deterioration, for example blistering (except in the area within 2.0 mm from the X-cut), cracking and staining. Any corrosion shall extend not more than 2.0 mm at the most from the X-cut. It shall not be possible to remove by means of clear plastic tape more than 3.0 mm of the coating in any direction from the area around the X-cut.

4.3.7 Resistance to artificial ageing

The test panels shall be aged at 80 °C in a circulating oven for 100 h, followed by conditioning for 24 h at 18 °C to 25 °C and < 80 % relative humidity.

After ageing, subject the test panels to a bend test in accordance with 4.3.8.

4.3.8 Bend test (conical mandrel)

Prepare steel panels and condition them using clause 4.3.2. When the panels are tested in accordance with ISO 6860, the maximum extend of cracking along the panel from the small end of the mandrel shall be less than or equal to 13 mm, and there shall be no loss of adhesion.

4.3.9 Resistance to gas pressure variations

Prepare steel panels and condition them using clause 4.3.2. When the panels are tested in accordance with Annex C of ISO 15741 standard, they shall have a generally good appearance and shall not show any blistering. The adhesion value shall fulfill the requirements as given in 4.3.4 after conditioning for 24 h and 40 h at 18 °C to 25 °C and ≤ 80 % relative humidity.

4.3.10 Resistance to water immersion

Prepare steel panels and condition them using clause 4.3.2. When the panels are tested in accordance with ISO 2812-2 for 480 h, the coating shall not show any blistering or appreciable softening. The examination shall be carried out 3 min after the panels have been removed from the test liquid.

4.3.11 Resistance to chemicals

Prepare steel panels and condition them using clause 4.3.2. When the panels are tested in accordance with ISO 2812-1 for 168 hours, the coating shall not show any blistering or

appreciable softening. Use the following test liquids: cyclohexane; 95 % by volume diethylene glycol solution in water; hexane; methanol; toluene and lubricating oil (e.g. compressor seal oil in accordance with ISO 6743-4). The test panels shall be completely immersed in the test liquid.

The examination shall be carried out at 18 °C to 25 °C and ≤ 80 % relative humidity 3 min after the panels have been removed from the test liquid. After conditioning for 24 h at 18 °C to 25 °C and ≤ 80 % relative humidity, the adhesion value shall fulfill the requirements given in 4.3.4. A change in the colour of the coating shall not be considered as an indication of interior coating quality.

4.3.12 Resistance to hydraulic blistering

Prepare steel panels and condition them using clause 4.3.2. When the panels are tested in accordance with Annex D of ISO 15741 standard, the coating shall not show any blistering. The examination shall be carried out at 18 °C to 25 °C and ≤ 80 % relative humidity 3 min after the panels have been removed from the test liquid. The adhesion value shall fulfill the requirements given in 4.3.4 after conditioning at 18 °C to 25 °C and ≤ 80 % relative humidity for 24 h.

4.3.13 Curing test

The test is carried out on coated test panels that are immersed for 4 hours at ambient temperature in the coating thinner recommended by its manufacturer.

The coating is considered acceptable if:

- there are no coating blisters (Grade 0 or 1, in accordance with ISO 4628-2) observed on the surface of the coating examined within 3 min of the steel test panel being removed from the thinner;
- there are no wrinkles;
- there is no significant softening (rating from 0 to 2 in accordance with ISO 4628-1) observed 30 min after removal from the thinner.

4.3.14 Appearance

The coating shall be free from blisters, visual holidays, scratches or any other irregularities and shall have a uniform colour and gloss.

4.3.15 Coating roughness

The final cured coating shall have a maximum surface roughness of 10 µm over the specified blast cleaned surface profile (In each points more than 10 µm shall not be accepted). The surface roughness shall be determined in accordance with ISO 4287.

4.4. Packaging, labeling and storage

All material shall be supplied in the coating manufacturer's original containers, durably and legibly marked with the description of the contents. This shall include:

- the specification number;

- the colour reference number;
- the method of application for which it is intended;
- the batch number;
- date of manufacture;
- the shelf-life expiry date;
- HSE guidelines;
- the coating manufacturer's name or recognised trade mark.

The storage and preparation of coating materials shall be in accordance with the coating manufacturer's instructions.

Different brands or types of coating materials shall be stored separately.

4.5 Quality assurance

It is necessary to ensure that the goods or services supplied comply in all respects with the requirements of this standard. The applicator shall therefore set up and maintain a quality assurance system as, for example, detailed in ISO 9001, for line pipes and services supplied.

The purchaser shall have the right to undertake inspection and testing of the coating materials and coated line pipes during any stage of coating to ensure compliance with requirements of this standard specification.

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4.6 Product data sheet

The coating material manufacturer's product data sheet shall give information regarding at least the items listed in Table 1.

Table 1. Minimum information to be included in product data sheet

Date of issue	
Name of coating material	
Name of coating material manufacturer	
Colour of coating material	
Type of curing agent	
Shelf life	
Non-volatile matter by volume ^a	Test method used (see 4.2.3)
Density ^b	Test method used (see 4.2.5)
Pot life ^a (see 4.2.7)	
Flash point ^c	
Time to complete curing	
Recommended thinner	
Maximum allowed quantity of thinner, in %	
Recommended surface preparation grade	
Recommended method of application	
Recommended maximum / minimum dry film thickness of the applied coating	
Recommended cleaning solvent (for the application equipment)	
Recommended application conditions (air and steel temperature and relative humidity)	
Recommended minimum curing conditions	
Recommended maximum / minimum service temperature	
Recommended storage conditions	
Reference to instructions and warnings regarding health, safety and environmental protection	
Theoretical spreading rate (l/m ² or kg/m ²) for a given dry film thickness	
Wet film thickness to give dry film thickness of 50 µm , in one coat	
^a Only for the mixed coating material.	
^b Give separately for base component and curing agent component (if pigmented).	
^c Give separately for base component, curing agent component and mixed coating material.	

4.7 Qualification certificate

The qualification certificate shall give, as a minimum, the values of the properties listed in Table 2.

Table2. Minimum information to be included in qualification certificate

Date of issue		
Name of coating material		
Name of coating material manufacturer		
Authority for issue		
Property	Test Method	Subclause
Non – volatile matter by mass ^a	ISO 3251	See 4.2.2
Ash ^b	ISO 15741 (Annex A)	See 4.2.6
Viscosity ^c	Iso 2431	See 4.2.4
Adhesion	ISO 2409	See 4.3.4
Buchholz hardness	ISO 2815	See 4.3.5
Resistance to neutral salt spray	ISO 9227	See 4.3.6
Resistance to artificial ageing		See 4.3.7
Bend test (conical mandrel)	ISO 6860	See 4.3.8
Resistance to gas pressure variations	ISO 15741 (Annex C)	See 4.3.9
Resistance to water immersion	ISO 2812-2	See 4.3.10
Resistance to chemicals – resistance to cyclohexane – resistance to 95% by volume diethylene glycol solution in water – resistance to hexane – resistance to methanol – resistance to toluene – resistance to lubricating oil (e.g. compressor oil)	ISO 2812-1	See 4.3.11
Resistance to hydraulic blistering	ISO 15741 (Annex D)	See 4.3.12
Surface condition (cleanliness, profile) after blasting	ISO 8501-1 ISO 8503-2 or -4	4.3.1
Dry film thickness	ISO 2808 ISO 15741 (Annex B)	4.3.3
Appearance		4.3.14
Coating roughness	ISO 4287	4.3.15
Curing test	ISO 4628-2 ISO 4628-1	4.3.13
^a Separately for base component, curing agent component and mixed coating material.		
^b Separately for base component and curing agent component (if pigmented).		
^c Only for the mixed coating material.		

4.8 Batch test certificate

The batch test certificate shall give, as a minimum, the information and test results for the items listed in Table 3.

Table 3. Minimum information to be included in batch test certificate

Item	Test method	Information from the coating material manufacturer	Test result
Date of issue			
Batch number			
Name of coating material			
Name of coating material manufacturer			
Production date			
Expiry date for use			
Non-volatile matter by mass – base component	See 4.2.2		
Non-volatile matter by mass – curing agent component ^a	See 4.2.2		
Viscosity – base component	b		
Viscosity – curing agent component	b		
Density – base component	See 4.2.5		
Density – curing agent component	See 4.2.5		
Ash – base component ^c	See 4.2.6		
Ash – curing agent component ^{c, d}	See 4.2.6		
Infrared spectrogram ^{d, e}	See 4.2.8		
^a The non-volatile matter by mass of the curing agent component shall not be used for any purposes other than batch consistency checks. ^b As specified by the coating material manufacturer. ^c If required. ^d If pigmented. ^e Separately for base component and curing agent component.			

4.9 Applicator qualification

4.9.1 General

Before production application of a coating system may commence, the applicator shall be qualified to apply the coating system. The qualification shall be carried out according to the following procedures:

4.9.2 Coating process and applicator selection

The contractor shall submit to the purchaser information on the required coating process and recommended applicators. The information shall include:

- description of the coating process for line pipe;
- pipe cleaning and surface preparation (cleanliness, profile, Chloride and dust contamination, chemical pre-treatment, etc.);
- required surface and material application temperatures;
- recommended applicators;
- coating repair procedures;

4.9.3 Coating plant

To demonstrate that the available equipment is capable of applying the specified coating according to the required standards, each recommended applicator shall submit full details of the coating plant, including:

- layout diagram of the coating plant and plant flow scheme;
- general description of the equipment available to carry out the coating process;
- details of process control and inspection equipment required for the coating process such as temperature control, thickness control, holiday testers, laboratory equipment, etc.;
- details on the line pipe marking, handling, storage and transport equipment and procedures;
- Applicator's quality control procedures.

4.9.4 Qualification

With approval of the process and plant details (4.9.2) and (4.9.3) and before production starts, the applicator shall submit evidence that he has successfully applied the coating system before on pipes of the specified material, and that the product complied with the requirements of this standard specification for the tests indicated in Table 4.

The applicator shall coat at least 5 pipes with the proposed coating system and shall subject samples from these pipes to the tests given in Table 4. These tests upon purchaser's description may be carried out in the applicator's own laboratory, or by an independent laboratory. The purchaser shall witness the application and the tests. The results of the tests shall be reported to the purchaser, signed by the head of the laboratory and the witness.

The tests described in the last column of Table 4 shall be performed on panels which have been attached inside the sample pipes at both pipe ends. The test panels shall be prepared in accordance with (4.3.1).

The test panels shall be fixed on the inside of the pipes or on a temporary pipe extension specifically designed for holding the test coupons using appropriate adhesive tape, at a distance of between 100 mm and 300 mm from the pipe ends. The adhesive tape shall overlap the long ends of the test samples by approximately 12 mm.

The test panels shall be removed 10 min after application of the coating on the pipe, with precautions being taken to prevent coating damage. The panel coating shall be dried and cured in an identical manner as the coating applied to the pipe.

Table4. Requirements and test samples required for qualification of coating system and applicator

Property	Requirement and test method	Coating System Qualification on panels	Applicator Qualification on pipes	Applicator Qualification on panels
Cleanliness of blast cleaned surface	5.2	5	5	3
Chloride and dust contamination	5.2	5	5	3
Surface profile	5.2	5	5	3
Appearance	4.3.14	5	5	3
Coating thickness	4.3.3	5	5	3
Porosity	4.3.16	5	5	3
Coating roughness	4.3.15	5	5	3
Bend testing	4.3.8	5		3
Adhesion	4.3.4	5		3
Hardness (Buchholz)	4.3.5	5		3
Curing test	4.3.13	5		3
Salt spray test	4.3.6	5		
Water immersion	4.3.10	5		
Resistance to chemicals	4.3.11	5		
Hydraulic blistering	4.3.12	5		
Resistance to gas pressure variations	4.3.9	5		
Artificial ageing followed by bend test	4.3.7	5		
System identification		Submit to purchaser		
Manufacturer's data				
Coating process and plant data			Approved by purchaser	

5. APPLICATION OF THE COATING MATERIAL

5.1 General

During application of the coating material, all steps in the coating process shall be assessed and recorded. The parameters listed in Table 5 shall be included.

Table5. Minimum items to be checked and recorded during the coating process

Property	Requirement and test method	Minimum frequency
Coating material Name of product Name of manufacturer Batch number		At every change of shift
Environmental conditions during blasting and coating Ambient temperature Steel temperature Relative humidity Dew point	6.1.2	Every 2 h
Surface condition before surface preparation	6.1.3	Every pipe
Surface condition after surface preparation Surface cleanliness Surface profile Surface contamination	6.1.4	Every pipe Every pipe Three pipes per shift, evenly spaced. Tests performed on both ends.
Wet coating (mixed) Viscosity and temperature	5.3	Every time coating is mixed and every time coating is interrupted
Testing coating on pipes Appearance Dry film thickness Coating roughness	4.3.14 4.3.3 4.3.15	Every pipe 10 pipes per shift, evenly spaced Three pipes per shift, evenly spaced
Testing coating on panels Adhesion Buchholz hardness Bend test Curing test	6.2.2 6.2.3 6.2.4 6.2.5	Three pipes per shift, evenly spaced

5.2 Pipe surface preparation

Before blast cleaning and application of the coating system, the internal pipe surface shall be free of all surface contamination. Oil, grease, and other contaminants shall be removed, before blast cleaning, by a suitable solvent or detergent. Salt contamination, chemical cleaning agents and remaining detergents shall be washed off using potable water.

The pipe surface shall be cleaned of mill scale, rust and other foreign matter by a blast cleaning or another abrasive cleaning method to achieve a minimum surface cleanliness of Sa 2½ in accordance with ISO 8501-1. The surface profile shall be measured in accordance with ISO 8503-2 or ISO 8503-4 and shall within 25 µm and 50 µm, unless otherwise agreed. During blast cleaning the pipe surface temperature shall be simultaneously higher than 5 °C and more than 3 °C above the ambient dew point. The ambient relative humidity shall not exceed 85 %.

The maximum residual chloride level on the blast-cleaned surface shall be 20 mg/m², in accordance with ISO 8502-2 or ISO 8502-6 or using Elcometer 130-SCM400 or any other method approved by purchaser.

The dust level on the blast-cleaned surface shall be of Class 2 or better in accordance with ISO 8502-3.

Immediately after blast cleaning, all remaining weld spatter and irregularities shall be removed from the pipe surface by chiseling and/or grinding. Any treated surface with an area larger than 25 cm² shall be re-blasted to the cleanliness and roughness as specified above.

No repairs to the pipe shall be made without a procedure agreed by the purchaser.

After any grinding or mechanical repairs, the remaining wall thickness shall be checked and compared with the minimum requirements of the IGS-M-PL-001-2(0) standard specification. Pipes not meeting the minimum wall thickness shall be rejected.

Before coating, the pipe surface shall be cleaned from all dust and foreign matter using clean dry compressed air or vacuum cleaning. The compressed air shall be free of any trace of oil.

If heating is employed for pipe drying, the maximum pipe temperature shall be 50 °C. The temperature shall be monitored using digital contact thermometers.

Suitable abrasives shall be selected from those defined in ISO 8504-2. Each batch of abrasive shall be traceable and shall be certified as being in accordance with the appropriate part of ISO 11124 or ISO 11126. Batch certificates shall be available for review by the inspector. Abrasives without batch certificates shall not be used.

Abrasives may be recycled only when indicated as being suitable for recycling by the abrasive manufacturer.

Fresh abrasives shall be stored in the original packaging in suitable storage buildings, which will prevent them from becoming damp or contaminated. Damp or contaminated fresh and recycled abrasives shall not be used and shall be removed from the site.

5.3 Coating preparation

Before removing each component from its container, stir or agitate it until it is homogeneous, using equipment which is capable of homogenizing the entire contents of the container without excessively entraining air into the material. Mix the two components (base component and curing agent component) thoroughly, and if necessary, dilute in accordance with the coating material manufacturer's instructions. After the material has been homogenized, it shall be continuously mixed at a slow speed. The mixed coating shall be free of any lumps and pieces of skin. Measure the viscosity in accordance with the method recommended by the manufacturer and record it. Check whether it complies with the value specified by the manufacturer and keep it constant during the application procedure.

The applicator shall batch-test the materials for:

- density, in accordance with ISO 2811;
- non-volatile content (mass), in accordance with ISO 3251 ;
- pigment dispersion (fineness of grind), in accordance with ISO 1524;
- viscosity (mixed), in accordance with ISO 2431.

The values shall be within the ranges specified by the coating manufacturer.

If either the applicator or the inspector finds the sample to be outside of the material specification, the applicator shall remove all applied non-conforming coating from the pipe. The pipe shall then be recoated with a verified batch of material. The sequence of use of the batches of coating materials should be in order in which they were manufactured, i.e. first-in/ first-out from the warehouse to coating operation. All coating materials shall be used or discarded prior to the expiration date. Coating material shall be rejected if any defective or contaminated material is found. The coating material shall be such that it can be easily mixed into a homogeneous state free from skinning, curdling and other irregularities. Any material which has exceeded its pot life shall be rejected.

5.4 Coating application

Check the surface to be coated to see whether it still complies with the specified surface preparation grade and profile (see 5.2)

Pipes showing any visible rust or stains shall be blasted again.

The coating material shall be applied in a covered or enclosed space, shielded from wind, blowing dust and inclement weather, using the application parameters recommended by the coating material manufacturer and approved by the applicator.

Coating application shall not be performed when the relative humidity exceeds 85 %, or when the substrate temperature is less than 5 °C, or less than 3 °C above the determined atmospheric dew point. Substrate temperature shall not exceed 50 °C. In locations with consistent high humidity, the purchaser may agree atmospheric criteria based on ISO 8502-4; in which case, continued coating operations shall be subject to the agreement of the inspector.

Air atomization application is not permitted under this standard specification. Spot repairs may be made with a manual atomizing spray gun or brush.

The coating material shall be sprayed continuously and uniformly. The coating shall be uniform and particular attention shall be given to achieving the specified DFT. The cutback length shall be maintained 80 ± 10 mm.

The final cured coating shall have a maximum surface roughness of 10 μ m over the specified blast cleaned surface profile. The surface roughness shall be determined in accordance with ISO 4287.

The applicator is responsible for the quality control production tests to ensure conformance with this standard specification. Applicator shall be certified and qualified for application of raw materials by manufacturer.

The inspector representing the purchaser shall have free entry at all times while work on the contract of the purchaser is being performed, to all parts of the application site which concern surface preparation, coating of the pipe, and quality control tests.

6. PRODUCTION CONTROL

6.1 Assessment of the coating on the pipes

6.1.1 General

During production application of the coating, the applicator shall carry out all quality control activities needed to ensure that the coating is being applied in accordance with the approved coating application procedures and that the final product complies with the requirements of this standard specification. The minimum quality control tests to be performed shall be as indicated in Table 4. Records of all coating application and quality control test results shall be kept in accordance with (9).

6.1.2 Ambient conditions

The applicator shall measure the ambient conditions at regular intervals during blasting and coating and keep records of prevailing temperature, humidity and dew point. If the conditions are outside the limits specified in this standard specification, the process shall be suspended until the requirements are met.

6.1.3 Inspection of uncoated pipes before blasting

Before surface preparation starts, each pipe shall be visually examined for dents, laps, defective bevels and any other defects to avoid coating unusable pipes. Defective pipes shall be marked and set aside to be inspected by the purchaser's representative and repaired or rejected as per IGS-M-PL-001-2(0). The pipe surface shall be visually checked for contamination with salts, oil or grease. Contaminated pipes shall be cleaned and rinsed with portable water.

6.1.4 Inspection after blasting

Each pipe shall be inspected for surface cleanliness. Pipes that do not comply with the requirements of (5.2) shall be rejected and cleaned again. The surface profile shall be measured on three pipes per shift (evenly spaced) and on the first 5 pipes following each change of blast-cleaning material. If the surface profile is outside the specified limits, the blasting material shall be checked and replaced as necessary. The affected pipes shall be re-blasted. Three pipes per shift (evenly spaced) shall be checked for chloride and dust contamination on the blasted surface. If the surface is contaminated, the quality of the blast cleaning material and process shall be examined. If the conductivity of the blasting materials greater than 50 $\mu\text{S}/\text{cm}$, the blasting material shall be replaced.

Compressed air for drying and blast cleaning shall be free from water and aerosol oil when tested in accordance with ASTM D4285. The testing frequency shall be once per day.

6.1.5 Appearance, thickness and holidays

Immediately following coating application, coated pipes shall be visually checked for imperfections and irregularities of the coating, for coating thickness and roughness and if required for the number of holidays. Pipes that do not comply with the requirements shall be marked and removed from the coating line for repair or recoating. If subsequent pipes do not comply with the requirements, the coating process shall be checked or stopped to eliminate the cause of the problem.

The maximum allowable area per repair is 40 cm^2 and maximum 6 repairs are allowed per single pipe. Pipes with damages area larger than the maximum permitted repair areas shall be rejected, stripped and recoated.

Each pipe shall be checked for cleanliness of the pipe ends and for damage to the beveled ends. Damaged bevels shall be repaired by means of procedures approved by the purchaser.

6.2 Assessment of the coating on steel panels

6.2.1 General

Three test panels per shift, from the start, middle, and end, shall be prepared and evaluated. Each test shall be performed at least twice.

6.2.2 Preparation of test panels

Metal test panels shall be used and shall receive identical surface preparation to that of the pipe using production equipment.

The panel coating shall be dried and cured in an identical manner to the coating applied to the pipe.

The required frequency of the tests on steel panels is shown in Table 6.

Table 6. Assessment of the coating on steel panels required frequency of, and acceptance criteria for, the production-control tests specified in 6.2.2 to 6.2.5

Item	Test	Method	Frequency	Acceptance Criteria
1	Adhesion	ISO 2409	6.2.1	classification ≤ 1
2	Bend test	ISO 6860	6.2.1	no loss of adhesion
3	Buchholz hardness	ISO 2815	6.2.1	hardness ≥ 94
4	Curing test	ISO 15741 (Annex F)	6.2.1	no softening, wrinkling or blistering

6.2.3 Test failures

In the event of test panels failing to meet the specified acceptance criteria, the coating shall be removed from the pipes used to support the test panels and the pipes shall be recoated.

Applied coating which fails to comply with this standard specification shall be removed from the pipes. The pipes shall then be re-prepared and the coating re-applied and inspected in accordance with this standard specification.

Application of a second coat for thickness build shall only be performed if a two coat system has been qualified in accordance with (4).

7. COATING REPAIR

Defective coating or areas with insufficient DFT shall be repaired in accordance with the coating material manufacturer's recommendation.

Defective or damaged coating shall be repaired by the applicator. The maximum allowable area per repair is 40 cm² and maximum 6 repairs are allowed per single pipe. Pipes with damaged areas larger than the maximum permitted repair areas shall be rejected, stripped and recoated.

The contractor shall submit detailed procedures for coating repairs. All coating repair procedures shall be qualified.

8. HANDLING, STORAGE AND TRANSPORT

8.1 Handling

Coated pipes shall be handled in such a way that no damage is caused to the coating. Instructions by the pipe manufacturer and/or coating manufacturer shall be strictly followed.

Pipes shall only be lifted using slings, hooks or vacuum lifters, fitted with suitable spreader bars. Chains shall not be used to lift pipes. Wire ropes shall not be used to lift externally coated pipes. Hooks shall be padded with soft material to prevent damage to the beveled ends.

Lifting trucks or front-end loaders shall have soft padded forks or grips to prevent damage to pipes or pipe coating.

Externally coated pipes shall not be rolled or dragged over the ground.

Pipes shall not be lifted in bundles without prior approval by the purchaser.

When more than one pipe is lifted, separate sling or hooks shall be used for each pipe and coated pipes shall be provided with soft padding between the pipes.

8.2 Transportation to the storage area

During transportation to the storage area at the applicator's workshop, the applicator shall take all relevant precautions to avoid damage to the coating.

8.3 Storage

Coated pipes shall be stored in such a way that the quality of the coating will not be affected.

Instructions by the pipe manufacturer and/or coating manufacturer shall be strictly followed.

Pipes shall be stored in designated areas. Pipes shall not be stored with other consignments or pipes for other contracts.

Pipes shall be stacked only to such a height that damage or deformation due to the weight of other pipes cannot occur. Coated pipes shall be stacked only to such a height that no damage to the external or internal coating occurs.

Pipe supports shall be spaced so that no bending of pipes occur. Pipe supports shall be made of soft padded wooden bolsters or sand rows, free of stones, covered with plastic sheets. The pipe surface shall be at least 150 mm clear of the soil.

Piles of pipe shall be secured by wooden wedges or ground pins, provided with adequate padding to prevent coating damage, and of sufficient size to prevent collapse of the piles.

Externally coated pipes shall be stacked using soft separators such as rubber pads or tyre tread.

When stored outdoors, pipes shall be placed at a small angle to allow drainage of any rainwater from the inside of the pipes. Pipe or external coating that is damaged by handling operations shall be repaired in accordance with the original specifications.

8.4 Transport

When loading pipes at the workshop or in the field, all relevant precautions shall be taken to avoid the possibility of damage to the pipes or to the coating during transportation.

The applicator is responsible for ensuring that all pipes delivered to the purchaser are correctly coated and the coating is properly cured.

Coated pipes shall be prepared for transport or shipment in accordance with IGS-C-PL-001(0) or API RP 5L1 or API RP 5LW, whichever is applicable.

During transportation, pipes shall be stacked and secured such as to prevent movement, abrasion and/or peening.

8.5 Records

The contractor shall take receipt of the pipes delivered by the pipe manufacturer/supplier, and shall keep a record of the pipe numbers of the delivered pipes. Upon receipt, the pipes shall be inspected for transport damage or other defects. Damaged pipes shall be separately stored and their damage shall be reported to the purchaser.

9. DOCUMENTATION

9.1 Pre-manufacturing documentation

The coating contractor's contract-specific quality plan shall be submitted to the purchaser for review and approval and agreement within an agreed time period.

Note: Review of a draft quality plan at the enquiry stage of the contract might assist the process.

The format and issue of the quality plan shall be consistent with the document control requirements of the coating contractor's quality system.

The content of the quality plan should be based on ISO 10005 and shall include the following:

1. Identification of the product and contract to which the plan is to be applied.
2. Reference to ISO 15741 and this standard specification.
3. Location of coating application.
4. The quality plans of all subcontractors.
5. All sequenced activities for the contract, and references to the quality system procedures and work instructions which will be applied to these activities.
6. Copies of all the quality system procedures and work instructions covering production, test and inspection, special processes, control of non-conforming product, handling, storage, packing, and shipping as requested for agreement by the purchaser.
7. The location of each inspection and test point in the process sequence.
8. Points where the purchaser has established witnessing or verification requirements.
9. Coating manufacturer's data sheets and qualification test report.

9.2 Certification

The coating contractor shall provide the purchaser with a certificate of compliance with the order prior to shipment of the pipe. If the purchaser has deployed an inspector, the certificate of compliance with the order shall be issued after the inspection records have been reviewed and approved by the inspector.

The certificate of compliance with the order shall be drawn up on the basis of specific inspection and testing on the product supplied.

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