

# Gas Industry Standard

GIS/CW6:2020

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Specification for

**The external protection of steel line pipe and fittings using fusion bonded powder and other coating systems - requirements and methods of test for coating materials and factory applied coatings.**

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## Foreword

Gas Industry Standards (GIS) are revised, when necessary, by the issue of new editions. Users should ensure that they are in possession of the latest edition. Contractors and other users external to Gas Transporters should direct their requests for copies of a GIS to the department or group responsible for the initial issue of their contract documentation.

Comments and queries regarding the technical content of this document should be directed in the first instance to the contract department of the Gas Transporter responsible for the initial issue of their contract documentation.

This standard calls for the use of procedures that may be injurious to health if adequate precautions are not taken. It refers only to technical suitability and does not absolve the user from legal obligations relating to health and safety at any stage.

Compliance with this engineering document does not confer immunity from prosecution for breach of statutory or other legal obligations.

## Mandatory and non-mandatory requirements

For the purposes of a GIS the following auxiliary verbs have the meanings indicated:

**can** indicates a physical possibility;

**may** indicates an option that is not mandatory;

**shall** indicates a GIS requirement;

**should** indicates best practice and is the preferred option. If an alternative method is used then a suitable and sufficient risk assessment needs to be completed to show that the alternative method delivers the same, or better, level of protection.

## Disclaimer

This engineering document is provided for use by Gas Transporters and such of their contractors as are obliged by the terms of their contracts to comply with this engineering document. Where this engineering document is used by any other party, it is the responsibility of that party to ensure that the engineering document is correctly applied.

## Brief history

First published as BGC/PS/CW6: Part 1	January 1985
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## 1. Scope

This specification specifies fusion bonded epoxy powders and multi-component liquid materials for use as anti-corrosion coatings on steel line pipe and fittings (tees and bends) used for the transmission and distribution of natural or manufactured gas as defined in ISO 13623.

The specification focuses on compliance with properties and performance tests to establish a materials suitability for use with GIS/CW2 which deals with field applied coatings and GIS/CW5 for selection and surface preparation of some field applied coatings.

For fusion epoxy coatings this specification has been aligned with coating system specific requirements given in the published standard ISO 21809-2. Compliance with material and performance testing requirements beyond that of ISO 21809-2 are also stated. It is a pre-requisite that ISO 21809-2 is reviewed in parallel with this Specification.



**Buried UK pipelines can operate between -20°C and 50°C. Selected coatings shall be suitable for temperatures specified by the Gas Transporter in this range.**

**For bespoke application >50°C seek guidance from the Gas Transporter.**

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GIS/CW6 is not intended to inhibit a Contractor from offering, or the Gas Transporter from accepting alternative coating solutions, particularly where there is an innovative or developing technology. If a new technology is available, it is the responsibility of the Contractor to identify any variations from this Specification, provide details and submit the new technology for consideration.

## 2. Normative References, Terms and Definitions

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

### 2.1 Standards

#### British and European standards

BS 3900-0:2010, *Methods of test for paints: Resistance to continuous salt spray*

BS EN ISO 9001, *Quality management systems. Requirements*

#### International Organisation for Standardization

ISO 8501-1, *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 8503-4, *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 8503-5, *Preparation of steel substrates before application of paints and related products — Surface roughness characteristics of blast-cleaned steel substrates — Part 5: Replica tape method for the determination of the surface profile*

ISO 11124 (all parts), *Preparation of steel substrates before application of paints and related products — Specifications for metallic blast-cleaning abrasives*

EN ISO 3251, *Determination of volatile matter and non-volatile matter*

ISO 6270, *Determination of resistance to humidity (cyclic condensation)*

ISO 11507, *Paints and varnishes: Exposure of coatings to artificial weathering*

### **Gas Industry Standards**

GIS/CW2, *Performance tests for the supply of cold applied wrapping tapes and tape systems*

GIS/CW5, *Field applied external coatings for buried pipework and systems*

### **IGEM Standards**

IGEM/TD/1, *Handling, transport and storage of steel pipe, bends and fittings*

### **Statutes and Regulations**

Control of Substances Hazardous to Health (COSHH) Regulations 2002

Chemicals (Hazard Information and Packaging for Supply) Regulations 2009

Convention Covering International Carriage by Rail - International Carriage of Dangerous Goods by Rail 2015

International Carriage of Dangerous Goods by Road (ADR 2017)

The Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations 2012

Environmental Protection Act - EPA - (Duty of Care) 1991

Health and Safety at Work etc. Act 1974 and other relevant legislations, such as European Union (EU) if applicable

Regulation (EC) No 1907/2006 of the European Parliament and of the Council on the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH)

### **Bibliography**

ISO 3183, *Petroleum and natural gas industries — Steel pipe for pipeline transportation systems*

ISO 14001, *Environmental management systems — Requirements with guidance for use*

ISO/TS 29001, *Petroleum, petrochemical and natural gas industries — Sector-specific quality management systems — Requirements for product and service supply organizations*

### **NOTE**

Where no date is shown, the latest edition of each standard and specification shall apply.

- Gas Transporters will each have their own procedures & specifications normally in the referenced format \*/SP/XX/No, where \* is replaced by the Gas Transporters reference e.g. T for National Grid, or SGN, WWU etc. followed by the specification initials and number reference.



## **2.2 Terms and Definitions**

Aligned with ISO 21809-2, Clause 3.

For the purposes of this document, the following definitions apply.

**Coating Register:** the controlled list of materials and manufacturers which meet the technical specification requirements, highlighting any restrictions, and for which written notification has been issued.

## **3. Health, Safety and Environment**

See Annex A and Clause 2.1 (Statutes and Regulations) of this specification for guidance.

## **4. Quality**

See Annex B of this specification for guidance.

## **5. General Requirements**

### **5.1 Rounding**

Compliance with ISO 21809-2, Clause 5.1.

### **5.2 Compliance with this document**

Compliance with ISO 21809-2, Clause 5.2.

Compliance with Annex A and B of this specification.

## **6. Information Supplied by the Purchaser**

Compliance with ISO 21809-2, Clause 6.

## **SECTION 1 – FUSION EPOXY BONDED COATED PIPELINE**

### **7. Coating Materials**

#### **7.1 Epoxy powder**

Compliance with ISO 21809-2, Clause 7.

After aging for 120 days at 25°C ±1°C in a sealed container the powder should not exhibit any significant change of properties.

### **8. Coating Qualification (pipe)**

#### **8.1 Qualification by manufacturer – Epoxy powder**

Compliance with ISO 21809-2, Clause 8.

Additional testing requirements should include:

- i. Salt spray resistance test - Coated steel test plates should be cross-cut across diagonal corners and exposed for 2000 h to continuous salt spray conditions in accordance with BS 3900-0:2010. The coating shall not lose adhesion when tested in accordance with Annex D, Clause D5 and no under-film corrosion or blistering of the film shall occur. At the discretion of the gas transporter the coating's manufacturer may propose alternative qualification test programmes if equivalence can be demonstrated.
- ii. Artificial weathering test - Coated steel test plates should be exposed for 2000 h to artificial weathering, in accordance with ISO 11507, and should show no signs of deterioration, apart from superficial chalking. UVA lamps should be employed, and the test cycle should consist of 4h UV and 4h condensation, both at a temperature of 50 °C. At the discretion of the gas transporter the coating's manufacturer may propose alternative qualification test programmes if equivalence can be demonstrated.
- iii. Heat blister test - Coated steel test plates should be subjected to a heat blister test as specified in Annex E. The test shall not show blistering after 3 days immersion.
- iv. Thermal stability - for pipeline applications >50°C coating manufacturer shall provide qualification evidence to demonstrate performance. Acceptance shall be at the gas transporters discretion.

#### **8.2 Qualification by applicator (pipe)**

Compliance with ISO 21809-2, Clause 8.2.

The production coating shall be qualified by the applicator for each coating line in accordance with ISO 21809-2, Clause 8.2.1.

APS shall be verified by a PQT in accordance with ISO 21809-2, Clause 8.2.4 and Annex B.

### **9. Application of Coating (pipe)**

Compliance with ISO 21809-2, Clause 9.

All identification markings, whether internal or external to the component, must be carefully recorded before surface preparation begins.

When applicable, identification plates must be carefully removed and, after the coating has been accepted, replaced using an adhesive compatible with the coating. Special care must be taken to ensure that the original data is re-affixed to the correct component.

The coating thickness shall be a minimum of 350µm and a maximum of 500µm, unless specified otherwise.

To ensure that the properties of all coating materials are maintained in compliance with Clause 8.1, all coating materials consigned to the coating plant shall have been properly stored in accordance with the manufacturers' safety requirements and recommendations, at all times, to prevent damage and deterioration prior to use. Materials should be used in date order in which they are manufactured.

Out-gassing from welds - sufficient time must be allowed (typically 72 hours), subsequent to pipe and fitting manufacture, to prevent out-gassing from welds which may lead to coating defects.

The temperature of the pipe must not exceed 250 °C at any stage of the production process. At the Gas Transporters discretion, a maximum temperature  $\leq 275$  °C aligned with ISO 21809-2, Clause 9.3.1 may be considered.

### **10. Inspection and Testing (pipe)**

Compliance with ISO 21809-2, Clause 10.

### **11. Repair of Coated Pipe**

Compliance with ISO 21809-2, Clause 11.

Rejected coating should be removed only by a procedure which must not cause any mechanical damage to the pipe or cause the steel temperature to exceed 250 °C. At the Gas Transporters discretion, a maximum temperature  $\leq 275$  °C aligned with ISO 21809-2, Clause 9.3.1 may be considered.

### **12. Markings (pipe)**

Compliance with ISO 21809-2, Clause 12.

### **13. Handling and Storage in the Coating Area (pipe)**

Compliance with ISO 21809-2, Clause 13

### **14. Test and inspection reports (pipe)**

Compliance with ISO 21809-2, Clause 14 and Annex B of this specification.

## **SECTION 2 - FUSION BONDED POWDER COATINGS ON FITTINGS**

### **15.Procedure Qualification**

#### **15.1 General**

Before bulk coating fittings commences, the requirements of Clause 15.2 and Annex B must be met and a detailed sequence of operations to be followed for the coating of pipes and fittings demonstrated.

#### **15.2 Application procedure specification (APS)**

The APS should as a minimum, incorporate full details of the following:

- a) Quality plan;
- b) Powder system to be used together with appropriate data sheets;
- c) Fitting dimensions;
- d) Process temperature profile;
- e) Fitting cleaning;
- f) Blast cleaning medium and technique and the method for protecting the weld end preparation;
- g) Blast cleaning finish, surface profile, surface cleaning and metal defect removal;
- h) Dust removal;
- i) Concentration and application method and parameters for the chemical pre-treatment;
- j) Provision of coating cut-back and the means of protecting the weld bevel from the coating;
- k) Heating method, time and temperature;
- l) Chemical pre-treatment and powder application;
- m) Curing and quenching time and temperature;
- n) Post-cure time and temperature;
- o) Repair technique;
- p) Coating stripping technique;
- q) Handling procedures.

##### **15.2.1 Recycled powder**

Recycled powder must not be used to coat fittings.

##### **15.2.2 Fluidized bed dipping**

Where fluidized bed dipping is to be used, the applicator must provide written evidence that the powder in the fluidized bed at the time of the procedure qualification test complies with GIS/CW6.

#### **15.3 Coating procedure approval tests**

A batch of fittings should be coated in accordance with the APS, the coating operations being witnessed at the discretion of the Gas Transporter. Pipe pups of equivalent dimensions may be used instead of fittings.

Three coated fittings or pipe pups from the batch shall be subjected to the complete set of tests specified in Clauses 15.4 to 15.10.

The contractor must ensure that the tests specified in Clauses 15.6 to 15.10 are carried out in duplicate and the results of all the tests, demonstrating compliance, made available.

No coated fittings must be dispatched until the procedure has passed the approval tests.

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#### 15.4 Thickness test

The coated fittings should be subjected to a thickness test in accordance with the APS. The thickness must be not less than 350µm and not greater than 1500µm.

#### 15.5 Holiday detection test

The coated fittings should be subjected to a holiday detection test over 100% of the coated surface in accordance ISO 21809-2, Clause 10.3.2. The number of holidays detected shall meet the requirements of Table 1.

**Table 1 - Component diameter ranges, permissible holidays and repairs**

Component diameter range / mm	Number of holidays on fitting - acceptable	Number of holidays on fitting - permissible	Maximum total repair area (fitting) / cm <sup>2</sup>
14 – 49	one per square metre	two per square metre	75
50 – 299	one per square metre	two per square metre	125
300 – 599	one per square metre	two per square metre	250
600 – 899	one per square metre	two per square metre	350
900 – 1099	one per square metre	two per square metre	500
1100 - 1399	one per square metre	two per square metre	600

#### 15.6 Impact resistance test at minimum design temperature

Impact resistance should be determined in accordance with ISO 21809-2, Appendix A.8. A minimum mean impact value of ≥2J shall be achieved without resulting in a breakdown or loss of adhesion in the coating.

#### 15.7 Adhesion test

The adhesion of the coating should be tested and must meet the pass rating of 1-2 in accordance with ISO 21809-2, Clause A.4.

#### 15.8 Degree of cure

The degree of cure of the coating should be determined by DSC analysis of a sample of the coating taken from the area of thickest coating and any identified 'cool spots', and tested in accordance with ISO 21809-2, Appendix A.8.

The acceptance range of  $\Delta T_g$  will depend on the type of powder used (see also 18.6) as specified by the powder manufacturer and qualified by Clause 8.

#### 15.9 Cathodic disbonding test

Disbondment shall meet the requirements stated by ISO 21809-2, Table 4.

### **15.10 Water immersion test**

24 h hot water adhesion (75°C ±3°C) - A rating of 1-2 shall be achieved in accordance with ISO 21809-2, Appendix A.16.

28 d hot water adhesion (75°C ±3°C) - A rating of 1-3 shall be achieved in accordance with ISO 21809-2, Appendix A.16.

## **16. Production Coating Procedure**

### **16.1 Surface preparation**

General compliance with ISO 21809-2, Clause 9 where applicable for fitting geometry. Manufacturer shall advise on variants.

Components must be blast cleaned to a minimum standard of BS EN ISO 8501 Sa 2½ quality using 100% grit in the final stage of blast cleaning. The surface profile should be between 50µm and 100µm peak to trough height and should be angular in nature.

All identification markings, whether internal or external to the component, must be carefully recorded before surface preparation begins.

When applicable, identification plates must be carefully removed and, after the coating has been accepted, replaced using an adhesive compatible with the coating. Special care must be taken to ensure that the original data is re-affixed to the correct component.

### **16.2 Coating Process**

The coating thickness shall be a minimum of 350µm and a maximum of 1500µm, unless specified otherwise.

To ensure that the properties of all coating materials are maintained in compliance with Clause 8.1, all coating materials consigned to the coating plant shall have been properly stored in accordance with the Manufacturers' safety requirements and recommendations, at all times, to prevent damage and deterioration prior to use. Materials should be used in date order in which they are manufactured.

Out-gassing from welds - Sufficient time must be allowed (typically 72 hours), subsequent to fitting manufacture, to prevent out-gassing from welds which may lead to coating defects.

The temperature of the fitting must not exceed 250 °C at any stage of the production process. At the Gas Transporters discretion, a maximum temperature ≤275 °C aligned with ISO 21809-2, Clause 9.3.1 may be considered.

### **16.3 Spray applied coating**

#### **16.3.1 Operator qualifications**

When required, the individual operators carrying out the powder spraying application should be subjected to a qualification test in which they will be required to demonstrate proficiency in the spraying process as laid down in the relevant section of the procedures.

#### **16.3.2 Heating**

Heating should be carried out using suitable heating equipment and its duration should not be extended for more than 30 min beyond the time at which the required surface temperature is reached. The surface temperature should be continuously monitored at a selected point by means of a surface pyrometer, or any other method, which may be proposed as a variant for consideration by the Gas Transporter, which should be calibrated against a standard method of surface temperature measurement. If the appearance of the fitting after heating is unacceptable for coating (e.g. a blued surface oxide), it must be re-blasted before continuing the coating procedure.

### 16.3.3 Spraying equipment

The spraying equipment should be adequate for applying the powder in accordance with the powder manufacturer's instructions and the qualification procedure. The equipment should be maintained in good order by the Contractor and/or the equipment supplier. All air lines should be provided with filters and vapour traps to ensure that the air is free from oil and moisture. All critical parameters must be monitored.

### 16.3.4 Spraying procedure

The spraying procedure must be in accordance with the qualification procedure, which should include a total time allowed for coating. Individual operators should be experienced in the use of equipment and should be suitably qualified (see Clause 16.3.1). The temperature of the fitting should be checked at selected points on the surface, in such a manner as to ensure that the surface temperature does not fall outside the range established during the procedure qualification trial as being acceptable. If the limits of time and temperature are exceeded, the fitting must be re-blasted.

### 16.3.5 Post cure

If post curing is required by the qualification procedure, the component should be moved within a defined period into the post curing oven. The time and temperature should be monitored as in Clause 16.3.2.

## 16.4 Dip applied coatings

### 16.4.1 Heating

The duration of heating should not be extended for more than 30 min beyond the time at which the required surface temperature is reached. The surface temperature should be monitored at a selected point by means of a surface pyrometer or any other method, which may be proposed as a variant for consideration by the Gas Transporter, which should be calibrated against a standard method of surface temperature measurement. If the appearance of the fitting after heating is unacceptable for coating (e.g. a blued surface oxide), it must be re-blasted before continuing the coating procedure.

### 16.4.2 Dipping bath

The dipping bath should meet the following requirements:

- a) The dipping bath should be of dimensions which enable a fitting of the maximum stated size to be freely dipped;
- b) The method of fluidization should promote even fluidization and control of powder density within the bed;
- c) The powder within the bed must be renewed completely if the powder ceases to comply with GIS/CW6: or if the condition of the powder results in a coating which is visually unacceptable (see Clause 17) or outside the requirements of Clauses 18.2 to 18.6.

### 16.4.3 Dipping procedure

The dipping procedure should be as follows:

- a) When the powder is fluidized to the required density, the fluidized bed should be made up to a depth adequate for dipping the fittings;
- b) Prior to dipping, the temperature of the fitting should be checked at selected points on the surface to ensure that the surface temperature does not fall outside the range established during the procedure qualification trials;
- c) The coating time must be specified for each type and size of fitting;

- d) If limits of time and temperature are not achieved, the fitting must be re-blasted and recoated.

#### **16.4.4 Post cure**

If post curing is required by the qualification procedure, the fitting should be moved with the minimum delay into the post curing oven. The time and temperature should be monitored as specified in Clause 16.4.1.

### **17. Visual Inspection**

The coating colour and appearance should be uniform and free from runs, sags, blistering, roughness, foaming and general film defects.

### **18. Testing of Cured Coatings**

#### **18.1 Testing of coated fittings**

Cured coatings on fittings must comply with the requirements of Clauses 18.2 to 18.6.

The contractor must ensure that the tests specified in Clauses 18.4 to 18.6 inclusive are carried out in duplicate and the results of all tests, demonstrating compliance, made available to the Gas Transporter.

#### **18.2 Thickness test**

The coated fittings should be subjected to a thickness test of the cured coating at not less than 20 locations spaced evenly to represent the total area of the coated fitting. The thickness measuring gauge used should be calibrated hourly for the specified thickness range (see Annex G). The thickness must be not less than 350µm and not greater than 1500µm.

#### **18.3 Holiday detection test**

The coated fittings should be subjected to a holiday detection test over 100% of the coated surface in accordance with ISO 21809-2, Clause 10.3.2.

The number of holidays detected must comply with Clause 15.5, Table 1. If, on any two consecutive fittings, the number of holidays detected is greater than the normally acceptable level but less than the maximum permissible level, the cause must be immediately investigated.

If four further consecutive fittings are detected as having holidays between the normally acceptable level and the maximum permissible level given in Table 1, all production to that point must be quarantined until the reason for the high frequency of holidays is determined. A total of 5% of daily production will be accepted with up to the maximum permissible number of holidays provided that the 5% are not consecutive.

Fittings with more holidays than permitted by Table 1 should be rejected for subsequent stripping (see Clause 22) and recoating.

All holidays must be repaired in accordance with Clause 20 and satisfactorily retested before dispatch of the fitting.

Defects detected immediately before dispatch should not be repaired but must be conspicuously and permanently marked on the fitting and recorded on the relevant inspection documentation.

#### **18.4 Impact resistance test at minimum design temperature**

Initially, the impact resistance of the coating must be checked for compliance with Clause 15.6. determined at five locations chosen to represent the area coated. Impact resistance should be



determined in accordance with ISO 21809-2, Appendix A.8. A minimum mean impact value of  $\geq 2J$  shall be achieved without resulting in a breakdown or loss of adhesion in the coating.

The frequency of testing should, initially, be once every two hours or five fittings, whichever is the more frequent. Subsequently, this test frequency may be varied by the Gas Transporter based on quality history.

### **18.5 Adhesion test**

The coated fittings should be subjected to an adhesion test of the cured coating, at one location on the fitting. The adhesion of the coating should be tested and must meet the pass rating of 1-2 in accordance with ISO 21809-2, Clause A.4.

The frequency of testing should, initially, be once every two hours or five fittings, whichever is the more frequent. Subsequently, this frequency may be varied based on quality history.

### **18.6 Degree of cure**

In order to meet the acceptance requirements of Cause 15.8, the degree of cure of the coating should be initially carried out on each fitting. Subsequently, at the Gas Transporters discretion this rate of testing may be varied based on quality history.

Testing shall be undertaken in accordance with ISO 21809-2, Appendix A.8.

If a test does not result in a value of  $\Delta T_g$  within the powder manufacturer acceptable range, the following retest procedure should be used:

- a) For a measured  $\Delta T_g$  within  $+2^\circ C$  of the upper acceptable limit, a further two samples from the test section should be tested;
- b) If the value of  $\Delta T_g$  obtained lies within the acceptable range, the fitting should be accepted;
- c) If the value of  $\Delta T_g$  obtained does not lie within the acceptable range specified by the powder manufacturer, the fitting should be rejected and adjacent fittings in the production run should be successively sampled and tested until acceptable coating is identified.

## **19. Check Procedure**

If any fitting fails the requirements of Clauses 18.4 to 18.6 inclusive, a check procedure must be initiated. This should involve checking all fittings back to the preceding acceptable fitting. The fitting numbers must be available from the final inspection bench. These fittings should be subjected to an examination like that carried out on the failed fitting. If the number of defects detected is significant, the entire coating production for that day must be quarantined and investigated.

## **20. Repairs**

All holidays and other coating defects must be repaired with multi-component materials to ensure compatibility with the applied coating. All repairs must be retested for holidays in accordance with ISO 21809-2, Clause 10.3.2.

The maximum repair area should be in accordance with Clause 15.5, Table 1.

Repairs should not be carried out within 200 mm of the end of the coating, but all areas of damage must be recorded and marked.

### **21. Handling of Coated Fittings**

All coated fittings should be handled and stored in accordance with IGEM/TD/1 and the relevant fitting standard where appropriate to prevent damage to the component and coating. At the discretion of the Gas Transporter variants may be considered.

### **22. Stripping of coatings**

Rejected coating should be removed by a procedure which must not cause mechanical damage to the fitting or cause the steel temperature to exceed 250 °C. At the Gas Transporters discretion, a maximum temperature  $\leq 275$  °C aligned with ISO 21809-2, Clause 9.3.1 may be considered.

### **23. Identification**

The contractor must be responsible for ensuring that all internal or external identification markings are noted before surface preparation begins and are replaced after the coating process in accordance with Clause 9 of this specification.

## SECTION 3 – MULTI-COMPONENT LIQUID COATINGS ON PIPE AND FITTINGS

### 24. Basic Properties and Tests of Multi-Component Liquid Coating Materials and Cured Coatings

#### 24.1 Basic properties of unmixed materials

This section covers multi-component liquid systems suitable for both spraying and brush application.

The contractor shall obtain, from the manufacturer, specified and qualified ranges of values for all properties listed in this section, that will ensure an acceptable coating. The frequency of testing should be in accordance with the quality control requirements in this section.

- i. **Total non-volatile content** - The total non-volatile content should be specified by the manufacturer for each individual material component as supplied. The method of test should be in accordance with the method given in ISO 3251.
- ii. **Viscosity** - The viscosity of each material component as supplied, and that of the mixture when prepared for use in the correct ratio, should be specified by the Manufacturer, together with the method of test.
- iii. **Relative density** - The relative density of each material component as supplied, and that of the mixture when prepared for use in the correct ratio, should be specified by the Manufacturer, together with the method of test.
- iv. **Mixing ratio** - The mixing ratio of material components should be specified by the Manufacturer, both by weight and by volume.
- v. **Pot life** - The pot life measured in accordance with the definitions contained in BS 2015 should be quoted by the Manufacturer.
- vi. **Flash point** - The flash point of each material component as supplied, and that of the mixture when prepared for use, should be specified by the Manufacturer.
- vii. **Stability** - The separate material components when stored at 20 °C to 25 °C for a period of 6 months should:
  - o Show no signs of hard settlement;
  - o Show no deterioration in application properties;
  - o Show no deterioration in curing properties.

### 25. Basic Properties of Detached Coating Film

#### 25.1 General requirements

The contractor should ensure that the following tests are carried out by the manufacturer at the frequency specified in Clause 25.2.4. The tests should be carried out on detached coating samples which have been prepared by application on to polished steel plates, 6 mm thick, previously coated with PTFE. The coating should be applied to give a minimum dry film thickness of 1.5 mm and allowed to cure at 20 °C to 25 °C and 60% to 70% relative humidity for a period of seven days to achieve optimum properties before test. Samples should be of uniform thickness for all tests.

- i. **Micro-sectioning** - A cross-section of the cured film should be examined at a magnification of X100 and should be seen to be homogeneous and essentially free of voids or other defects.
- ii. **Tensile strength & Elongation** - Test specimens of detached coatings should be tested at an extension rate of 1 mm/min. Values for tensile strength should be quoted in MN/m<sup>2</sup> as maximum strength and strength at break. The elongations at 'yield' and 'break' should be quoted by the Manufacturer.
- iii. **Dielectric strength** - The dielectric strength of the cured material should be quoted by the Manufacturer as kV/mm together with the method of test.
- iv. **Water permeability** - The water permeability of the cured material, expressed as g/24 h m<sup>2</sup> /mm thickness should be specified by the Manufacturer together with the method of test.
- v. **Water absorption** - The quantity of water absorbed after three months immersion at 20 °C should be quoted by the manufacturer.

## 25.2 Basic properties of cured applied coating

### 25.2.1 General

Coating materials should develop adequate handling properties within 24 h of application to suit factory or field conditions. The contractor should ensure that the tests specified in this section are carried out in duplicate by the manufacturer in accordance with the Quality Control Requirements in this section and the results of the tests, demonstrating compliance, made available.

The tests should normally be carried out on standard steel surfaces which have been blast cleaned, using G34 grit, to ISO 8501, Sa 3 quality to produce a profile of between 100µm and 50µm peak to trough height. Coating application should normally be by a suitable technique with pre-heating of components, where necessary. The coating should be applied to manufacturers dry film thickness requirements and allowed to cure at 20 °C to 25 °C and 60% to 70% relative humidity for a period of 24 h to achieve optimum properties before test.

Testing of applied coatings should be carried out seven days after the coating application.

- i. **Cissing and pinholing test** - The coating should show no signs of cissing or pinholing when applied to a prepared steel panel. In cases of doubt, a further test may be carried out by applying the coating to a grit roughened glass panel and examining it by viewing over a bright light source.
  - ii. **Blistering and appearance test** - The coating should show no signs of blistering and should exhibit uniform appearance when examined by either of the tests specified above.
  - iii. **Sagging test** - The coating should not exhibit sagging when applied to a steel panel in the vertical plane prepared and coated in accordance with the General Requirements and which, immediately subsequent to coating, has been placed in a vertical position and has remained in that position until the coating is dry.
  - iv. **Flexibility (Annex F)** - Steel plates, 50 mm x 300 mm x 6 mm thick, should be coated in accordance with and be properly cured. After bending in accordance with Annex F (at a deflection rate of 25 mm/min) over appropriate sized mandrels, the coating must not crack, disbond or pinhole and must pass a holiday test in accordance with ISO 21809, Clause 10.3.2.
  - v. **Impact resistance at minimum design temperature** – Impact resistance should be determined in accordance with ISO 21809: Part 2: Appendix A.8. A minimum mean impact value of 5 J shall be achieved without resulting in a breakdown or loss of adhesion in the coating.
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- vi. **Adhesion test** – a pass shall be achieved when tested in accordance with Annex C.
  - vii. **Hardness and cure of coating** - The hardness and degree of cure of the coating should be determined and the manufacturer should specify the hardness range, and the temperature at which hardness values were conducted, to indicate the correct degree of cure of the coating.

### 25.2.2 Environmental Test Requirements

The contractor should ensure that the tests specified in this section are carried out in duplicate by the manufacturer in accordance with the General Requirements of this section and the results of the tests, demonstrating compliance, made available.

The tests specified in this section inclusive should be carried out once, unless specified otherwise, to provide evidence of satisfactory long-term performance.

- Cathodic disbondment testing (28 d, 20 °C ± 3 °C, -1,5 V) – The coating shall not disbond for greater than 5 mm radius from the edge of the coating pre-damage; testing undertaken in accordance with ISO 21809: Part 2: Appendix A.9.
- Water immersion test - The sample panels should be subjected to a water immersion test as specified in Annex D. The test shall show no loss of adhesion greater than 3 mm after 28 days.
- Humidity resistance test - Coated steel test plates should be exposed for 2000 h in accordance with EN ISO 6270. The coating shall not lose adhesion when tested in accordance with Annex D, Clause D5 and no under-film corrosion or blistering of the film shall occur.
- Salt spray resistance test - Coated steel test plates should be cross-cut across diagonal corners and exposed for 2000 h to continuous salt spray conditions in accordance with BS 3900-0:2010. The coating shall not lose adhesion when tested in accordance with Annex D, Clause D5 and no under-film corrosion or blistering of the film shall occur.
- Artificial weathering test - Coated steel test plates should be exposed for 2000 h to artificial weathering, in accordance with ISO 11507, and should show no signs of deterioration, apart from superficial chalking. UVA lamps should be employed and the test cycle should consist of 4h UV and 4h condensation, both at a temperature of 50 °C.

### 25.2.3 Thermal stability tests

For pipeline applications >50°C coating manufacturer shall provide qualification evidence to demonstrate performance. Acceptance shall be at the gas transporters discretion.

### 25.2.4 Quality control requirements

Before dispatch from the factory, the manufacturer should carry out sampling and testing of the manufactured material covered by this specification in accordance with this section.

During the production of each separate batch or twice every 8 h of continuous production (whichever is the more frequent), the tests specified in “Basic Properties of Unmixed Materials” Section should be carried out and the requirements of the testing shall be met. At the Gas Transporters discretion an alternate test duration can be considered if continuity of performance can be evidenced.

At least once every 8 h of continuous production, the tests specified in the “Physical Performance Test Requirements” for this section inclusive should be carried out. At the Gas Transporters discretion an alternate test duration can be considered if continuity of performance can be evidenced.

The tests specified in “Basic Properties of Detached Coating Film” and in “Environmental Test Requirements” (considered as type tests) and the requirements of Stability testing should be

carried out once per year or at any time a production, source, process or formulation change is made to the coating system. At the Gas Transporters discretion an alternate test duration can be considered if continuity of performance can be evidenced.

### **25.2.5 Compliance**

The coating material shall not be dispatched until it has been demonstrated that the manufacturers inspection and testing complies with the requirements of this specification and Annex B.

## **26.Procedure Qualification**

### **26.1 General**

Before bulk coating of pipes and fittings commences, the requirements of Clause 26.2 and Annex 3 must be met and a detailed sequence of operations to be followed for the coating of pipes and fittings demonstrated.

### **26.2 Application procedure specification (APS)**

The APS should as a minimum, incorporate full details of the following:

- a) Quality plan;
- b) Multi-component liquid coating to be used together with appropriate data sheets;
- c) Pipe or fitting dimensions;
- d) Process temperature profile;
- e) Pipe or fitting cleaning;
- f) Blast cleaning medium, technique and means of protecting the weld bevels;
- g) Blast cleaning finish, surface profile, surface cleaning and metal defect removal;
- h) Dust removal;
- i) Provision of coating cut-back and means of protecting the weld bevel from coating;
- j) Heating method, time and temperature for coating constituents (if specified);
- k) Multi-component liquid and primer (if used) mixing and application;
- l) Curing regime;
- m) Repair technique;
- n) Coating stripping technique;
- o) Handling procedures.

### **26.3 Coating procedure approval tests**

#### **26.3.1 General requirements**

Three test pieces for the coating procedure approval tests should be selected from pipes or fittings coated in accordance with Clause 26.2. Test pieces must be subjected to the complete set of tests specified in Clauses 26.3.2 to 26.3.8 inclusive after curing in accordance with the manufacturer's recommendations. Testing should be witnessed by the Gas Transporter or nominated Third Party. A full set of test results must be recorded and made available to the Gas Transporter. No coated pipe or fittings must be dispatched until the procedure has passed the approval tests.

The contractor must ensure that the tests specified in Clauses 26.3.2 to 26.3.8 inclusive are carried out and the results of the tests, demonstrating compliance, made available to the Gas Transporter.

### **26.3.2 Thickness test**

The coated test pieces should be subjected to a thickness test of the cured coating as specified in Clause 29.2. The cured coating thickness must be not less than 1.5 mm and uniform for all tests.

### **26.3.3 Holiday detection test**

The coated test pieces should be subjected to a holiday detection test over 100% of the coated surface as detailed in ISO 21809-2, Clause 10.3.2. The number of holidays detected must meet the requirements of Clause 29.3, Table 2.

### **26.3.4 Hardness and cure test**

The coated test pieces should be subjected to a hardness and cure test as specified in Clause 29.4.

### **26.3.5 Impact resistance test at minimum design temperature**

The coated test pieces should be subjected to an impact resistance test as detailed in Clause 29.5

### **26.3.6 Adhesion test**

The coated test pieces should be subjected to an adhesion test as detailed in Clause 29.6.

### **26.3.7 Flexibility test (for pipe only)**

The coated test pieces should be sectioned and subjected to a flexibility test as detailed Annex F. The coating must not exhibit signs of cracking, disbondment or pinholes and the test pieces must also pass a holiday detection test conducted in accordance with ISO 21809-2, Clause 10.3.2.

### **26.3.8 Cathodic disbonding test**

Cathodic disbondment testing (28 d, 20 °C ± 3 °C, -1,5 V) – The coating must not disbond for greater than 5 mm radius from the edge of the coating pre-damage; testing undertaken in accordance with ISO 21809: Part 2: Appendix A.9.

### **26.3.9 Water immersion test**

The coated test pieces should be prepared and subjected to a water immersion test as detailed in Annex D. The coating must show no loss of adhesion greater than 3 mm after 28 days.

## **27. Production Coating Procedure**

### **27.1 Surface preparation**

The surface of the pipe to be coated should be prepared in general accordance with ISO 21809, Clause 9.

The cleanliness achieved at entry to the application line shall be in accordance with ISO 8501-1:2007, grade Sa 2<sup>1/2</sup> (“very thorough blast-cleaning”).

The height of the surface profile attained shall be within 50 µm and 100 µm as measured in accordance with ISO 8503-4 (Stylus method) or ISO 8503-5 (Replica tape method) and shall be angular in nature.

### **27.2 Coating process**

#### **27.2.1 General**

The production coating process must be carried out using a procedure approved in accordance with Clause 25. This should normally be a spray coating process, but brush application may be used on small areas.

The thickness of the coating should be not less than 1.5 mm.

### **27.2.2 Pre-mix agitation**

Each coating component should, when necessary, be mixed to a homogeneous state before any part of the component is withdrawn from its container.

### **27.2.3 Mixing for use**

The components (e.g. base and curing agent) of a coating material are normally supplied separately packed. They should be mixed in accordance with the manufacturer's instructions.

If preheating of one or more of the coating material components is required prior to mixing and application, the procedure should be monitored and controlled to avoid excessive heating which might affect application or the integrity of the coating.

Material cure time is dependent on ambient temperature. Should it be necessary to shorten the cure time, this may be achieved by the application of heat to the prepared surface before coating commences. The maximum preheat temperature should be within the range recommended by the coating manufacturer.

Thinners shall not be used unless recommended by the manufacturer.



**Thinners shall not be used unless recommended by the Manufacturer**

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### **27.2.4 Spraying equipment**

The spraying equipment should be adequate for applying the coating in accordance with the coating manufacturer's instructions and the qualification procedure. The equipment should be maintained in good order by the contractor and/or the equipment supplier. All air lines should be provided with filters and vapour traps to ensure that the air is free from oil and moisture. All critical parameters must be monitored.

Tools and equipment should be cleaned using only such solvents as are recommended by the coating material manufacturer.

### **27.2.5 Operator qualifications**

When required, the individual operators carrying out the multi-component liquid spraying application should be subjected to a qualification test in which they will be required to demonstrate proficiency in the spraying process as laid down in the relevant section of the procedures.

### **27.2.6 Spraying procedure**

The spraying procedure must be in accordance with the qualification procedure which should include a total time allowed for coating. Individual operators should be experienced in the use of equipment and should be suitably qualified (see Clause 27.2.5).

Solvent flushing of spray equipment used for rapid cure materials is normally employed to prevent coating material gelling in the gun when spray operations cease for significant periods of time.

It is essential that, on recommencement of spraying, the operator ensures that solvent-free material only is applied to the work to avoid ensuing problems caused by solvent blistering of the coating. Additionally, all solvent flushing operations should be carried out by discharging the solvent into a suitable container. Solvent should not be discharged at random on to the surrounding work area.



Coating material filters should be installed as part of the spray equipment to ensure that particles, which would be detrimental to the coating application, are not deposited on to the surfaces being coated. Regular inspection and maintenance of the filters is recommended.

The coating component feed lines to the spray-gun should be equipped with a pressure gauge fitted with a pulsation damper, to facilitate pressure readings. The location of this gauge should be downstream of all pressure drop devices and as near to the gun tip as is reasonably practicable.

The coating contractor should monitor and record all relevant ambient conditions during application and cure.

The temperature of the metal surface at the time of application should be not lower than 10 °C. Ideally, for optimum results, the metal surface temperature should be between 25 °C and 35 °C, but it is essential that care be taken to avoid contaminating the surface. The relative humidity should be 80% or less during application and the ensuing first hour of cure time.

Coating operations must be stopped when the conditions are such that an inferior coating will result. Such conditions include inadequate surface preparation, unsatisfactory application procedure, poor coating material performance and when the steel temperature at any stage of the process falls to within 3 °C of the dew point measured in the work area.

## **28. Visual Inspection**

The coating colour and appearance should be uniform and free from runs, sags, blistering, roughness, foaming and general film defects.

## **29. Testing of Cured Coatings**

### **29.1 Testing of coated pipes and fittings**

Cured coatings on pipe and fittings must comply with the requirements of Clauses 29.2 to 29.7.

The Contractor must ensure that the tests specified in Clauses 29.4 to 29.7 inclusive are carried out in duplicate and the results of all tests, demonstrating compliance, made available to the Gas Transporter.

### **29.2 Thickness test**

The coating thickness on each pipe or fitting should be checked at not less than 20 equidistant locations spread over the coated surface of the pipe or fitting. All readings of the dry film thickness must meet the requirements specified in Clause 26.3.2. The thickness measuring gauge used should be calibrated hourly for the specified thickness range (see Annex G). Values less than those specified in Clause 26.3.2 must constitute cause for rejection.

### **29.3 Holiday detection test**

Every pipe and fitting should be subjected to a holiday detection test over 100% of their coated surfaces as detailed in ISO 21809-2, Clause 10.3.2.

The number of holidays detected must not exceed the number quoted in Table 2. If, on any two consecutive pipes or fittings, the number of holidays detected is greater than the normally acceptable level, but less than the maximum permissible level, the cause must be immediately investigated.

**Table 2 - Component diameter ranges, permissible holidays and repairs**

Component diameter range / mm	Number of holidays on pipe - acceptable	Number of holidays on pipe - permissible	Maximum total repair area (pipe or fitting) / cm <sup>2</sup>
14 – 49	2	4	75
50 – 299	2	4	125
300 – 599	3	6	250
600 – 899	4	8	350
900 – 1099	5	10	500
1100 - 1399	6	12	600

**NOTE** – For fittings, the number of normally acceptable holidays shall be one per square metre of coated area and maximum permissible shall be two per square metre of coated area.

If four further consecutive pipes or fittings are detected having holidays between the normally acceptable level and the maximum permissible level given in Table 2, all production to that point must be quarantined until the reason for the high frequency of holidays is determined. A total of 5% of daily production will be accepted with up to the maximum permissible number of holidays provided that the 5% are not consecutive.

Pipes or fittings with more holidays than permitted by Table 2 should be rejected for subsequent stripping (see clause 32) and recoating.

All holidays must be repaired in accordance with Clause 30 and satisfactorily retested before dispatch of the pipes or fittings.

Defects detected immediately before dispatch should not be repaired but must be conspicuously and permanently marked on the pipe or fitting and recorded on the relevant inspection documentation.

#### **29.4 Hardness and cure of coating test**

The hardness and cure of the coating on every pipe and fitting should be determined.

The value of the hardness obtained must be within the range specified by the manufacturer of the material to indicate the correct degree of cure of the coating.

#### **29.5 Impact resistance test at minimum design temperature**

The coated test pieces should be subjected to an impact resistance test at minimum design temperature in accordance with ISO 21809: Part 2: Appendix A.8. A minimum mean impact value of 5 J shall be achieved without resulting in a breakdown or loss of adhesion in the coating.

The frequency of testing should be, for pipes, once every two hours or 20 pipes and, for fittings, once every two hours or five fittings, whichever is more frequent.

The cured coating must withstand a minimum impact of 5 J without resulting in a breakdown or loss of adhesion of the coating.

#### **29.6 Adhesion test**

The coated pipes and fittings should be subjected to an adhesion test of the cured coating as detailed in Annex A and achieve a pass rating.

The frequency of testing should be, for pipes, once every two hours or 20 pipes and, for fittings,

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once every two hours or five fittings, whichever is the more frequent.

This initial test frequency may subsequently be varied by the Gas transporter, the revised test frequency being based on quality history.

### **29.7 Heat blister test**

After initial cure, a test plate of representative wall thickness, coated at the same time as the batch of pipe and fittings with multi-component liquid systems, should be subjected to a heat blister test in general accordance with Annex E by heating the steel to a temperature in the range 50 °C to 60 °C and holding the temperature within that range for one hour.

After heating, the test plate should be inspected for blisters. In the event of blistering being observed, an investigation into the cause of the defect must be immediately undertaken. Samples of coating may have to be removed for nitrogen analysis or other appropriate tests and the coating operations may have to cease during the period of the investigation. When the cause of the defect has been established, components in the coating sequence during which the plate has been coated, should be tested until an acceptable coating is identified.

For pipes, testing should normally be carried out at a frequency of once every two hours or 20 pipes, whichever is the more frequent. For fittings, testing should normally be carried out at a frequency of once every two hours or five fittings, whichever is the more frequent. These test frequencies may be varied by the Gas Transporter.

Localized blisters must be repaired.

### **29.8 Check procedure**

If any pipe or fitting fails the requirements of Clauses 29.4 to 29.7 inclusive, a check procedure must be initiated. This should involve checking all pipes or fittings back to the preceding acceptable one. The pipe or fitting numbers must be available from the final inspection bench. These pipes or fittings should be subjected to an examination like that carried out on the failed pipe or fitting. If the number of defects is significant, the entire coating production for that day should be quarantined and investigated.

## **30.Repair of Defects**

All repairs to holidays and other coating defects must be with multi-component liquid materials qualified by the manufacturer to ensure compatibility with the applied coating. Repair methods must include adequate surface preparation techniques, agreed overlaps, coating thicknesses and a demonstration of satisfactory adhesion and cure. All repairs must be retested for holidays as detailed in ISO 21809-2, Clause 10.3.2.

Maximum areas of repair should be not greater than those given in Clause 29.3, Table 2. At the Gas Transporters discretion variants may be considered.

The area to be overlapped should extend to at least 75 mm from the periphery of the defect. The repair material should be applied to the prepared surfaces using a scraper, palette knife or paint brush.

Care should be taken to ensure that the thickness over the repair area is not less than 1.5 mm when cured.

## **31.Handling of Coated Fittings**

All pipes and fittings should be handled and stored in accordance with IGEM/TD/1 Supplement 1

and the relevant fitting standard where appropriate to prevent damage to the component and coating. At the discretion of the Gas Transporter variants may be considered.

### **32.Stripping of Coatings**

Rejected coating should be removed by a procedure which must not cause mechanical damage to the fitting or cause the steel temperature to exceed 250 °C. At the Gas Transporters discretion, a maximum temperature  $\leq 275^{\circ}\text{C}$  aligned with ISO 21809-2, Clause 9.3.1 may be considered.

### **33.Identification**

The Contractor must be responsible for ensuring that all internal or external identification markings are noted before surface preparation begins and are replaced after the coating process in accordance with Clause 16 of this specification.

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## Annex A – Health, Safety & Environment

### Health & Safety

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**All work carried out on the Plant or Site shall comply with safe working practices and the specific conditions of a Permit to Work**

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Contractor shall ensure that all activities involved in the selection, application, inspection and testing of protective coating systems are managed to ensure personnel safety, minimal environmental impact and safe, operable facilities including but not limited to:

- i. Implementation of safety measures for protecting workers in accordance with all local and national regulations including provision of appropriate personal protective equipment and training in its use, regular safety briefings/tool-box talks etc. Operations covered in this Specification are subject to the Health and Safety at Work etc. Act 1974 and other relevant legislations, such as European Union (EU) if applicable;
- ii. Implementation of appropriate training schemes to ensure personnel have necessary competence to perform their allocated tasks;
- iii. Development of method statements and risk assessments for potentially hazardous activities.
- iv. Provision of MSDS for all materials;
- v. All activities concerning substances shall have been subjected to an assessment under the Control of Substances Hazardous to Health (COSHH) Regulations 2002;
- vi. Provision of adequate ventilation and extraction facilities in confined spaces to prevent the build-up of toxic or flammable atmospheres, dust etc;
- vii. Provision of appropriate Personal Protective Equipment (PPE) including breathing and hearing protection.
- viii. Provision of appropriate breathing and hearing protection;
- ix. Provision of adequate access/scaffolding/working platforms in accordance with the Gas transporters procedure if relevant;
- x. Provision of adequate access and secure, temporary formwork to ensure safe working environments below grade; in accordance with Gas transporters procedure if relevant;
- xi. Provision of adequate safety systems to prevent electric shock and build-up of static electricity;
- xii. Provision of appropriate safety systems for use of pressurised air, including test certificates, 'dead-man' handles, whip-checks;
- xiii. Provision of appropriate fire-fighting equipment and personnel training in the use of equipment;
- xiv. Provision of appropriate first aid facilities;
- xv. Adherence to local hazardous/flammable area classification restrictions;

- xvi. Adherence to appropriate permit-to-work system requirements, including adequate training of personnel in their use;
- xvii. Provision of appropriate waste disposal and/or recycling systems to meet all local, national and international requirements.

## **Environment**

Contractor shall ensure that manufacturing and application processes, and any associated materials and substances, do not constitute a toxic, microbiological or organoleptic hazard.

Any Hazard including toxic, corrosive risks and fire risks, associated with the coating materials offered for use to meet the requirements of this specification and associated with the method of application of the product shall be specified by the manufacturer, together with his recommendations for safe handling in accordance with the European Agreement concerning the International Carriage of Dangerous Goods by Road (ADR 2017) Appendix C of the Convention Covering International Carriage by Rail - International Carriage of Dangerous Goods by Rail. The Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations 2009 and the general principles of classification and labelling for supply are explained by the European Regulation (EC) No 1272/2008 on classification, labelling and packaging of substances and mixtures (CLP) on classification, labelling and packaging of substances and mixtures. Seek further guidance from HSE where required.

Materials and substances shall not contain asbestos, heavy metals (such as lead or cadmium), PCBs, CFCs and Halon refrigerants, nor VOCs or isocyanates in excess of local, national and international legal limits.

Provision of appropriate waste disposal and/or recycling systems to meet all local, national and international requirements such as the Environmental Protection Act - EPA - (Duty of Care) 1991.



**Contractor shall ensure that manufacturing and application processes, materials and substances do not constitute a toxic, microbiological or organoleptic hazard.**

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**Guidance note:** *Isocyanates are typically present during the manufacture and application of polyurethane coating systems – these are potential carcinogens and their use is discouraged however, Company recognises that isocyanate-free coating systems with relevant service experience are currently limited therefore strict adherence to applicable regulations and use of personal protective equipment when handling or applying polyurethane coating systems must be observed.*

*There is no known case of isocyanate used in paints causing cancer! But they are the biggest cause of occupational asthma in the UK. To confuse the two may cause someone to overlook the classic early symptoms of asthma – wheezing, breathlessness and tightness of the chest. This means they don't seek medical attention and the problems at work that are leading to exposure aren't put right because they are unlikely to link their symptoms to work*

*Regarding the use of chromate-based pre-treatments for fusion bonded epoxy coating, hexavalent chromium has now been prohibited in Europe under REACH. Their use is prohibited.*

## Annex B – Quality

The Contractor shall have an accredited Quality and Environmental Management System that complies with a National or International Standard applicable to their service or supply. The quality system shall be based upon recognised quality standards of which ISO 9001 is a suitable example.

### Guidance note:

- i. ISO/TS 29001 gives sector-specific guidance on quality management system;
- ii. ISO 14001 gives guidance on the selection and use of an environment management system.

A quality assurance group shall have been established, which shall be responsible for reviewing the quality system and ensuring that it is implemented.

Training, experience and competency records for all operatives involved in coating operations shall be maintained and available upon request.

The following competencies are acceptable:

- ICorr Pipeline Coatings Inspector - Level 2;
- NACE Coating Inspector Program - Level 2 & 3;
- Frosio - Level 2 & 3;
- BGAS-CSWIP Site and or Paint Coating Inspector.

Application and test procedures, which comprise the quality system and the ITP shall be submitted to the Gas Transporter for agreement.

The Gas Transporter shall if required make any investigation necessary in order to be assured of compliance by the Contractor and third parties and to reject any material and/or coating that does not comply.

A quality plan and ITP for the activities necessary to satisfy the requirements of this Specification shall be prepared and issued to the Gas transporter for agreement before commencement of work.

The quality plan and ITP shall:

- i. include any sub-contracted work and the subcontractor's quality plans shall be submitted;
- ii. be sufficiently detailed to indicate sequentially, and for each discipline, the requisite quality control, inspection, testing, and certification activities with reference to the associated procedures and the acceptance standards;
- iii. with due notice, be subject to formal audits by the Gas Transporter. The application of quality control may be monitored by the Gas Transporter or nominated third-party inspectors, who will witness and accept on behalf of the Gas Transporter the inspection, testing, and associated work required by this Specification.

The provision of inspection services reporting directly to the Gas transporter shall in no way relieve the responsibility to verify that the full scope of work is performed entirely in accordance with this Specification and the agreed quality plan and ITP.

The contractor shall issue testing and inspection reports to the Gas Transporter in accordance with ISO 10474.

The contractor shall issue qualification test reports, certificates of compliance for the coating in accordance with the requirements of this Specification and cited parts of ISO 21809-9; and any other requirements specified in the purchase order.

## Annex C – Adhesion

### C.1 General

The equipment and procedures detailed in Clauses C.2 to C.6 inclusive serve to assess the comparative resistance of coatings applied to components to loss of adhesion by a destructive process. This method is only applicable for coating layers with a thickness less than 500 µm.

### C2. Equipment

The following equipment will be required:

- a) Pointed sharp knife, e.g. Stanley type or similar.
- b) A steel rule, if required.
- c) A steel rod, if required

### C3. Preparation of Test Panels

#### C3.1 Laboratory prepared specimens

Prepare 100 mm x 100 mm x 6 mm panels under conditions of application and cure similar to those for a coated component.

#### C3.2 Specimens taken from components

Cold cut 100 mm x 100 mm specimens from a sample pipe or, in the case of a fitting from the pipe pup which has been coated as a test piece.

### C.4 Preparation of Test Area

To ensure freedom from holidays, test the prepared panels for holidays with the holiday detector set at the required voltage in accordance with ISO 21809: Part 2, Clause 10.3.2.

The adhesion test shall be done at 23 °C ± 3 °C unless otherwise stated.

### C.5 Investigation Procedure

For all coated components and coatings on panels equal to or less than 500 µm thickness, use the following procedure:

- a) Using a sharp pointed knife (e.g. Stanley knife or similar), make two incisions, using a steel rule if necessary, approximately 13 mm long through to the metal surface to form a V with an angle of approximately 30° at the intersection point as shown in Figure C.1.
- b) Starting at the point of intersection force the coating from the steel substrate using the sharp pointed knife. If necessary use a levering action against a fulcrum (such as a steel rod). Take care to protect the eyes and hands when carrying out this operation.

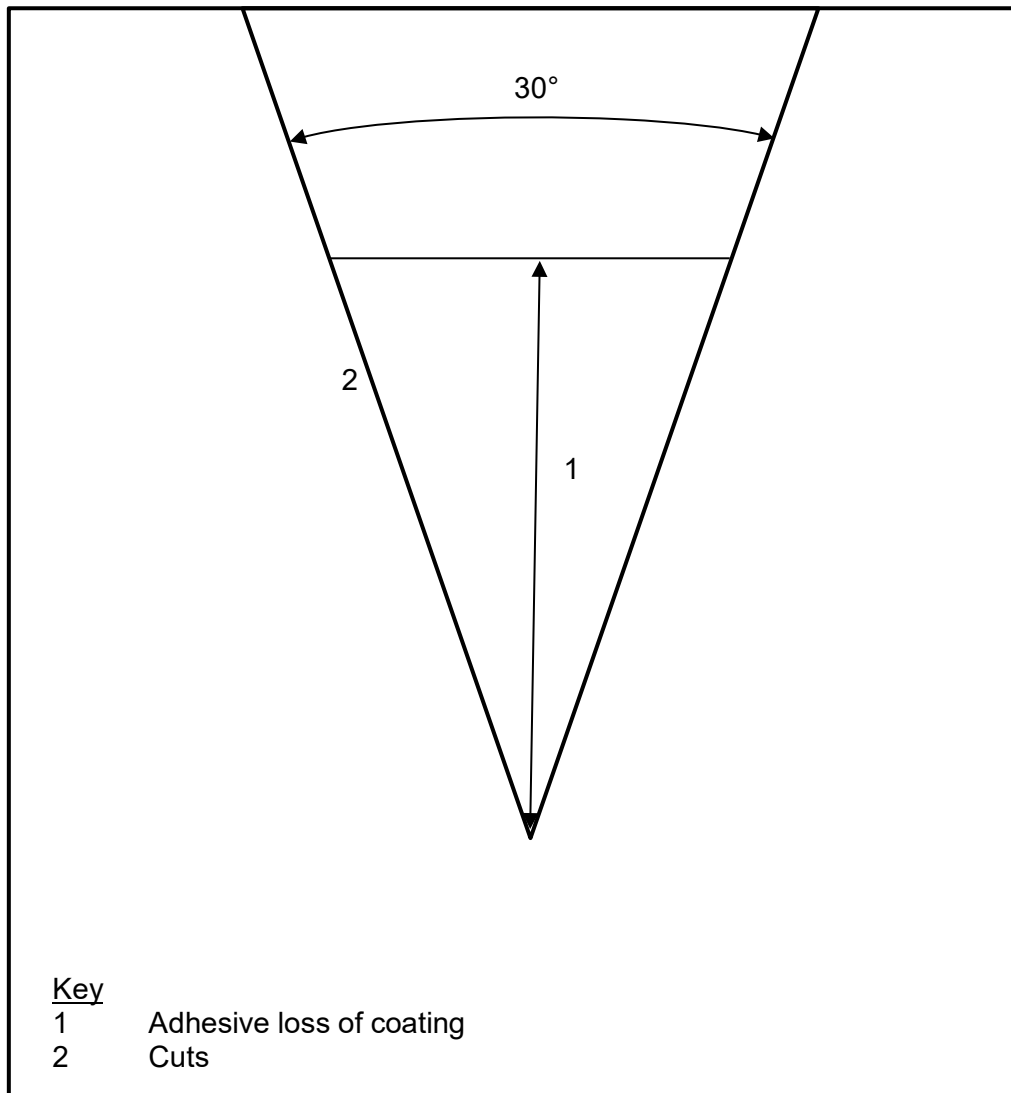
### C6. Reporting Results

Refusal of the coating to peel or a cohesive failure within the coating where no more than 2 mm of adhesive is removed from the metal surface, should be recorded as a 'Pass'.

For the purpose of this test, cohesive failure will be recorded where some coating material remains on the metal surface and where difficulty in coating removal has been experienced.

The extent of the adhesive failure between the coating and the metal substrate should be recorded. Adhesive loss greater than 2 mm shall be recorded as a 'Failure'.





**Figure C.1 - Adhesive loss of coating**

## **Annex D – Evaluation of Resistance to Water Immersion**

### **D.1 General**

The equipment and procedure detailed in Clauses D.2 to D.7 inclusive should be used to assess the comparative resistance of coating applied to components (free of holidays) to loss of adhesion due to water absorption.

### **D.2 Equipment**

The following equipment will be required:

- a) A water bath which should be maintained at a temperature of  $50 \pm 2$  °C.
- b) A holiday detector.
- c) Internal pipe coating material (complying with CM2).
- d) 6 mm diameter twist drill.
- e) Pointed sharp knife, e.g. Stanley type or similar.
- f) 5 mm diameter steel rod 450 mm long.
- g) Elastomeric adhesive for repairing test areas, e.g. Silastic silicone-rubber, grades RTV 738 or RTV 732 or equivalent.

### **D.3 Sample Preparation**

#### **D.3.1 Laboratory prepared specimens**

Prepare 100 mm x 100 mm x 6 mm panels under conditions of application and cure similar to those for a coated component.

#### **D.3.2 Specimens taken from components**

Cold cut 100 mm x 100 mm specimens from a sample pipe or, in the case of a fitting, from the pipe pup which has been coated as a test piece.

#### **D3.3 Preparation of Test Area**

To ensure freedom from holidays, test the prepared panels for holidays with the holiday detector set at the required voltage – see ISO 21809: 2, Clause 10.3.2.9.

Drill a 6 mm diameter hole through the test panel within 25 mm of one end.

Protect the bare metal of the panel with internal coating material (see Clause D.2 c)).

### **D.4 Initial Test Procedure**

Carry out an initial adhesion test as described in Clause D.5.

Using the steel rod fitted through the 6 mm diameter hole, suspend the specimen panel in the water bath immersing all but the top 50 mm of the panel.

After 7 days, remove the panel from the water bath and allow it to cool to ambient temperature. No longer than 30 minutes should be allowed between removing the test panel from the bath and performing the adhesion test.

Test the coating adhesion as specified in Clause D5.

Repair the test area using elastomeric adhesive.

Return the panel to the water bath immediately.

If, after seven days immersion, the coating is retested and is found to be satisfactory, return the panel to the water bath and repeat the adhesion test at intervals of seven days up to a total immersion time of 28 days.

If the coating fails the requirements of this specification at any test interval within the 28 days, it should be removed from test.

### **D.5 Investigation Procedure**

Use one or other of the following procedures as appropriate.

For all coated components and coatings on panels equal to or less than 600 µm thickness, use the following procedure:

- a) Using a sharp pointed knife (e.g. Stanley knife or similar), make two incisions approximately 13 mm long through to the metal surface to form a V with an angle of approximately 30° at the intersection point.
- b) Starting at the point of intersection force the coating from the steel substrate using the sharp pointed knife until significant coating has been removed or the coating shows a definite resistance to removal. Take care to protect the eyes and hands when carrying out this operation.

For laboratory panels with coatings greater than 600 µm thickness use the following procedure:

- a) Using a small hacksaw blade (e.g. 'Junior' type or similar) make two incisions through to the metal surface to form an X with an angle of approximately 30° at the point of intersection.
- b) Draw a sharp knife along the cut lines to ensure that the hacksaw blade has reached the metal surface.
- c) Starting at the point of intersection, force the coating from the steel substrate using the sharp pointed knife until significant coating has been removed or the coating shows a definite resistance to removal. Take care to protect the eyes and hands when carrying out this operation.

### **D.6 Reporting Results**

Refusal of the coating to peel or a cohesive failure within the coating should be recorded as a 'Pass'.

Cohesive failure, caused by voids leaving a honeycomb structure on the specimen surface, should constitute a failure.

For the purpose of this test, cohesive failure will be recorded where some coating material remains on the metal surface and where difficulty in coating removal has been experienced.

The extent of the adhesive failure between the coating and the metal substrate should be recorded. Adhesive loss greater than 3 mm shall be recorded as a 'Failure'.

## **Annex E – Evaluation of Resistance to Heat Blistering**

### **E.1 General**

The equipment and procedures detailed to Clauses E.2 to E.5 inclusive should be used to assess the resistance of FBE coatings to heat blistering.

### **E.2 Test Requirement**

#### **E.2.2 Equipment**

The following equipment will be required:

- a) A water bath which should be maintained at a temperature of  $50 \pm 2$  °C.
- b) 6 mm diameter twist drill with included cutting angle of 160°.
- c) A chrome/aluminium (K type) thermocouple.
- d) A thermocouple welder.
- e) A digital thermometer capable of recording and logging the response of a chrome/aluminium electrode.
- f) A hot air blower (typically 2kW).

### **E.3 Preparation of Test Panels**

#### **E.3.1 Laboratory prepared specimens**

Sample panels 50 mm x 50 mm x 6 mm should be prepared simulating the conditions of application for a factory coated pipe.

### **E.4 Initial Test Procedure**

Immerse the coated specimens in a 50 °C water bath (tap water) for a period of 24, 48 and 72 hours.

After each period of exposure remove the specimens from the water bath and immediately remove excess water.

Drill a 6 mm diameter hole through the coating to expose the metal surface in the centre of the panel. The thickness of the panel should not be reduced by more than 0.5 mm.

Attach the chrome/aluminium thermocouple to the 6 mm bare area by welding.

Heat the coated test panel<sup>(\*)</sup> from the back at a rate of  $110 \pm 10$  °C/minute, until the thermocouple registers a temperature of 240 °C. No longer than 15 minutes should elapse between removing the test panel from the water bath and commencing heating.

When the test plate attains a temperature of 240 °C quench the panel immediately in cold water. Quenching will prevent blisters from deflating and will allow the size and blister density to be recorded.

### **E.5 Investigative Procedure**

Monitor the temperature continuously during the heating process and observe the temperature at which blistering first occurs.

Assess the blister size and blister intensity

A 2kW hot air gun has proved to be suitable for this purpose. By adjusting the distance between the gun and the test panel the heating rate can be varied. Ensure that the heating process is reproducible prior to performing the heat blister tests.

## **C.2 Reporting Results**

A graph showing the heating profile should be recorded and the temperature at which blistering first appears marked on the graph.

A photographic record of the appearance of the test plate after quenching should be made.

*(\*) A 2kW hot air gun has proved to be suitable for this purpose. By adjusting the distance between the gun and the test panel the heating rate can be varied. Ensure that the heating process is reproducible prior to performing the heat blister tests.*

## Annex F – Flexibility Test

### F.1 Laboratory Prepared Test Panels

Apply the coating to steel plates 50 mm x 300 mm x 6 mm thick and properly cure. Bend (at a deflection rate of 25 mm/min) over appropriately sized mandrels (see below) at two substrate test temperatures (5 °C and 20 °C). After bending, the coating shall not crack, disbond or pinhole when holiday tested in accordance with ISO 21809. Inspect plates immediately after bending and again 24 h at 20 °C.

Select mandrel sizes according to the following formula:

$$D = \frac{t(1-S)}{S}$$

- Where D = Mandrel diameter, in mm (see Figure F.1).  
t = Plate thickness, in mm.  
S = one of the values in Clause F.3 depending on the intended coating application and the temperature of the test.

The arc length of the mandrel should be fixed at 225 ±25 mm.

Set the panel support gap according to the following formula:

$$\text{Support gap} = M + 2t + 4\text{mm}$$

- Where M = Chord length across the mandrel arc, in mm (see Figure F.1).  
t = Plate thickness, in mm.

Bend the panel until it contacts the entire surface area of the mandrel.

During bending, peaking (point at which a gap occurs between the mandrel and the panel) may be observed at the centre of the panel. In this case, the area of the panel where the gap exceeds 0.254 mm (0.010 in.) should be disregarded in evaluating the test results. This area should not exceed 25% of the mandrel surface area.

### F.2 Test on Pipe Specimens

Cold cut test specimens 356 mm long x 50 mm wide from a pipe section with the long axis in the circumferential direction. Where seamless pipe is being tested, select specimens which show a minimal variation in pipe wall thickness, particularly within the test area (i.e. middle 75 mm to 100 mm of specimen). Bend the test specimens over appropriately sized mandrels at two substrate test temperatures (5 °C and 20 °C). After bending, the coating shall not exhibit visible signs of cracks, disbanding or pinholes and shall pass a holiday detection test when tested in accordance with ISO 21809:2, Clause 10.3.2 9. Inspect specimens immediately after bending and again after 24h at 20 °C.

Select mandrel sizes according to the following formula:

$$D_1 = \frac{1}{\frac{S}{t + \frac{1}{D_0 - t}}} - t$$

- Where D<sub>1</sub> = Mandrel diameter, in mm.  
D<sub>0</sub> = Original specified pipe outside diameter, in mm.  
t = Pipe wall nominal thickness, in mm.  
S = One of the values specified in Clause F.3 depending on the intended coating application and the temperature of the test.

The arc length of the mandrel should be fixed at  $225 \pm 25$  mm.

For specimens from pipes having an outside diameter in the range 406 mm to 1219 mm, set the panel support gap according to the following formula:

$$\text{Support gap} = M + 2t + 4\text{mm}$$

Where M = Chord length across the mandrel arc, in mm (see Figure F.1).

t = Plate thickness, in mm.

Bend the specimen until contact is made with  $75 \pm 10\%$  of the mandrel area.

For specimens from pipes having an outside diameter in the range 305 mm to 405 mm set the panel support gap according to the following formula:

$$\text{Support gap} = M + 2t + 29\text{mm}$$

Where M = Chord length across the mandrel arc, in mm (see Figure F.1).

t = Plate thickness, in mm.

Bend the specimen until it contacts the entire surface area of the mandrel. Test specimens from pipes having an outside diameter below 305 mm by an appropriate method.

During bending, peaking (point at which a gap occurs between the mandrel and the panel) may be observed at the centre of the panel. In this case, the area of the panel where the gap exceeds 0.254 mm (0.010 in.) should be disregarded in evaluating the test results. This area should not exceed 25% of the mandrel surface area.

### F.3 S Values

For coatings intended for use on fittings, the following S values should apply:

S = 0.005 at a temperature of 5 °C.

S = 0.01 at a temperature of 20 °C.

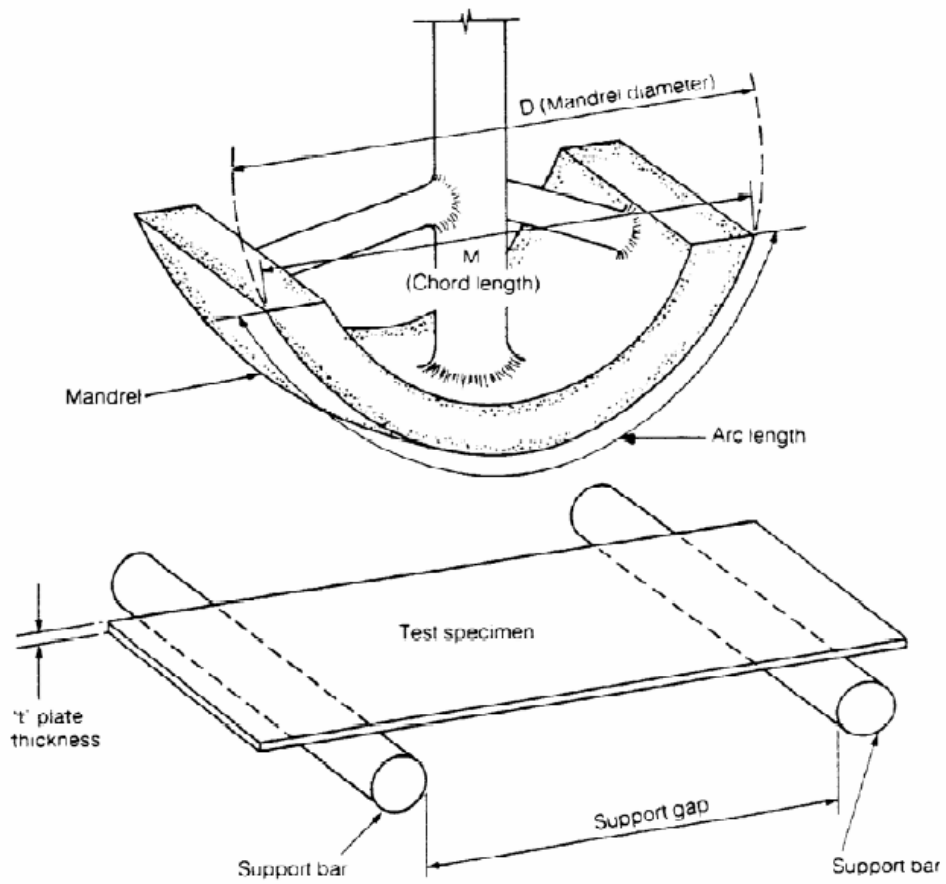
For coatings intended for use on line pipe, the following S values should apply:

S = 0.02 at a temperature of 5 °C.

S = 0.03 at a temperature of 20 °C.

### F.4 Testing at 5 °C

Testing at 5 °C may be carried out by pre-cooling the panel in a refrigerator to a temperature slightly lower than 5 °C and carrying out the bending operation when the panel temperature reaches  $5 \pm 2$  °C. Alternatively, an environmental chamber that controls the temperature of the bending apparatus may be used. The test specimens should not be immersed in any liquefied coolant to achieve the test temperature.



**Figure F.1 - Typical mandrel for flexibility tests**



## **Annex G – Calibration Procedure for Thickness Measurement of Fusion Bonded Epoxy Powder and Multi-Component Liquid Coatings**

The thickness gauge should be calibrated on a clean dry grit-blasted area of the pipe or fitting which is representative of the steel cleanliness and surface roughness at the time of coating. To obtain accurate thickness readings using magnetic 'pull-off' and eddy current instruments, the following precautions should be taken during calibration:

- a) Non-metallic shims of known thickness with certification traceable to national standards should be used.
- b) The shims should be examined before use to ensure that they are in good condition with no sign of roughness or wear.
- c) The shims selected for calibration should be close to the expected thickness of the coating being evaluated.
- d) The surface profile and steel cleanliness when calibration is being carried out should be typical of the steel condition at the time of coating excluding any pretreatment used.
- e) The steel substrate should be at ambient temperature.
- f) The probe on the thickness gauge should be clean and free from contaminants.
- g) The instrument should be re-calibrated at hourly intervals.