

Water Industry Specification

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SPECIFICATION FOR POLYMERIC ANTI-CORROSION (BARRIER) COATINGS

FOREWORD

This specification has been prepared by WRc plc under the direction of the Sewers and Water Mains Committee. Representatives of the UK Water Industry, coatings material suppliers and coating applicators were regularly consulted during the development of the document through the Materials and Standards Working Group's Coatings Liaison Group.

The specification has been issued to satisfy the needs of both users and suppliers for a national Water Industry performance based specification covering the broad range of polymeric coating types used within the industry.

An Information and Guidance Note (IGN No. 4-52-02) has also been prepared in parallel with this specification for use in conjunction with it. The purpose of the IGN is to provide the Water Industry with guidance in the following important areas:

- The design of metallic fittings, pipework and structures which are to be protected with polymeric anti-corrosion coatings.
- The selection of polymeric anti-corrosion coatings for the protection of metallic fittings, pipework and structures.
- The packaging and handling of products protected with polymeric anti-corrosion coatings.

This specification calls for the use of substances and/or 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.

Where reference is made to a British Standard or other specification, this shall be understood to refer equally to any other equivalent specification.

Enquiries regarding the availability of third party certification to this specification should be addressed to an appropriate third party NACCB or equivalent accredited certification body or to WRc Swindon.

It has been assumed in the drafting of this specification that the execution of its provisions is entrusted to appropriately qualified and experienced people.

Information contained in this specification is given in good faith but neither the Foundation for Water Research, Water Services Association nor WRc plc can accept any responsibility for actions taken as a result.

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16. QUALITY ASSURANCE REQUIREMENTS	15	It is not intended to cover lower molecular weight hydrocarbon-based materials such as bituminous paints and enamels. (See IGN No. 4-52-02 for guidance on the selection of these coatings and their alternatives). It is intended to cover the following service application areas:	
PART THREE - REQUIREMENTS OF SUBCONTRACT COATING APPLICATORS			
17. SCOPE OF PART THREE	15	<ul style="list-style-type: none"> • Factory applied coatings and associated coatings used for repair and the making good of intentionally uncoated areas of substrate. • Ductile iron, cast iron, steel and aluminium based substrates. • Pipes, fittings, their components and associated equipment. (Structural steel for buildings, etc. is not covered). • Contact with all grades of "clean" water, including potable water as an option, and domestic effluent. Most soil conditions (except for contaminated land) are included, as well as above ground applications. 	
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APPENDICES		The specification is divided into three working parts:	
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APPENDIX B - COATING THICKNESS MEASUREMENT	16		
APPENDIX C - HIGH VOLTAGE HOLIDAY DETECTION	17	Part Two deals with the requirements of the factory-applied coatings and includes requirements for materials to be used, work pieces to be coated, qualification of production procedures to be used, production quality control, rework and subcontracted work.	
APPENDIX D - ADHESION	18	This part of the specification is aimed primarily at suppliers of pipeline components which are offered with coatings applied.	
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Part Three deals with the requirements for Subcontract Coating Applicators and includes the relevant clauses of Part Two together with specific requirements for subcontractors.

Subcontractors complying with the requirements of Part Three may apply to become certificated for the range of production procedures qualified in accordance with Part Three.

The test methods referred to in the specification are either specified in BS or ISO Standards, or in the Appendices.

2. DEFINITIONS

For the purpose of this specification the following definitions apply:

Acceptable Quality Level (AQL): The maximum percentage of non conformity that, for the purposes of sampling inspection, can be considered satisfactory.

Coated Product Supplier: Supplier of the finished coated product to the UK Water Industry (UKWI). The Coated Product Supplier may supply the coated product directly to the UKWI or indirectly via a factor.

Coating System: Details of coating, priming and other intermediate layer materials, together with production procedures pertaining to the pre-treatment and coating work or test pieces.

Coating System Materials: Coating materials, intermediate layers and primers identified in the declaration of Coating System Details.

d_n : Nominal outside diameter.

Holiday: A discontinuity in the coating indicated by the passage of electrical current between the metallic substrate and a test probe passed over the coating surface. (See Appendix C).

Holiday-Critical Surfaces: Product surfaces which cannot tolerate the premature onset of corrosion and are therefore required to be holiday-free.

Manufacturer: Manufacturer of the Coating System Materials.

Sample: A group of test pieces or work pieces taken from a larger collection or population. The term may also be used to describe a portion of material taken from a larger bulk of material.

Subcontractor: Subcontractor employed by the Coated Product Supplier to prepare, pre-treat and coat work pieces.

Test Piece: A single test specimen.

Thickness-Critical Surfaces: Product Surfaces which are subject to particularly close control of coating thickness. This close control may be required in order to ensure that coated items comply with dimensional tolerances. (See Appendix B, Clause B3). Such surfaces shall be identified on appropriate work piece drawings.

PART ONE - REQUIREMENTS OF COATING SYSTEM MATERIALS

3. SCOPE OF PART ONE

This part of the specification covers the requirements for polymeric anti-corrosion coating system materials. It deals specifically with the properties and performance required to establish the suitability of a material for use with Part Two and Part Three of this specification.

4. COATING SYSTEM DETAILS

4.1 General

Together with each coating system submitted for evaluation, the following corresponding information shall be declared to the certifying body by the coating material manufacturer.

4.2 Coating material formulation (to be treated strictly in confidence)

The coating material formulation shall include details of all the component parts by chemical name together with typical quantities and the degree to which these quantities are likely to be permitted to vary in manufacture. This information should be supplemented by an infra-red spectrum of a representative sample of material to this formulation.

NOTE: This information shall be regarded as strictly confidential to the certifying body and it shall not be disclosed to any other third party. Any change in formulation must be notified to the certifying body.

4.3 Primer and other intermediate layer formulations

Where the coating system includes a primer or some other intermediate layer, the formulation for that material shall be declared, and shall include the details listed in 4.2. Any change in formulation must be notified to the certifying body.

NOTE: This information shall be regarded as strictly confidential to the certifying body and it shall not be disclosed to any other third party. Any change in formulation must be notified to the certifying body.

4.4 Substrate material

The substrate material(s) for which the coating system and procedures have been developed shall be declared.

4.5 Work piece preparation procedure

Where the work piece requires preparation prior to pre-treatment, (e.g. fettling of castings, filling of casting blowholes, removal of surface scale or corrosion product, or removal of surface contamination), the minimum level of preparation required shall be specified.

4.6 Substrate pre-treatment procedure

The pre-treatment procedure shall include details of the surface cleaning and roughening requirements, dust, sliver and grit removal

requirements and any other work piece surface treatments (e.g. phosphating or chromating) which must take place prior to the application of primers or coating materials. Minimum requirements or tolerances shall be defined for each of the pre-treatment procedures.

4.7 Application procedures

The critical parameters of the coating system application procedures shall be declared together with general manufacturing tolerances for the guidance of coating applicators.

For multi-component mixtures, the mix ratio shall be defined both by weight and volume, with proposed tolerances.

4.8 Coating repair procedure

Coating repair (including touch-up) materials shall be identified by the manufacturer and the repair procedure specified. Coating damage or flaws repaired in accordance with the specified procedure shall meet the coating system type performance requirements specified in Section 5.

If the Coating System Manufacturer requires certification for the repair material, samples shall be prepared as detailed below and shall be tested to the requirements specified in Section 5.

Test samples of repair materials shall be prepared as follows:

Coat the end quarters of the plates/bars with the original coating system, with the middle half masked. Then coat the middle half of the plate/bar with the repair system, using the recommended procedure. All tests should be carried out on the middle half of the plate/bar (see Figure 4.1). In tests which involve testing adhesion, this should be checked on the interface between the two coatings as well as on the repair coating.

It is acceptable for the visual appearance of a repair to be different from the original coating.

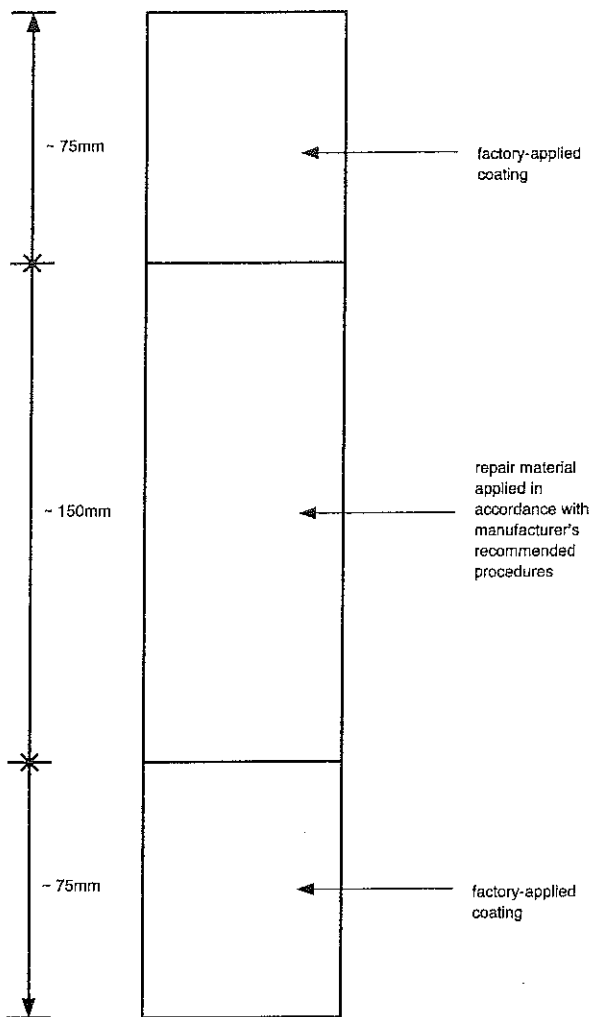


Figure 4.1 - Samples for testing coating repair and field joint coating materials

4.9 Field joint coating procedure

Coating systems which include materials intended for coating pipeline joints in the field shall meet the requirements of this clause.

The field joint coating material shall be identified by the coating system manufacturer and the field coating procedure specified. The field joint coating material formulation shall be declared and shall include the details required in 4.2. Any changes to this formulation shall be notified to the certifying body.

Field joint test pieces coated in accordance with the specified procedure shall meet the coating system type performance requirements specified in Section 3 of Part One of this specification.

Field joint coating test samples shall be prepared as in Figure 4.1.

4.10 Stripping procedure

A procedure for stripping a non-conforming coating from a salvageable work piece shall be specified. This procedure shall not significantly alter the metallurgical condition of the work piece.

4.11 Thickness

The range of coating thicknesses which can be expected to conform to the requirements specified in Section 5 shall be declared.

Where a primer or intermediate layer is used, the range of primer or intermediate layer thicknesses (or other relevant measurable quantity such as rate of primer application) required shall be declared.

4.12 Material safety information

A material safety data sheet shall be provided and shall include the following information.

4.12.1 Flash point

The flash point of coating materials and primers shall be declared. In the case of liquid mixtures, both the flash point of the mixture and the separate components shall be quoted.

4.12.2 Toxicity and handling

Any toxic hazard associated with coating materials submitted shall be declared, together with recommendations for safe handling in accordance with the requirements of the Health and Safety at Work etc. Act 1974, and the Control of Substances Hazardous to Health Act 1989.

4.13 Production quality control records

Copies of quality control records relating to the production of the coating material batches submitted for evaluation shall be provided. (See Section 6).

5. COATING SYSTEM PERFORMANCE REQUIREMENTS

5.1 Properties of the applied coating

Coated test pieces shall be tested to and meet the requirements of clauses 5.3.1, 5.3.2 and 5.3.3.

The test pieces (conforming to the requirements of Figure 5.1) shall have been prepared, pre-treated and coated in accordance with the procedures and thickness requirements declared in Section 2, (i.e. 4.5, 4.6, 4.7 and 4.11).

The coating system materials used shall comply with the descriptions and manufacturing tolerances declared in Section 2, (i.e. 4.2, 4.3 and 4.11).

The substrate material shall be steel, unless the coating has been designed specifically for use only on another substrate material, in which case that material shall be used.

The number of test pieces required for each of the tests is given in Table 5.1.

All tests shall be carried out at ambient temperatures unless specifically stated otherwise.

5.2 Test Samples

The number of samples required for testing is given in Table 5.1.

Clause No.	Test	Type of Sample	No. of Samples
5.3.2.1	Thickness	Plates/Bars	All
5.3.2.2	Holidays	Plates/Bars	All
5.3.2.3	Visual appearance	Plates/Bars	All
5.3.2.4	Adhesion	Plates	5
5.3.2.5	Cure	Plates/Bars	5
5.3.2.6	Flexibility	Plates	5
5.3.2.7	Impact (sphere)	Plates	5
5.3.2.8	Impact (stone)	Bars - 600mm long	5
5.3.2.9	Penetration	Plates	5
5.3.2.10	Wear	Bars - 400mm long	5
5.3.3.1	Water immersion	Plates	5
5.3.3.2	Domestic effluent imm.	Plates	5
5.3.3.3	Salt spray	Plates	10
5.3.3.4	Cathodic disbondment	Plates	5
5.3.3.5	Natural weathering	Plates	15*
5.3.3.6	Accelerated weathering	Plates	20*
TOTAL		Plates	85
		Bars	10
* This assumes that the 5 control samples are common and that visual comparison, holiday testing and thickness measurement are carried out on all samples.			

Table 5.1 - Test samples

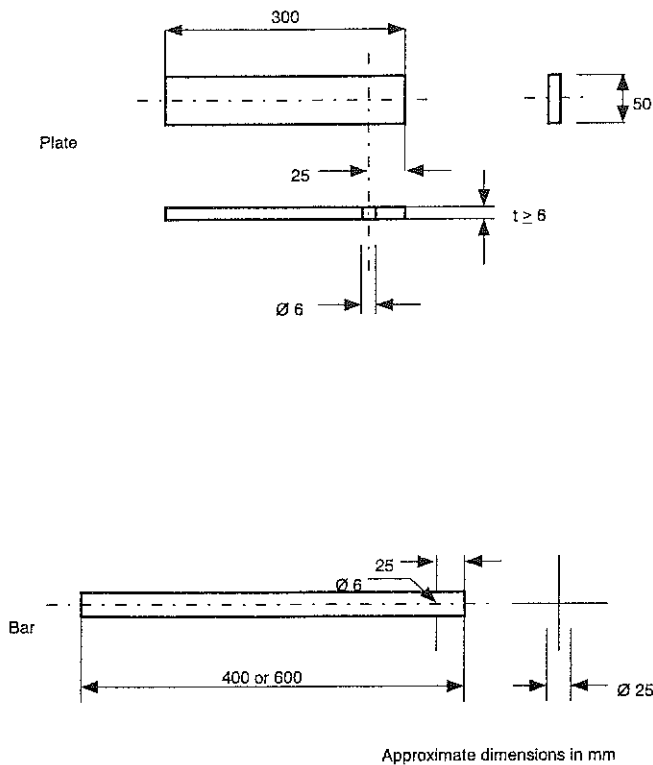


Figure 5.1 - Test Piece Details

5.3 Performance testing

5.3.1 Effect on water quality

When used under the conditions for which they are designed, all coating materials in contact with or likely to come into contact with potable water shall meet the requirements of Appendix A.

5.3.2 Physical characteristics and performance

5.3.2.1 Thickness

The coating thickness of all test pieces shall be measured and recorded in accordance with Appendix B. Only test pieces having coating thicknesses within the range declared in 4.11, shall be used in subsequent performance tests.

Where a primer and/or intermediate layer is used, the thickness(es) applied shall be measured and recorded during the processing of the test pieces submitted for evaluation against this specification. The method of measurement shall be declared. The thickness(es) of primer and/or intermediate layer shall conform to the requirements declared in 4.11.

NOTE: The manufacturer shall supply an uncoated test panel for calibration purposes. This should be representative of the panels coated for testing.

5.3.2.2 Holidays

Each coated test piece shall be tested for holidays in accordance with Appendix C.

Only holiday/pinhole-free coated test pieces shall be used in subsequent performance tests.

5.3.2.3 Visual Appearance

Each coated test piece shall be examined visually. The coating shall be free of any defects which are likely to be detrimental to coating performance (such as blisters, sagging and runs etc.) and where appropriate shall conform to the manufacturer's tolerance for colour and gloss.

5.3.2.4 Adhesion

Coated test pieces shall be tested in accordance with Appendix D. The coating shall exhibit no adhesive disbondment.

5.3.2.5 Cure

This test applies only to thermosetting coatings, including liquid thermosets. After an appropriate combination of time and conditions (both to be defined prior to the test by the manufacturer) from the point of coating application, thermosetting coatings on coated test pieces shall be demonstrated to have been cured within declared limits. The method used shall also be declared. Wherever practicable, the method chosen should produce quantitative results.

5.3.2.6 Flexibility

Coated test pieces shall be tested in accordance with Appendix E. All coated test pieces shall pass when tested at a strain of 1% at 0°C. (This test does not apply to coatings formulated specially for inflexible substrates, since it cannot be performed on inflexible panels).

NOTE: Where required, the manufacturer may opt to uprate the strain in order to demonstrate the coating's suitability for use on products which are highly strained in use.

5.3.2.7 Impact (sphere)

Coated test pieces shall be tested in accordance with Appendix L. Each test piece shall exhibit an impact energy of not less than 2J.

5.3.2.8 Impact (stones)

Coated test pieces shall be tested in accordance with Appendix I.

Each coated test piece shall be checked for holidays in accordance with Appendix C after two loads of 14mm nominal diameter rounded aggregate (to BS 882) have been dropped onto the coated test piece. Each coated test piece shall be holiday free after the two drops.

5.3.2.9 Penetration

Coated test pieces shall be tested in accordance with Appendix J. Penetration of the coating as detected by a holiday test in accordance with Appendix C shall constitute failure.

5.3.2.10 Wear

Coated test pieces shall be tested in accordance with Appendix K. Each coated test piece shall be holiday free when checked in accordance with Appendix C after 200 hours of abrasion.

5.3.3 Environmental performance

5.3.3.1 Water immersion

Coated test pieces shall exhibit no adhesive disbondment when tested in accordance with Appendix F at 50°C for 7 days.

5.3.3.2 Domestic effluent immersion

Coated test pieces shall be tested in accordance with Appendix H at 20°C for 28 days. At the end of the test, coated test pieces shall exhibit no adhesive disbondment.

5.3.3.3 Salt spray

Prior to exposure, each coated test piece shall have a 'v' cut made through the coating in accordance with Appendix D clause 2.1. Coated test pieces shall undergo 2,000 hours exposure to salt spray in accordance with BS 3900:F4. After exposure, the underfilm corrosion must not extend more than 1mm from the cut edge of the coating (See Figure 5.2). There shall be no blistering in this area.

In addition, a 'v' cut test shall be carried out in accordance with Appendix D clause 2.1 on the undamaged side of the sample after exposure. On this side, there shall be no more than 1mm disbondment, no underfilm corrosion, and no blistering.

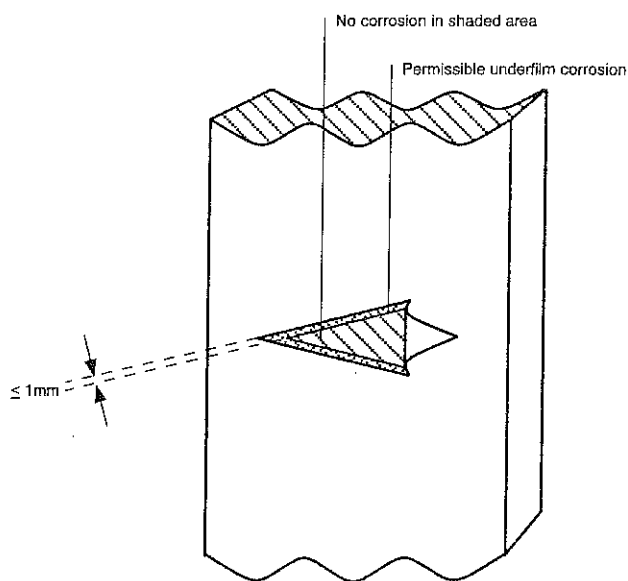


Figure 5.2 - Acceptance limit for salt spray test - Permissible underfilm corrosion on damaged side

5.3.3.4 Cathodic disbondment

Coated test pieces shall be tested according to Sections 5, 6, 7, 8 and 9 of BS 3900:F11. The coating, when subjected to an impressed current at a negative voltage of 1.5V, shall not disbond more than 5mm radially from the end of the damaged coating after 28 days.

5.3.3.5 Natural weathering

From 31 July 1994, all products which have previously been certificated shall meet this requirement in order to maintain their continued certification. After that date, all coatings shall meet this requirement prior to certification.

Coated test pieces shall be exposed to natural weathering in accordance with Appendix G. After exposure, the coated test pieces shall be tested in accordance with the requirements specified in Appendix G, clause 4, and shall show no signs of deterioration. There shall be no sign of cracking or blistering. Where manufacturers specify colour and gloss retention, these parameters shall also be checked.

5.3.3.6 Accelerated weathering

Coated test pieces shall be exposed either to:

- (a) 1000 hours in a QUV cabinet equipped with UV-B lamps in accordance with ASTM G53-88. The cycle shall consist of 4 hours UV at 60°C followed by 4 hours condensation at 50°C.

or

- (b) 2000 hours of artificial weathering in accordance with BS 3900:Part F3.

After exposure, the coated test pieces shall be tested in accordance with the requirements specified in Appendix G clause 4, and shall show no signs of deterioration. There shall be no sign of cracking or blistering. In applications where colour and gloss retention requirements are specified by the purchaser, these parameters shall also be checked.

6. PRODUCTION QUALITY CONTROL REQUIREMENTS

The coating system manufacturer shall ensure that all coating material production operations are carried out under controlled conditions. The objective of this control is to ensure that all production batches of coating materials are of a consistent quality which in turn is capable of meeting the specified coating system type performance requirements listed in Section 5.

Controlled conditions shall include documented work instructions defining the manner of manufacturing or processing, suitable manufacturing equipment and any special working environment.

Criteria for product quality shall be prescribed to the greatest practicable extent by written standards, photographs or representative samples. Where appropriate, the criteria for product quality shall be agreed by the coating system manufacturer and the Certifying body.

The coating system manufacturer shall provide for inspection, as required, after each work operation

that affects quality. Alternatively, control by monitoring process methods, equipment and personnel shall be provided.

When essential, both inspection and monitoring shall be provided. Inspection methods or controls shall be corrected whenever their unsuitability is demonstrated.

7. BATCH IDENTIFICATION AND OTHER INFORMATION TO BE SUPPLIED

All packs of materials supplied for coating or priming shall be identified with the following information:

- (a) Manufacturer's name;
- (b) The material;
- (c) The batch number;
- (d) Date of manufacture and stable working shelf life;
- (e) The number of this specification, i.e. WIS No. 4-52-01.

(The use of this mark is a claim by the manufacturer that the product has been manufactured in accordance with the requirements of this specification and the claim is his sole responsibility.)

NOTE: Batch number and date of manufacture may be expressed as a code providing traceability.

Storage recommendations and product safety data sheets shall also be supplied with each consignment of material, together with a certificate stating that the material batch conforms to the requirements of this specification. Copies of production quality control records shall be kept and made available as and when requested by the purchaser.

8. QUALITY ASSURANCE REQUIREMENTS

Manufacturers shall operate a quality system relating to this specification in compliance with BS 5750: Part 2 (EN 29002).

PART TWO - REQUIREMENTS OF THE FACTORY APPLIED COATING

9. SCOPE OF PART TWO

This part of the specification covers the requirements for polymeric anti-corrosion coatings applied in the factory.

10. COATING SYSTEM MATERIALS

10.1 Conformity of materials

All coating system types selected for use in production shall be certificated to Part One of this specification.

All batches of coating system materials accepted for use in production shall comply with the requirements of Part One of this specification.

10.2 Identification and safety

The Coating Applicator shall ensure that each batch of material used has been certificated by the Manufacturer and that all packs are marked in accordance with Section 7 of Part One of this specification.

The Coating Applicator shall ensure that all consignments of coating system materials are accompanied by an appropriate safety data sheet. The recommendations of this safety data sheet shall be strictly followed by users of the material.

10.3 Storage conditions

All coating system materials shall be stored in accordance with the Manufacturer's recommendations. Batches shall be used in the order in which they were manufactured before the respective shelf life expiry date.

11. WORK PIECES

11.1 Design and suitability for coating

Work pieces to be coated should be designed so as to be suitable for coating. (IGN No. 4-52-02 recommends general good design practice for objects which are to be coated).

11.2 Work piece quality

Prior to coating, work pieces shall be inspected. The work pieces shall conform to the relevant product quality requirements.

11.3 Identification

All temporary identification and inspection markings shall be carefully removed from work pieces or recorded prior to surface preparation. Care shall be taken to ensure that the original information is re-affixed to the correct work piece. Permanent identification marks, where required, shall be legible after the coating operation.

11.4 Handling and storage

It is recommended that work pieces should be handled and stored in accordance with the guidance given in IGN No. 4-52-02. This guidance includes recommendations for handling and storage within the factory and during transportation.

Particular attention shall be paid to protecting both the work pieces being handled in the factory and the finished products from contamination and mechanical damage.

12. PRODUCTION PROCEDURE QUALIFICATION

12.1 General

The Coating Applicator shall develop and specify production procedures for all stages of the process in consultation with the Coating System Manufacturer. Processed work pieces shall then be tested in accordance with, and meet, the requirements of 12.7

The production procedures shall be qualified only when the work pieces submitted have met the requirements of 12.7.

Production process procedures for cast iron, steel and aluminium work pieces shall be considered separately and qualified as such.

For the purposes of this clause the following classifications apply:-

- Cast iron includes ductile, grey and malleable irons.
- Steel includes low alloy (i.e. <5% alloy content), mild and plain carbon steels.
- Aluminium includes its alloys.

12.2 Selection of work pieces

12.2.1 Pipe coaters

Pipe coaters shall declare the diameter range of pipes which they are prepared to coat. A pipe coater shall demonstrate his capability of coating items of this declared range by coating one standard length of pipe from each of the size ranges at the extremes of his declared range. These size ranges are:

- (a) 50mm d_n to 300mm d_n
- (b) 301mm d_n to 600mm d_n
- (c) 601mm d_n to 1200mm d_n
- (d) 1201mm d_n upwards.

Each pipe coated shall then be sectioned in a suitable manner so as to provide test pieces for the tests detailed in 12.7.

12.2.2 Fittings coaters

Fittings coaters shall declare the diameter range of fittings which they are prepared to coat. A fitting coater shall coat a surface representative of the surface normally being coated, which shall then be sectioned in a suitable manner so as to provide test pieces for the tests detailed in 12.7.

In addition, a fitting in each of the size ranges at the extremes of the declared range shall be inspected visually. Particular attention shall be paid to coverage over edges and lettering, and to recesses where coating material could accumulate to the detriment of the fitting's serviceability. Size ranges are:

- (a) 50mm d_n to 300mm d_n
- (b) 301mm d_n to 600mm d_n
- (c) 601mm d_n to 1200mm d_n

- (d) 1201mm d_n upwards.

12.3 Work piece preparation

The preparation procedure shall take account of both the minimum requirements specified by the Manufacturer, (see Part One clause 4.5) and any special requirements relating to the actual work pieces to be coated.

The preparation procedure shall include minimum requirements for such aspects as the fettling of castings, weld preparation as required, removal of surface scale or corrosion product and the removal of surface contamination, etc.

12.4 Work piece pre-treatment

The pre-treatment procedure shall include details of the abrasive blasting requirements, dust, sliver and grit removal and any other surface treatments which take place prior to the application of primers or coating materials. It shall also take account of the minimum requirements or tolerances for pre-treatment specified by the Manufacturer, (see Part One, clause 4.6). For all work pieces, the maximum time allowed to pass between the final pre-treatment prior to primer or coating application shall be 4 hours. The primer or coating shall be applied before visible deterioration sets in.

12.5 Application

The priming (where relevant) and coating procedures shall include details of critical process parameters together with production tolerances, (see Part One, clause 4.7). Where a primer is used, the maximum time allowed to pass before coating is carried out shall be agreed with the Coating System Manufacturer.

12.6 Rework of non-conforming coated work pieces

The procedure for rework of non-conforming production items where required shall take account of the Coating System Manufacturer's recommended procedure for stripping non-conforming coatings, (see Part One Clause 4.10).

12.7 Production procedure qualification testing

A number of work pieces shall be processed in accordance with the specified preparation, pre-treatment, priming and coating procedures declared in 4.3 to 4.5 This number shall be sufficient to provide enough work pieces, or sections thereof, on which to carry out the qualification tests. These work pieces shall meet the requirements of the following qualification tests.

NOTE: Where repaired holidays on work pieces are acceptable, those below 3mm² in area will not be subject to testing.

12.7.1 Thickness

The coating thickness shall be measured on each coated work piece in accordance with Appendix B.

The minimum coating thickness measured in any one place on any one coated work piece shall be no less than the lower thickness limit declared by the Coating System Manufacturer, (see Part One clause 4.11).

Similarly, the maximum coating thickness measured in any one place on any one coated work piece shall be no greater than the thickness limit declared by the Coating System Manufacturer, (see Part One clause 4.11).

The coating thickness on any Thickness-Critical Surface identified on the product outline drawing shall be within the limits stated on that drawing.

12.7.2 Holiday detection

This test should be done, and any necessary repairs carried out, before any of the other tests in this section.

- *Class A coatings*

All work piece surfaces protected with Class A coatings shall be checked in accordance with Appendix C. The number of holidays detected on such surfaces shall be recorded for each work piece and shall not exceed the limit agreed between the manufacturer and the purchaser/or certification authority. All holidays detected shall be repaired together with jiggling marks in accordance with the procedure specified by the Coating System Manufacturer.

- *Class B coatings*

All work surfaces protected with Class B

coatings shall be checked in accordance with Appendix C. The number of holidays detected on such surfaces shall be recorded for each work piece and shall not exceed the limit agreed between the manufacturer and the purchaser/or certification authority.

The thickness of Class B coatings shall be at least 150µm on edges and 250µm on surfaces having radii of curvature greater than 3mm.

12.7.3 Impact resistance

Five coated work pieces, selected at random from the batch shall be tested in accordance with Appendix L. The test sites shall be evenly distributed over as much of the work piece surface as is practicable.

Each coated work piece shall exhibit an impact energy greater than 2J.

12.7.4 Adhesion

Each of the coated work pieces in the batch shall be tested for coating adhesion on one randomly selected site in accordance with Appendix D.

The coating shall exhibit no adhesive disbondment. The test site shall be repaired in accordance with the procedure specified by the manufacturer.

12.7.5 Degree of cure

Where thermosetting coatings have been applied, five work pieces shall be randomly selected from the batch and after an appropriate period of time, tested for the degree of coating cure according to the method declared in Part One 5.3.2.5. Each work piece shall be checked for coating cure at the points of maximum and minimum coating thickness. These five coating samples shall be shown to have been cured to within the limits declared by the manufacturer.

12.7.6 Visual appearance

The coating on each work piece shall comply with any colour or gloss requirements specified by the purchaser and shall not exhibit any evidence of sagging, blistering, or runs which may be detrimental to its performance.

12.7.7 Water immersion

Five work pieces (or five representative sections removed from a large work piece) shall exhibit no

adhesive disbondment after being tested in accordance with Appendix F at 50°C for 7 days.

12.7.8 Cathodic disbondment

Five work pieces shall be tested in accordance with Appendix N. The coating, when subjected to an impressed current at a negative voltage of 1.5V, shall not disbond more than 5mm radially from the edge of the damaged coating after 28 days.

(Aluminium work pieces are exempt from this test).

13. PRODUCTION QUALITY CONTROL

Once the coating and associated production procedures have been qualified (see Section 12) production coating may commence in accordance with these procedures. This section specifies the minimum inspection and testing requirements which are necessary in order to demonstrate a continuing satisfactory level of product quality.

Inspection and testing procedures shall be written by the Coating Applicator based on the details of the qualified production procedures and the requirements of 13.1, 13.2, 13.3 and 13.4.

13.1 Control of work piece preparation

Prior to being pre-treated, the sample (see 13.4), shall be inspected and tested to ensure that the required level of preparation (specified in the qualified production procedure) has been carried out.

13.2 Control of work piece pre-treatment

Prior to being coated, the sample (see 13.4), shall be inspected and tested to ensure that the pre-treatment requirements (specified in the qualified production procedure) have been met.

13.3 Inspection and testing of the finished coated work piece

Finished work pieces shall be inspected and tested in accordance with the sampling plan (see 13.4) to ensure that they meet the requirements of 13.3.1 to 13.3.6.

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13.3.1 Coating thickness

Each work piece in the sample taken shall be checked for coating thickness. The coating thickness shall be measured in accordance with Appendix B. Work pieces which have coating thicknesses outside the acceptable limits defined by the Coating System Manufacturer or the requirements specified for Thickness-Critical Surfaces shall be rejected, (see Part One clause 4.11 and Appendix B).

13.3.2 Holiday detection

In cases where production procedures are not capable of yielding completely holiday-free coatings, 100% sampling shall be carried out and each work piece shall be repaired accordingly. Automatic holiday testing is acceptable in such cases, provided that all surfaces required to be holiday-free are tested.

Production procedures which have been demonstrated to yield holiday-free coatings consistently in qualification testing (see Section 12) may be subject to sampling inspection.

Each work piece in the sample taken shall be checked for holidays in accordance with Appendix C.

- *Class A coatings*

Product surfaces coated to Class A standard are required to be holiday-free.

- *Class B coatings*

Product surfaces coated to Class B standard are permitted to include a limited number of pin-holes or holidays. This limit is to be agreed between the supplier and the purchaser/or certification authority. It shall not exceed 20 holidays per square metre or the equivalent per work piece. A holiday, for the purpose of this clause, is an area of uncoated substrate no greater than 3mm². Surfaces which are intended to be coated to Class B standard shall be identified on representative work piece drawings.

NOTE: The permission of holidays in Class B coatings is intended to reflect the practical difficulties of achieving holiday

free coatings on certain substrate surfaces. Holidays caused by inadequate control of the coating application process, or by inadvertent impact during handling, are not acceptable under this clause and as such will need to be repaired as and when they are detected. It is strongly recommended that, as a minimum, Class A coatings are applied to all internal, water wetted surfaces, together with any others where premature corrosion initiation could be problematical. Class B coatings are only acceptable on surfaces where premature corrosion initiation is thought to be tolerable.

All surfaces coated to Class B standard are required to comply with the following minimum coating thickness requirements: 250µm on surfaces having radii of curvature greater than 3mm, 150µm on sharper surfaces.

Jigging marks shall be repaired on all surfaces.

All repairs shall be carried out according to the procedure specified by the Coating System Manufacturer, (see Part One clause 4.8).

13.3.3 Impact resistance

Each coated work piece in the sample taken shall be tested in accordance with Appendix L. The test sites shall be selected at random. Each work piece shall exhibit an impact energy greater than 2J. Work pieces failing to meet this requirement shall be rejected.

NOTE: The supplier is required to provide suitable impact test equipment which has been developed specifically, or adapted to facilitate testing on actual work pieces in a controlled and repeatable manner. In this respect, it is particularly important for both the work piece and test equipment to be rigidly supported.

13.3.4 Adhesion

Each coated work piece in the sample taken shall be tested in accordance with Appendix D, on one randomly selected site. The coatings shall exhibit no adhesive disbondment. Work pieces which fail this test shall be rejected.

13.3.5 Cure

Where thermosetting coatings have been applied, each coated work piece in the sample taken shall be tested after an appropriate period of time to assess the degree of coating cure according to the method and limits declared by the Coating System Manufacturer. The cure shall be checked at the points of maximum and minimum coating thickness on each work piece.

Where a coating is found not to have been cured within the limits specified by the Coating System Manufacturer, the corresponding work piece shall be rejected.

13.3.6 Visual appearance

Each coated work piece in the sample shall be examined visually. The coating shall be free of any defects which are likely to be detrimental to coating performance (such as blisters, sagging and runs etc.) and where appropriate shall conform to the Supplier's tolerance for colour and gloss.

13.4 Sampling frequency

Except where 100% sampling is called for in this specification, production quality control activities shall be carried out in accordance with an appropriate sampling plan. This sampling plan shall take account of both the particular batch size or equivalent quantity, and the acceptable quality level which is to be agreed between the Coated Product Supplier and either the Purchaser's representative or the Certification Authority.

Sampling procedures are described in BS 6000 and BS 6001.

The Coated Product Supplier shall not knowingly supply a defective unit in any batch.

14. REWORK

Where non-conforming coated work pieces are to be reworked this shall be done in accordance with the prequalified procedures (see 12) and subject to tightened production quality control inspection levels (see 13.4).

All re-coated work pieces shall meet the requirements of this specification.

15. SUBCONTRACTED WORK

Where the coating operation is to be subcontracted, the Coated Product Supplier is required to:

- Ensure that the requirements of Part Two (this part) of the specification are met.
- Either ensure that the subcontractor is third party certified in accordance with Part Three of this specification, or
- Demonstrate control over the point of subcontracted manufacture (for preparation, pre-treatment and coating of work pieces).

16. QUALITY ASSURANCE REQUIREMENTS

Coating Applicators shall operate a quality system relating to this specification in compliance with BS 5750: Part 2 (EN 29002). This should indicate that the design of the work piece takes into account the properties of the coating(s).

PART THREE - REQUIREMENTS OF SUBCONTRACT COATING APPLICATORS

17. SCOPE OF PART THREE

This part of the specification covers the requirements for Subcontract Coating Applicators (henceforth referred to as subcontractors) applying coatings on behalf of Coated Product Suppliers.

18. COATING SYSTEM MATERIALS

The requirements of Section 10 of Part Two of this specification shall be met.

19. WORK PIECES

The requirements of Section 11 of Part Two of this specification shall be met.

20. QUALIFICATION OF SUBCONTRACTOR'S PRODUCTION PROCEDURES

20.1 Production procedures developed by the subcontractor

In cases where no production procedures have been developed for the coating process subcontracted, the subcontractor shall develop and specify production procedures in conjunction with the Coated Product Supplier for all stages of the

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process. Work pieces which have been selected and processed by the subcontractor in accordance with these production procedures (see Part Two, 12.2 to 12.6) shall be tested in accordance with, and meet the requirements of Part Two, 12.7.

20.2 Production procedures developed by the coated product supplier

The subcontractor may alternatively process work pieces in accordance with production procedures which have been qualified previously or otherwise developed by Coated Product Suppliers, (see Part Two, 12). Work pieces which have been processed by the subcontractor in accordance with these production procedures (see Part Two, 12.2 to 12.6), shall be tested in accordance with and meet the requirements of Part Two, 12.7.

21. PRODUCTION QUALITY CONTROL

Once the subcontractor has become qualified to coat work pieces in accordance with specified production procedures, production coating may commence in accordance with these procedures.

In order to demonstrate a continuing satisfactory level of product quality the subcontractor shall meet the requirements for Production Quality Control specified in Section 13 of Part Two of this specification.

22. REWORK

The requirements of Section 14 of Part Two of this specification shall be met.

23. QUALITY ASSURANCE REQUIREMENTS

Subcontractors shall operate a quality system relating to this specification in compliance with BS 5750: Part 2 (EN 29002).

24. REFERENCES

This specification makes reference to the latest edition of the following publications (except where otherwise stated), including all addenda and revisions, which should also be consulted.

- BS 3900:F3 Resistance to artificial weathering (enclosed carbon arc).
- BS 3900:F4 Resistance to continuous salt spray.
- BS 3900:F6 Notes for guidance on the conduct of natural weathering tests.
- BS 3900:F11 Determination of resistance to cathodic disbonding of coatings for use on land-based buried structures.
- BS 5750:Part 2 Quality systems: Specification for production and installation.
- BS 5781:Part 1 Measurement and calibration systems: Specification for system requirements.
- BS 6000: Guide to the use of BS 6001. Sampling procedures and tables for inspection by attributes.
- BS 6001: Sampling procedures and tables for inspection by attributes.
- BS 6920:Part 1 Suitability of non-metallic products for use in contact with potable water intended for human consumption with regard to their effect on the quality of the water: Specification.
- BS 882: Specification for aggregates from natural sources for concrete.
- IGN No. 4-52-02: Information and Guidance Note for Polymeric anti-Corrosion (Barrier) Coatings.

APPENDIX A - EFFECT OF COATING MATERIALS ON WATER QUALITY

Coating materials which are used in the treatment and distribution of public water supplies must be used in accordance with the requirements of Regulation 25 of the Water Supply (Water Quality) Regulations 1989.

In practice, new materials must be proven to satisfy the requirements of BS 6920 and be approved under the Water Byelaws Scheme. If the surface area in contact with the water is small, the

above requirements are likely to be sufficient for the product to be used under Regulation 25(1) (b). If the surface area is relatively large, then Secretary of State approval under Regulation 25(1) (a) is required. This involves consideration of the product by the 'Department of the Environment Committee on Chemicals and Materials of Construction for Use in Public Water Supply and Swimming Pools'. If the coating is to be applied in situ (e.g. on-site repair materials), the approval of the Secretary of State must be sought.

A list of approved substances and products is published annually and is available from the Technical Secretary of the Committee at the Drinking Water Inspectorate, Room B153, 43 Marsham Street, London SW1 3PY.

APPENDIX B - COATING THICKNESS MEASUREMENT

B.1 General

This appendix specifies methods and equipment requirements for non-destructive measurement of coating (dry film) thickness.

B.2 Equipment

B.2.1 Accuracy

Once calibrated (using a representative uncoated surface) for the range of thicknesses (maximum and minimum) to be measured, the thickness measuring gauge shall be capable of repeatably indicating coating thicknesses within this range to an accuracy of $\pm 5\%$.

NOTE: Accuracy shall be determined by reference to coating thickness measurements taken from a section of the coated work piece. The plane of this section shall be perpendicular to the plane or tangent of the coated surface. Where it is impractical to section a coated work piece, a representative coated test piece may be used.

B.2.2 Calibration

The thickness measuring gauge shall be calibrated for the specified range of thickness (maximum and minimum) at the start of each period of work (or hourly during continuous operation).

Records shall be kept of all accuracy checks and calibration adjustments made at the start of each period of work. These records shall include dates, the thickness range considered, the actual thickness measurements noted and any adjustments made. The requirements of BS 5781: 1981 shall apply.

B.3 Thickness-critical surfaces

Where special product considerations dictate that coating thickness needs to be controlled beyond the general limitations (e.g. reduced maximum thickness for ensuring minimum clearance between components) the critical product surfaces shall be identified on a product outline drawing. This drawing shall be made available to coating operatives and inspection staff.

B.4 Measurement procedure

B.4.1 Test pieces

For test pieces the coating thickness shall be measured on five equidistant sites along the test piece centre line, on both sides.

B.4.2 Work pieces

For work pieces the coating thickness shall be measured on all thickness-critical surfaces (see B.3) and at least 5 other sites distributed over the work piece surface (including edges) as required.

B.4.3 Records

For each piece measured, the maximum, minimum and mean coating thicknesses shall be recorded together with the standard deviation of the measurements.

In production situations, thickness measurements may be carried out on a pass/fail basis. In these cases the coating thickness acceptance limits shall be recorded together with the pass/fail results.

APPENDIX C - HIGH VOLTAGE HOLIDAY DETECTION

C.1 General

This appendix specifies methods and equipment requirements for the detection of holidays in coatings.

C.2 Equipment

Holiday detection shall be carried out using electrical detection equipment having the following facilities:

- Variable test voltage (typically 0-10kV dc)
- Audible and/or visible holiday alarm signals
- Sensitivity adjustment
- Splayed steel wire or conducting neoprene probe electrode*
- Earth electrode with clamp.

* Probe electrodes may be shaped to conform to the profile of coated products.

C.3 Test voltage

The holiday detector output voltage shall be adjusted to give 5V per μm of coating thickness. The coating thickness considered shall be the actual minimum measured thickness for the surface in question.

C.4 Procedure

- Identify a site on the work piece to which the earth electrode can be fixed.
- Fix the earth electrode to the substrate and ensure that a good electrical contact is made. When the probe is brought into contact with the exposed substrate alongside the earth electrode connection the holiday alarm signal should be activated.
- Pass the probe over the coated surface at a maximum rate of 10mm/s (type tests) or up to 50mm/s (Quality Control tests for Parts Two

and Three), paying particular attention to edges, holes and visible irregularities in the coating.

- Identify any holidays and damaged areas with a suitable marker. Such markings shall be made sufficiently distant from the coating defect to allow the repair procedure to be carried out without detriment to the adhesion of the repair material.

APPENDIX D - ADHESION

D.1 General

This appendix specifies the procedure for assessing coating adhesion.

D.2 Procedure

D.2.1 'V' cut

This test shall be carried out on plates conforming to Figure 5.1.

Two 20mm (approximately) long incisions shall be made through the coating to the substrate (using a sharp knife blade as illustrated in Figure D.1) to form a 'v' with an intersection angle of between 30° and 35°.

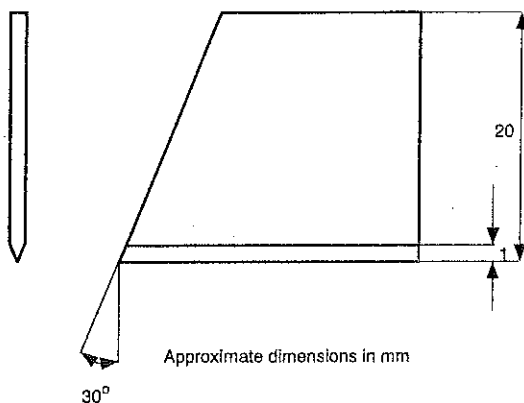


Figure D.1 - Knife blade details

Using a levering action against a fulcrum (such as a steel rod), force the flat point of the blade up from the metal surface, describing a single, vertical (i.e. at 90° to the surface) motion in an attempt to prise the coating off.

The test shall not be repeated at the same point nor shall the coating be prised at in any other position along the 'v' cut or by any other method.

D.2.3 Reporting

Refusal of the coating to disbond from the substrate shall be recorded as a 'pass'. A 'pass' shall also be recorded in cases where the coating refuses to disbond but fails cohesively. Partial or complete adhesive failure between the coating and the substrate shall be recorded as a 'failure'. Where a failure has been recorded, the length of disbondment from the 'v' tip shall be reported. Disbondment of the very tip of the 'v' is common even for well adhered coatings. It is therefore appropriate to ignore the first mm of coating disbondment from the 'v' tip when measuring the length of adhesive disbondment. (See Figure D.2).

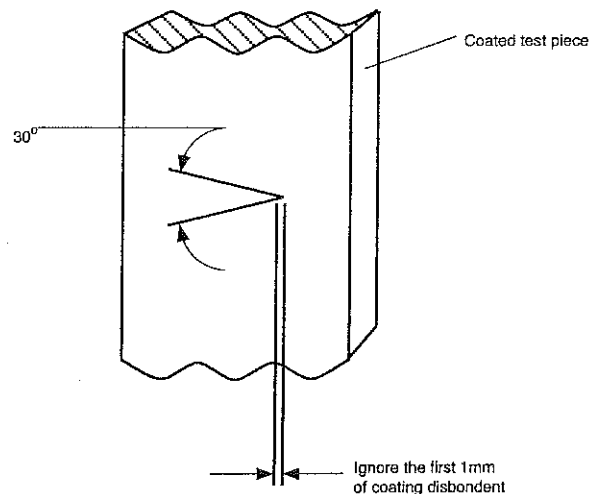


Figure D.2 - Diagram showing 'v' cut details

APPENDIX E - FLEXIBILITY

E.1 GENERAL

This appendix specifies methods and equipment requirements for the assessment of coating flexibility. The test involves bending a coated test piece to conform to a pre-selected mandrel. The effect of this bending on the coating is monitored.

E.2 EQUIPMENT REQUIREMENTS

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E.2.1 Bending mandrel

Mandrel sizes shall be selected using the following formula:

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

Where D = mandrel diameter in mm (see Figure E.1).

t = plate thickness in mm

and S = strain value for the intended coating application.

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

E.2.2 Test piece support bars

The space between the support bars (see Figure E.1) shall be set using the following formula:

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

Where m = chord length across mandrel arc in mm (see Figure E.1)

t = plate thickness in mm.

E.3 Procedure

E.3.1 Test pieces

Test pieces shall conform to the plate requirements of Figure 5.1. Initially the coatings shall be holiday free when tested in accordance with Appendix C.

E.3.2 Test method

The test pieces shall be bent between the mandrel and test piece support bars at a deflection rate of approximately 25mm/min.

The test piece shall be bent until contact is made with approximately 75% of the mandrel surface area.

During bending, a gap may develop between the mandrel and test piece. In this case, the size of the gap shall be measured and recorded at the point when the bending has reached a maximum. The area of the panel where the gap exceeds 0.254mm

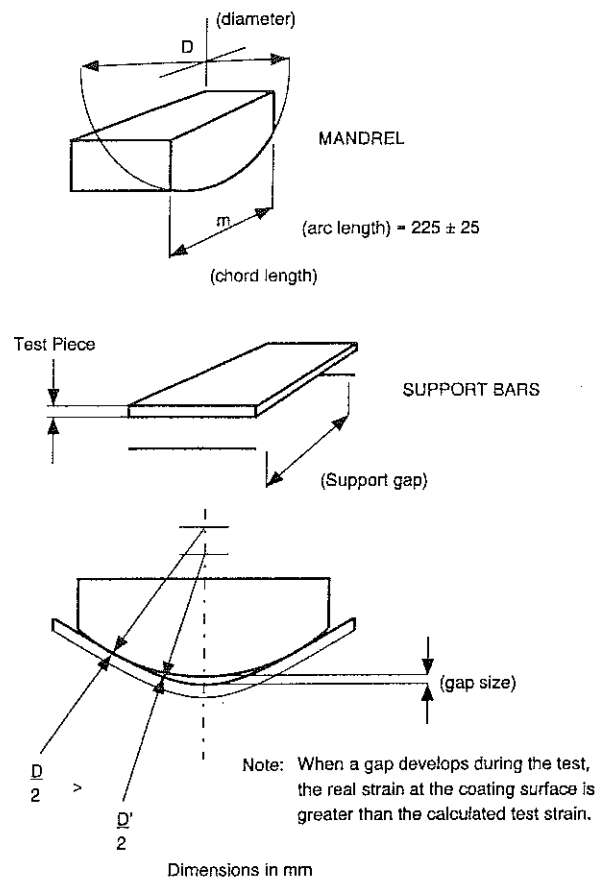


Figure E.1 - Flexibility test mandrel details

(0.01 inches) should be disregarded in evaluating the test results. This area should not exceed 25% of the mandrel surface area. Any area of the coating which has been damaged by the support bars shall be disregarded when evaluating the test results.

The bent test piece shall be examined and any visible evidence of cracking or disbondment of the coating shall be recorded. The coating shall also be checked for holidays in accordance with Appendix C.

E.3.3 Reporting

The report shall include the following:

- mandrel size and specified strain value(s)
- support bar gap

- maximum gap size between mandrel and the test piece.

If no holidays are detected in the coating and it does not exhibit visible signs of cracking or disbondment a 'pass' shall be recorded.

The detection of any holiday or visible evidence of cracking or disbondment shall constitute a failure.

APPENDIX F - WATER IMMERSION

F.1 General

This appendix specifies the procedure for evaluating the resistance of coatings to loss of adhesion arising from prolonged immersion in deionised or distilled water.

F.2 Equipment requirements

- water bath (at least 300mm deep) with stirrers and heaters (for 50°C test)
- 5mm diameter steel suspension rod (long enough to span water bath)
- elastomeric adhesive for repair of test damage.

F.3 Procedure

F.3.1 Water bath

The bath shall be filled and regularly topped up with deionised or distilled water. The water shall be continuously stirred and maintained at the specified temperature.

F.3.2 Test pieces

The test pieces shall be plates conforming to Figure 5.1. Initially, coated test pieces shall be holiday free when tested in accordance with Appendix C.

F.3.3 Initial adhesion

Each coated test piece shall be assessed for coating adhesion in accordance with Appendix D prior to immersion in the water bath. The damage arising from this test shall be repaired using the elastomeric adhesive.

F.3.4 Test piece suspension

The coated test pieces shall be suspended, by means of the steel rod passing through the 6mm hole, in the water bath to immerse all but the top 50mm of the panels.

F.3.5 Adhesion checks

After the specified period of immersion the coated test pieces shall be removed from the water bath and allowed to cool to ambient temperature.

The coating adhesion at a previously undamaged site shall be assessed in accordance with Appendix D.

F.3.6 Reporting

The test temperature and duration shall be recorded together with the results of the initial and final adhesion measurements for each test piece.

APPENDIX G - NATURAL WEATHERING

G.1 General

This appendix specifies the procedure for evaluating the resistance of coatings to the effects of natural weathering in the UK.

G.2 Pre-exposure tests

The coated test pieces (plates conforming to Figure 5.1) shall be subjected to the following tests before exposure. Five representative test pieces shall be retained (and stored in a dark, dry place at $20 \pm 2^\circ\text{C}$) for future comparison with the exposed test pieces.

G.2.1 Thickness

The coating thickness of each test piece shall be measured and recorded in accordance with Appendix B. Only test pieces having a minimum coating thickness greater than the minimum thickness specified in Part One clause 4.11 shall be used.

G.2.2 Holidays

The coating shall be checked for holidays in accordance with Appendix C. Only holiday-free coated test pieces shall be used.

G.2.3 Adhesion

The adhesion of the coating to the substrate shall be assessed in accordance with Appendix D. The damage arising from this test shall be repaired immediately in accordance with the repair procedure specified in Part One clause 4.8.

Only test pieces which pass this adhesion test may be used. The test piece shall be mounted on the weathering rack such that the repaired side faces towards the ground.

G.3 Exposure details

The coated test pieces shall be mounted on exposure racks in accordance with BS 3900: Part F6, 1976 Natural Weathering, Clause 6. The exposure site shall be in the UK and reasonable precautions should be taken to secure the site from interference.

The period of exposure for below ground end uses shall commence in March, April or May and be terminated no sooner than one year later. For above ground end uses the period of exposure shall also commence in March, April or May but will be terminated no sooner than five years later. Climatic records (i.e. temperature, relative humidity, amount of precipitation, wind speed and direction, mean daily sunshine and total incident radiation) corresponding to this period shall be measured or obtained from the nearest meteorological centre and submitted with the final test report.

G.4 Testing of weathered test pieces

After the specified period of exposure has elapsed the test pieces shall be removed and subjected to the following tests:

- Visual comparison with retained test pieces
- Coating thickness measurement
- Holiday testing
- Flexibility
- Adhesion
- Impact (sphere)

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G.5 Report

The report shall include the following:

- Exposure site location
- Photograph of exposure site including loaded racks and the surrounding area
- Exposure start and finish dates
- Records of climatic parameters
- Results of testing to G.4
- Any other notable observations.

APPENDIX H - SIMULATED DOMESTIC EFFLUENT EXPOSURE

H.1 General

This appendix specifies the procedure for evaluating the resistance of coatings to the effects of contact with domestic effluent.

H.2 Equipment requirements

- water bath (at least 300mm deep) with stirrers.
- 5mm diameter steel suspension rod (long enough to span water bath).
- elastomeric adhesive for repair of test damage.

H.3 Procedure

H.3.1 Test solution

The bath shall be filled with a solution of the following composition:

Tap water shall be used to make up the solution, and to top it up as and when necessary. The solution shall be continuously stirred.

	mg/l
Peptone	160
Meat extract	110
Urea $\text{CO}(\text{NH}_2)_2$	30
Sodium chloride NaCl	7

Calcium chloride $\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$	4
Magnesium sulphate $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$	2
Dipotassium hydrogen phosphate K_2HPO_4	28

H.3.2 Test pieces

The test pieces shall be plates conforming to Figure 5.1. Initially, coated test pieces shall be holiday-free when tested in accordance with Appendix C.

H.3.3 Initial adhesion

Each coated test piece shall be assessed for coating adhesion in accordance with Appendix D prior to immersion in the bath. The damage arising from this test shall be repaired using the elastomeric adhesive.

H.3.4 Test piece suspension

The coated test pieces shall be suspended, by means of the steel rod passed through the 6mm hole, in the bath to immerse all but the top 50mm of the panels.

H.3.5 Adhesion checks

After the specified period of immersion the coated test pieces shall be removed from the bath. The coating adhesion at a previously undamaged site shall be assessed in accordance with Appendix D.

H.3.6 Reporting

The test temperature and duration shall be recorded together with the results of the initial and final adhesion measurements for each test piece.

APPENDIX I - IMPACT (STONES)

I.1 General

This appendix specifies the procedure for evaluating the resistance of coatings to the impact of stones dropped from a chute. It is based on the procedure described in ASTM G13-85. The test shall be carried out at a temperature between 21 and 25°C.

I.2 Equipment requirements

- Drop chute with hopper to release stones from a height of approximately 2m above the coated test piece. (See ASTM G13-85).

- Previously unused riverbed aggregate or other rounded aggregate (nominal diameter 14mm) to BS 882. (At least 32kg is likely to be needed - See I.3.2)
- High voltage holiday detector (see C.2).

I.3 Procedure

I.3.1 Test pieces

Coated bar or tube diameter 25mm x 600mm long. Coating must be holiday free prior to test.

I.3.2 Drop test

Load 16kg of the stones evenly into the chute hopper and position the coated test piece in the vee blocks at the bottom of the chute, taking care to note the rotational orientation of the bar/tube.

Allow the stones to fall onto the coated test piece by withdrawing the hopper gate.

Remove the coated test piece and check for holidays in accordance with Appendix C. Record the number of holidays detected.

If the coated test piece is holiday free after the first drop, collect the fallen stones and reload the hopper with 16kg as before. Replace the coated test piece in the vee blocks taking care to rotate it such that the original original orientation is repeated to within $\pm 10^\circ$ (i.e. so that the same portion of the coated surface is always exposed to the falling stones).

Repeat the test for the specified number of drops.

The stones should be renewed after every 5 drops.

I.3.3 Reporting

Record the number of holidays detected after each drop.

Photograph each test piece at the conclusion of the test.

APPENDIX J - PENETRATION

J.1 General

This appendix specifies the procedure for testing the resistance of coatings to penetration. It is based on the procedure described in ASTM G17-83. The test shall be carried out at a temperature between 21 and 25°C.

J.2 Equipment requirements

- A dead weight loading jig that can press the flat tip of a rod against the coated test piece. The flat tipped end of the rod contacting the coating shall have a diameter of 6.350mm ± 0.0254 mm (0.250 inches ± 0.001 inch) and together with supplementary weight and any other weight-contributing parts shall have a total weight of 4.453kg (9.817 lb), resulting in a unit pressure of 14.060kg/cm² (200 psi) against the coating.
- A suitable measuring device capable of measuring the penetration movement of the rod accurately to 0.0254mm (0.001 inch).
- High voltage holiday detector (see C.2).
- Coating thickness measuring equipment (see B2).

J.3 Procedure

J.3.1 Test pieces

Coated plates conforming to Figure 5.1 shall be holiday free and stabilised at the test temperature for at least 24 hours prior to the commencement of the test.

J.3.2 Test method

Measure the test piece coating thickness (in accordance with Appendix B) exactly where the coating is to be loaded. Assemble the loading rod and weights in the jig and position the flat tip of the rod onto the coating surface at the point of known thickness.

Allow the weight to rest on the coating surface and record the reading on the measuring device used to detect movement of the penetrating rod.

Record the displacement of the penetrating rod every 24 hours.

Continue the test until three consecutive unchanged measurements are recorded, or for a period of 14 days, whichever is shorter.

Remove the test piece and check the loaded site for holidays in accordance with Appendix C.

J.3.3 Reporting

Record whether or not a holiday was detected at the site of loading on the coating surface.

Calculate and record the percentage change in coating thickness at the site of loading.

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Record the total duration of the test and each of the daily displacement measurements.

APPENDIX K - WEAR

K.1 General

This appendix specifies the procedure for evaluating the resistance of coatings to wear caused by dynamic contact with an abrasive slurry. It is based on the procedure described in ASTM G6-83. The test shall be carried out at a temperature between 21 and 25°C.

K.2 Equipment requirements

- A cylindrical container suitable for testing 5 test pieces simultaneously. (See ASTM G6-83 for details).
- A drive system for revolving the container at a linear surface rate of 30m/min.
- Coating thickness measuring equipment (see B.2).
- High voltage holiday detector (see C.2).
- The test slurry shall consist of 13.6kg of aluminium oxide grit (No. 3 mesh) in 5.7 litres of tap water.

K.3 Procedure

K.3.1 Test pieces

Holiday-free coated bars (400mm long) conforming to Figure 5.1. The test pieces shall be stabilised at the test temperature for at least 24 hours prior to the commencement of the test.

K.3.2 Test method

Measure and record the coating thickness in 10 evenly distributed locations on the test pieces, (see Appendix B). Assemble the test pieces into cylindrical container taking care not to damage the coating surfaces.

Load the unused test slurry into the cylindrical container and seal the opening with a suitable cover.

Revolve the container at a linear surface rate of 30m/min for the specified duration.

Relieve the internal pressure built up during the test by periodically releasing the container valve.

At the end of the specified duration removed the test pieces, and measure and record the coating thickness in 10 evenly distributed locations (see Appendix B).

Check the test pieces for holidays at a voltage corresponding to the reduced coating thickness, (see Appendix C).

Discard the used test slurry.

K.3.3 Reporting

Report whether or not holidays were detected after the test.

Report the 10 coating thickness readings before and after the test.

Confirm the total duration of the test.

APPENDIX L - IMPACT (SPHERE)

L.1 General

This appendix specifies the procedure for evaluating the resistance of coatings to the impact of a spherical load. It is based on the procedure described in BGC/P/CW6; Part 1, Appendix C and ASTM G14.

L.2 Equipment requirements

- A variable drop height impact tester with an indenter assembly having a total mass of approximately 1kg and a replacement steel ball (diameter 15mm) indenter. The equipment shall be securely mounted on a rigid support structure.
- Coating thickness measuring equipment (see B.2).
- High voltage holiday detector (see C.2).

L.3 Procedure

L.3.1 Test pieces

Holiday-free coated plates conforming to Figure 5.1. These should be conditioned at 20 - 25°C for 24 hours prior to the test.

L.3.2 Test method for production quality control (Parts Two and Three)

Mark five well-spaced points on the work piece. Measure the thickness at these points and check them for holidays with the holiday detector set at 5V/μm. Test only at holiday-free sites.

Position the impact tester at the first site. The impact weight should be dropped from a height calculated to impart the specified impact energy to the coating. The impact height may be calculated using the following formula:

$$H = \frac{J}{9.81W}$$

Where H = impactor height, in m
W = impactor mass, in kg
J = impact energy, in joules.

Raise the indenter assembly to the calculated height and allow it to fall. Retest the area for holidays. Repeat at the other four locations marked. The ball bearing should be rotated after each impact and discarded and replaced after 20 impacts.

L.3.3 Test method for type tests on panels (Part One)

Mark out 25 evenly distributed points on one face of each test piece. Measure and record the coating thickness at five points on this face. Position the test piece in the impact tester such that the indenter is lined up with the first mark on the test piece face and clamp securely.

Raise the indenter assembly to any chosen height and allow it to fall freely onto the marked point on the test piece. Test the impact area for holidays, with the detector set at 5V/μm (the coating thickness being that measured before impact). Use the next four marked locations on the test piece surface to establish the drop height at which impact just begins to create holidays.

Drop the indenter assembly from that height on the first of the remaining 20 marked points on the test piece face. If a holiday was created, drop the indenter from 1cm lower on the next marked point; if no holiday was created, drop it from 1cm higher on the next marked point. Continue in this way, recording 20 drop heights and the result at each height, (i.e. pass or failure).

Rotate the steel ball after each impact and replace it after 20.

L.4 Reporting

Use the following formula to calculate a mean impact energy from the last 20 results recorded for each test piece.

$$\text{Mean impact energy (kgcm)} = \left(h_0 + d \left[\frac{A \pm 1}{N} \right] \right) W$$

where h_0 = minimum height at which less frequent event occurs (i.e. passes or failures) (cm).

d = increment in drop height (1cm).

A = Σ of the frequency of occurrence of each height multiplied by the number of increments above h_0 for each result.

N = number of results on which A is based.

W = measured weight of indenter assembly (kg).

$+1/2$ = when N is based on number of passes.

$-1/2$ = when N is based on number of failures.

L.4.1 Example calculation of results

See tables opposite for example results.

$$\begin{aligned} \text{Mean impact energy} &= 23 + \left(\frac{23 - 1/2}{9} \right) \\ &= 25.05 \text{ kg cm} \end{aligned}$$

To convert in joules

$$\text{Mean impact energy} = \frac{25.05 \times 9.81}{100} = 2.46 \text{ J}$$

Marked site number	Drop height (cm)	Pass	Fail
1	30		✓
2	15	✓	
3	23	✓	✓
4	26		✓
5	25		✓
/	/	/	/
6	24	✓	
7	25	✓	✓
8	26		✓
9	25	✓	
10	26		✓
11	25		✓
12	24		✓
13	23		✓
14	22	✓	
15	23	✓	
16	24	✓	
17	25	✓	
18	26		✓
19	25	✓	
20	26	✓	
21	27		✓
22	26	✓	
23	27		✓
24	26		✓
25	25	✓	
Totals of each event		11	9

Calculation for A (based on failures. $h_0 = 23\text{cm}$).

Drop height (cm)	Frequency x increments above h_0	Product
23	1 x 0	0
24	1 x 1	1
25	1 x 2	2
26	4 x 3	12
27	2 x 4	8
		$A = 23$
		$N = 9$