BS 3900 : Part F10 : 1985

[Cathodic disbonding (marine)]

UDC [667.637.233.3 : 667.636.22] : 620.197.627

British Standard Methods of test for paints

Part F10. Determination of resistance to cathodic disbonding of coatings for use in marine environments

Méthodes d'essai des peintures
Partie F10. Détermination de la résistance au décollement cathodique des couches en milieu marin

Verfahren zur Prüfung von Anstrichstoffen
Teil F10. Bestimmung der Beständigkeit gegen kathodische Enthaftung von Beschichtungen im Meerwasserbereich

It is recommended that this Part be read in conjunction with the general information in the Introduction to BS 3900, issued separately.

Foreword

This Part of BS 3900 is one of a series of standards dealing with the sampling and testing of paints, varnishes and related products. It has been prepared under the direction of the Pigments, Paints and Varnishes Standards Committee.

The method of test described in this Part permits the assessment of the ability of paint and other organic coatings applied to metallic substrates to withstand cathodic disbonding. This method may also afford a basis for the comparison of particular coatings. The conditions of the test are more severe than those likely to be normally encountered and thus coating failure may be accelerated. It is recommended that the test should be carried out for a period of at least 26 weeks and hence this method is not suitable as a means of achieving quality control.

In order to carry out the method of test described in this Part it is necessary for certain supplementary information, itemized in clause 3, to be made available or to be agreed between the parties.

The procedure described in this Part is suitable for coatings to be used for the protection of ships and structures exposed to marine environments; it is based on the procedure developed and evaluated by COIPM (Comité International Permanent pour la Protection des Matériaux en Milieu Marin). The procedure described in Part F11 is based on that developed by the British Gas Corporation and should be used for coatings that are intended for the protection of land-based buried structures, such as pipelines.

For coatings for application to sub-sea pipelines it may be necessary to consider either this Part or Part F11 or an alternative procedure; the method to be used should be subject to agreement by the parties.

It has been assumed in the drafting of this British Standard that it will be used and applied by those who are appropriately qualified and experienced.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

British Standards Institution

1 Scope

This Part describes a method of test for determining the resistance to cathodic disbonding of a single coating or multi-coat system of paint, varnish or other organic coating applied to metallic substrates when the surface coating covering the metal substrate may contain or develop discontinuities. It is applicable to coatings that are subjected to marine environments, such as those on ships or partially exposed marine structures.

NOTE 1. For coatings that are used to protect land-based metallic structures, the conditions of the test differ from those for coatings to be used in marine applications. BS 3900 : Part F11 describes a method suitable for assessing coatings applied to buried structures.

NOTE 2. The test result may be influenced not only by the properties of the coating system under test, but also by the nature and preparation of the substrate, the method of application of the coating system and other factors.

NOTE 3. The titles of the publications referred to in this standard are listed on the inside back page.

2 Definitions

For the purposes of this British Standard, the definitions given in CP 1021 and BS 2015 apply, together with the following.

cathodic disbonding. The failure of adhesion between a coating and a metallic surface that is directly attributable to cathodic protection conditions and that is often initiated by a defect in the coating system, such as accidental damage, imperfect application or excessive permeability of the coating.

3 Supplementary information

For any particular application, the following supplementary information shall be provided for this method of test. This information shall be derived, partly or totally, from the product specification, British Standard or other document for the product under test or, where appropriate, should be agreed between the parties.

(a) Material, dimensions and surface preparation of the test surface or substrate (see clause **7**).

(b) The nature of the coating and the environment for which the coating is intended.

(c) Method of application of the test coating to the substrate or test surface and its thickness.

(d) Duration and conditions of drying or curing of the coating (or conditions of stoving and ageing, if applicable) before testing.

(e) The specific method of measurement of the thickness of the dry coating, in micrometres, in accordance with BS 3900 : Part C5, and whether it is a single coating or a multi-coat system (see **7.6**).

(f) Duration of the test and any special conditions for testing (see **8.3**), including the electrolyte used (see clause **5**).

(g) Details of the preparation of the artificial holiday (see **7.7**).

(h) Whether the procedure for inspecting the test coating during and after testing should include assessment of loss of adhesion (see **8.4.3**).

4 Sampling

A representative sample of the product to be tested (or of each product in the case of a multi-coat system) shall be taken as described in BS 3900 : Part A1.

Each sample shall be examined and prepared for testing as described in BS 3900 : Part A2.

5 Electrolytes

5.1 *Natural sea water, fresh.* If necessary, suspended solids may be removed by filtering through filter paper*.

5.2 *Synthetic sea water*†, prepared by dissolving 23.0 g of sodium chloride ($NaCl$), 8.9 g of sodium sulphate decahydrate ($Na_2SO_4 \cdot 10\,H_2O$), 9.8 g of magnesium chloride hexahydrate ($MgCl_2 \cdot 6H_2O$) and 1.2 g of anhydrous calcium chloride ($CaCl_2$) in water and diluting the solution to 1 L.

The reagents used shall be of recognized analytical quality, and water complying with BS 3978 shall be used.

6 Apparatus

6.1 *Tank,* of glass or other inert material that will not affect the pH of the electrolytes (**5.1** or **5.2**). The tank shall have a depth of not less than 200 mm and shall have one linear dimension (diameter or length) of not less than 700 mm (see **8.2**). A system for aerating the electrolyte shall be provided.

6.2 *Anode,* of graphite with a minimum length of 200 mm and a minimum diameter of 15 mm, or of platinum wire, platinum gauze or platinized titanium.

The anode shall be at least 10 % longer than the major dimension of the test specimen (see **7.2**).

6.3 *Reference electrode(s),* preferably of the saturated calomel type, constructed from either glass or plastics with a porous plug. If other reference electrodes, e.g. Ag/AgCl, are used these shall be checked against the standard calomel electrode and measured potentials shall be corrected in accordance with table 4 in CP 1021 : 1973.

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*Whatman No. 41 and No. 541 filter papers have been found to be suitable.

†This solution is in accordance with the synthetic sea water specified for the Armament Research Establishment (of the Ministry of Supply) salt droplet test described in clause 8 of BS 1391 : 1952.

6.4 *Voltmeter,* with minimum resistance of 10 MΩ, and capable of measuring in the range 0 V to 2 V to the nearest 1 mV.

6.5 *Cathodic protection circuit,* operating from a d.c. supply and capable of maintaining the electrode potential of the test substrates (**7.1**) at −1000 ± 5 mV relative to the calomel reference electrode (**6.3**).

The potential shall be controlled potentiostatically but if a potentiostat is not available a galvanostat may be used. The potential shall be frequently checked and adjusted to ensure that the electrode potential is within the specified limits (see **8.3.3**).

NOTE. Typical cathodic protection circuits are shown in figures 1 and 2.

7 Preparation of test specimens

7.1 Test substrates

Test substrates shall be representative of the substrate to which the test coating is to be applied.

If samples of the typical substrate are not available, test panels shall be used. The test panels shall be of steel and shall comply with the requirements of BS 3900 : Part A3.

NOTE. It may be necessary for the surface finish of the panels to correspond to that of the typical substrate to be used (see clause 3(a)).

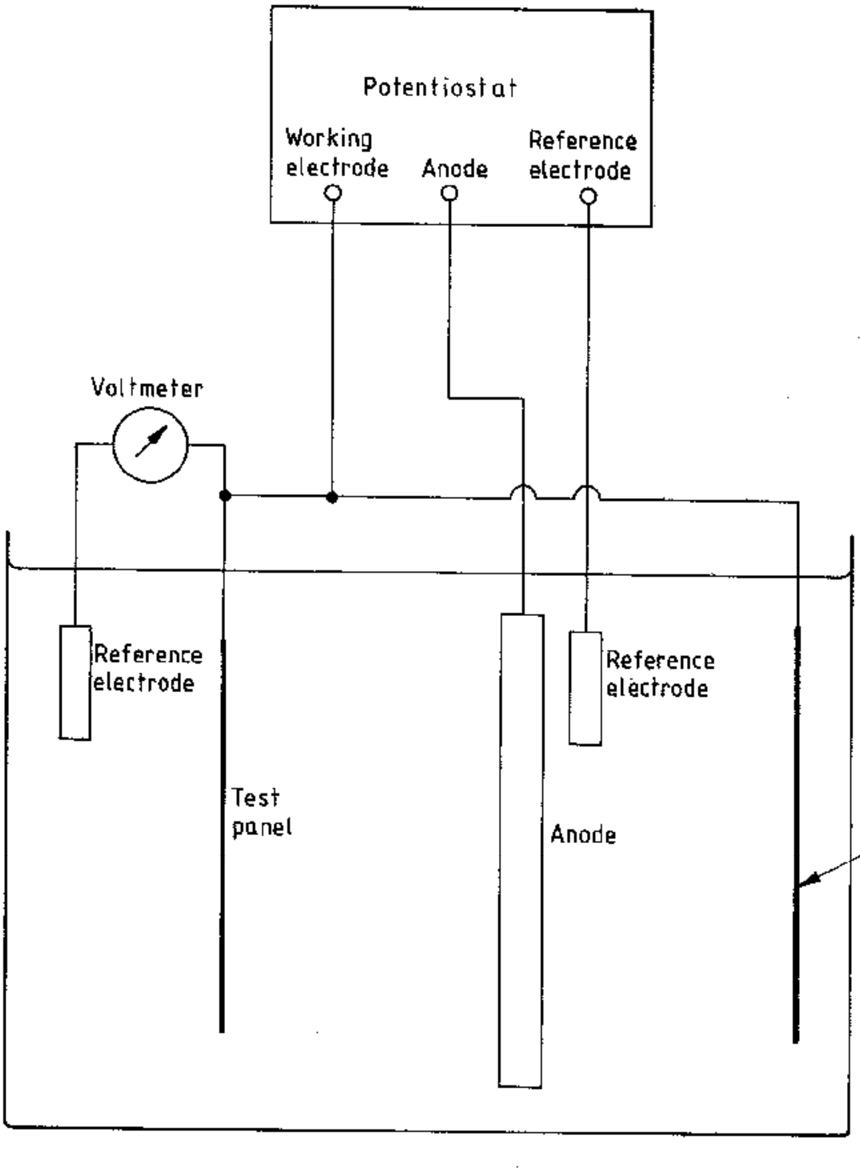

Figure 1. Potentiostatically-controlled cathodic protection circuit (see 6.5)

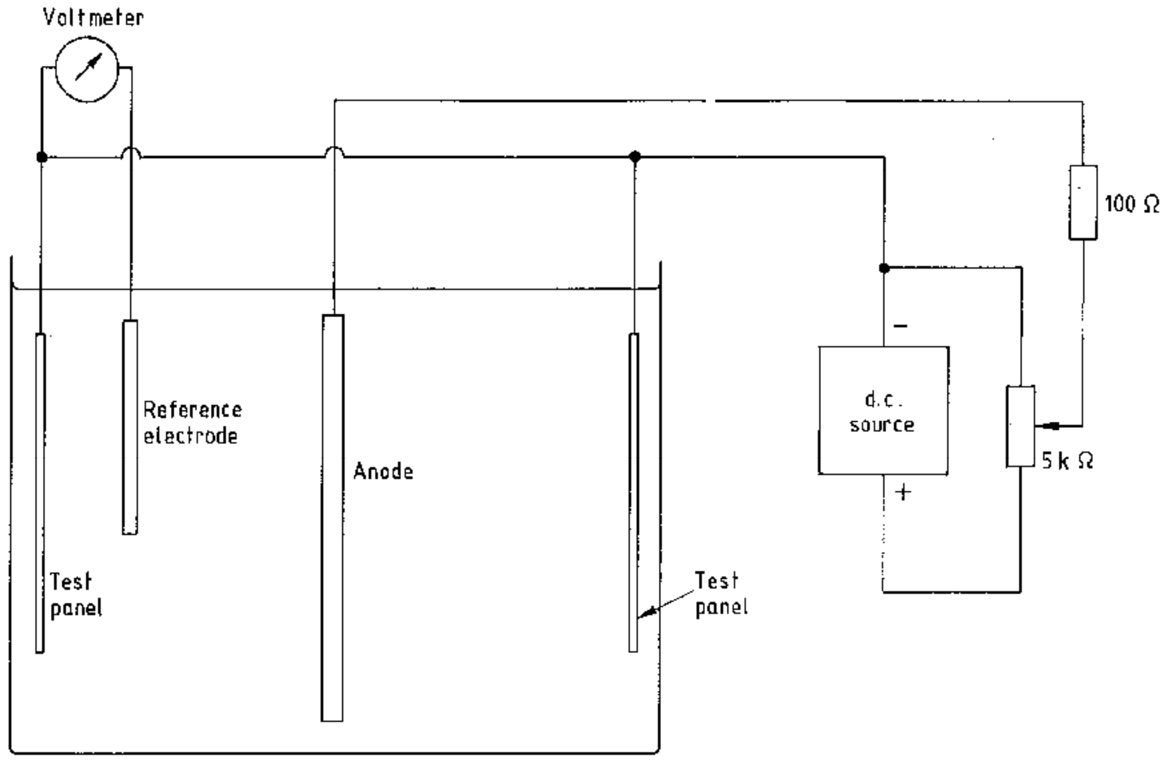

Figure 2. Galvanostatically-controlled cathodic protection circuit (see 6.5)

7.2 Dimensions

The minimum dimensions of each of the test substrates (7.1) shall be 150 mm × 100 mm × 2 mm, unless otherwise specified (see clause 3(a)).

7.3 Electrical connection

Each test specimen shall have an insulated conductor, firmly attached to the substrate by a self-tapping screw or a small nut and bolt.

NOTE. It may be convenient to attach the conductor after applying the coating to the substrate (see 7.4).

7.4 Preparation and coating of the test substrates

Either prepare and coat each substrate in accordance with the supplementary information given in the appropriate product standard or in the agreement between the parties (see clause 3), or blast clean each test panel (see note to 7.1) in accordance with BS 3900 : Part A3 and coat in accordance with the manufacturer's instructions for the product or system under test.

Coat all surfaces, including the edges, of the test substrate with the product or system under test, unless otherwise specified. Protect any uncoated surfaces of the test substrate and the connection to the insulated conductor (see 7.3) with a coating of paraffin wax, a solventless epoxy resin, or a resin consisting of approximately 80 % (*m*/*m*) beeswax and 20 % (*m*/*m*) colophony resin. Apply this latter resin at a temperature of about 70 °C.

Prepare and coat sufficient test specimens for each product or paint system to be tested in triplicate. Also prepare, in triplicate, control specimens which are not to be connected to the cathodic protection system.

7.5 Drying and conditioning of the specimens

Dry (or stove and age) the coated test and control specimens for the time and under the conditions specified for the product under test (see clause 3). Unless otherwise specified, condition the specimens at 23 ± 2 °C and at a relative humidity of 50 ± 5 % for a minimum of 16 h, with free circulation of air. Do not expose them to direct sunlight.

Carry out the determination of the coating thickness (see 7.6), formation of the artificial holiday (see 7.7) and the test procedure (see clause 8) as soon as possible after completion of conditioning (see clause 3(d)).

7.6 Thickness of the coating

Determine the thickness, in micrometres, of the dry coating on each test and control specimen in accordance with BS 3900 : Part C5 (see clause 3(e)).

7.7 Artificial holiday

Immediately before carrying out the test, prepare an artificial holiday on a coated surface of each of the specimens. Unless otherwise specified (see clause 3(g)), prepare the holiday by placing a mask with a cut-out hole of 10 ± 1 mm diameter on the surface and abrasive blastcleaning the specimen until the coating has been completely removed from the exposed area. Centre the artificial holiday not less than 30 mm from any edge of a specimen. Use chilled iron grit complying with grade G 17 or G 24 of BS 2451.

NOTE. Preparation of the holiday by the use of masking tape fixed to the substrate before coating is not recommended as, after removal of the tape, the presence of residual adhesive on the surface can invalidate the test.

Check that an electrical connection exists between the holiday and the conductor (see **7.3**).

7.8 Accidental holidays

Test the coating on each specimen for freedom from accidental holidays as described in appendix A.

8 Procedure

8.1 Determinations

Carry out the procedure on three test specimens for each test coating.

8.2 Arrangement of the test specimens in the tank

8.2.1 Place the anode (**6.2**) in the centre of the tank (**6.1**) and connect it to the positive terminal of the cathodic protection circuit (**6.5**).

Locate the prepared specimens (see clause **7**) and, if space permits (see **8.2.2**), the control specimens in racks in the tank and adjust their position such that each specimen is not less than 300 mm from the anode (**6.2**) in the tank, is not less than 50 mm from the base and will be totally immersed when the tank is filled with the electrolyte. Ensure that no specimen is touching another and that no specimen is in contact with the sides of the tank. Ensure also that no panel face containing a holiday is shielded from the anode by any obstruction or by another specimen, and that the flow of electrolyte around and between the specimens is not impeded.

Connect each test specimen to the negative terminal of the cathodic protection circuit by means of the insulated conductor (see **7.3**), but leave the control specimens unconnected.

8.2.2 If space is not available, place the control specimens in an equivalent tank without the anode and cathodic protection circuit, and state this in the test report.

8.3 Conditions

8.3.1 Fill the tank to a minimum depth of 200 mm with the electrolyte (**5.1** or **5.2**). Commence aeration and check that the electrolyte is at 23 ± 2 °C. If the electrolyte used is natural sea water (**5.1**) and it is not feasible to adjust its temperature to 23 ± 2 °C monitor the temperature of the electrolyte in the tank at regular intervals and record the readings in the test report.

Locate the calomel reference electrode or electrodes (**6.3**) in the vicinity of the test specimens but not shielding a holiday. Ensure that no electrode is less than 300 mm from the anode.

8.3.2 Maintain a continual flow of the electrolyte through the tank by introducing fresh aerated electrolyte at the base and allowing it to overflow. Adjust the rate of flow so that the electrolyte has been completely replaced in the tank in a maximum of 3 days. Alternatively, replace the electrolyte totally at intervals not exceeding 7 days, and report the use of this procedure and the frequency of replacement of the electrolyte in the test report.

8.3.3 Switch on the cathodic protection circuit and adjust the current by means of the controlling potentiostat so that each specimen is maintained at an electrode potential of -1000 ± 5 mV with reference to the reference electrode (**6.3**). Check the potential at least once in each 24 h and adjust if necessary. If the potential is controlled galvanostatically (see **6.5**), check frequently during the first 8 h. For the next 4 days check the potential at least once every 8 h, and adjust it if necessary. At the end of this period, check the potential at least once in every 24 h.

Check the temperature of the electrolyte daily and adjust if necessary (see **8.3.1**).

Unless otherwise specified, continue the test for a period of 26 weeks.

8.4 Inspection and assessment of the coating

8.4.1 Inspect the test and control specimens at any intermediate stages and at the completion of the test as specified (see **8.4.3**).

8.4.2 At an intermediate stage, remove each specimen in turn and quickly rinse with tap water, taking care not to damage the coating.

NOTE. As alkalis may be formed beneath the coating during the test, care should be taken when handling the specimens. While rinsing may reduce the alkali concentration beneath a blister, the concentration may still be sufficient to cause skin burns.

Examine the coating generally, including the back of the panel if this was also coated with the product under test, for signs of blistering. In the region of the holiday, examine the coating for loss of adhesion. Record the degree of blistering according to the rating scales described in BS 3900 : Part H2 and the distance of the blisters from the holiday. Record if the coating is peeling away from the substrate at the holiday. Compare the results obtained for the three test coatings with those obtained for the control coatings.

After the examination, replace the specimens in the tank, reconnect and continue the test.

8.4.3 At the completion of the test, thoroughly rinse each specimen with tap water, taking care not to damage the coating (see note to **8.4.2**).

Examine the coating generally, including the back of the panel if this was also coated with the product under test, for signs of blistering. Record the degree of blistering according to the rating scales described in BS 3900 : Part H2 and the distance of the blisters from the holiday.

If assessment of loss of adhesion is specified (see clause **3**(h)), use a sharp knife* to make two cuts through the coating to the substrate, intersecting at the holiday. With the point of the knife, attempt to lift and peel back the coating from around the holiday. Record whether the adhesion of the coating to the substrate has been reduced and the approximate distance, in millimetres, that the coating can be peeled.

Compare the results obtained for the three test coatings with those obtained for the three control coatings.

9 Test report

The test report shall include the following information:

(a) the type and identification of the coating under test;

(b) a reference to this British Standard, i.e. BS 3900 : Part F10;

(c) the items of supplementary information referred to in clause **3**;

(d) the British Standards or other published documents supplying the information referred to in (c) above;

(e) the electrolyte used in the test and its rate of replacement;

(f) the period of the test and any interruptions during the test including those required for the intermediate examination of the coating (see **8.4.2**);

(g) any deviation, by agreement or otherwise, from the test procedure described (e.g. if the procedure for preparing the artificial holiday (see **7.7**) differed from that described, if the control specimens were contained in a separate tank (see **8.2**), if the electrolyte temperature differed from 23 ± 2 °C (see **8.3.1**) and if the electrolyte was totally replaced and when (see **8.3.2**));

(h) the results of the test in terms of the extent of blistering and, if determined, the extent of the loss of adhesion (see **8.4.3**);

(i) the dates of the test.

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*A Stanley trimming knife blade, type 1991, has been found to be suitable.

Appendix A. Detection of accidental holidays

NOTE. This procedure for detecting accidental holidays in a coating is based on the method described in **J.3.1** of BS 4164 : 1980.

Examine the test specimen for the presence of accidental holidays by means of a flaw detector, fitted with a soft, metallic bristled, straight brush approximately 75 mm long and 6 mm wide with bristles 6 mm long, adjusted to provide a voltage of 10 kV but so arranged that the maximum short circuit current is not greater than 8 mA. If the flaw detector is not equipped with voltage indication, set it to give a 12 mm spark in air to a steel plate.

Pass the flaw detector over the coated specimen at a distance of approximately 6 mm from the coated steel surface. Ignore any edge effects.

Publications referred to

BS 1391	Performance tests for protective schemes used in the protection of light-gauge steel and wrought iron against corrosion
BS 2015	Glossary of paint terms
BS 2451	Chilled iron shot and grit
BS 3900	Methods of test for paints Part A1 Sampling Part A2 Examination and preparation of samples for testing Part A3 Standard panels for paint testing Part C5 Determination of film thickness Part H2 Designation of degree of blistering Part F11 Determination of resistance to cathodic disbonding of coatings for use on land-based buried structures
BS 3978	Water for laboratory use
BS 4164	Specification for coal-tar-based hot-applied coating materials for protecting iron and steel, including suitable primers where required
CP 1021	Code of practice for cathodic protection

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[Cathodic disbonding (marine)]

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