



Standard Test Methods for Cathodic Disbonding of Coated Steel¹

This standard is issued under the fixed designation G8; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 These test methods apply to procedures for determining the degree of disbondment of a coating from a steel substrate when placed in contact with an electrolyte and a potential is applied to the steel. Specimens may include coated steel pipe or coated flat or curved steel plate. The coating applied to the steel substrate shall be non-metallic and shall not show flow characteristics at the test temperature.

1.2 These test methods apply to specimens that are immersed in an electrolyte bath or specimens with an attached electrolyte cell at ambient room temperature, 21 °C to 25 °C (70 °F to 77 °F), conditions. If higher temperatures are required, use Test Method G42.

1.3 These test methods apply to methods of polarization including sacrificial anodes or impressed current applied to the steel by a rectifier.

1.4 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

¹ These test methods are under the jurisdiction of ASTM Committee D01 on Paint and Related Coatings, Materials, and Applications and are the direct responsibility of Subcommittee D01.48 on Durability of Pipeline Coating and Linings.

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2. Referenced Documents

2.1 ASTM Standards:²

A36 Specification for Carbon Structural Steel

D1141 Practice for Preparation of Substitute Ocean Water

D5162 Practice for Discontinuity (Holiday) Testing of Non-conductive Protective Coating on Metallic Substrates

D7091 Practice for Nondestructive Measurement of Dry Film Thickness of Nonmagnetic Coatings Applied to Ferrous Metals and Nonmagnetic, Nonconductive Coatings Applied to Non-Ferrous Metals

G42 Test Method for Cathodic Disbonding of Pipeline Coatings Subjected to Elevated Temperatures

G95 Test Method for Cathodic Disbondment Test of Pipeline Coatings (Attached Cell Method)

3. Summary of Test Method

3.1 Three test methods are described in this standard. In each method, an artificial holiday or defect is applied to the specimen's coating film through to the steel substrate. The specimen is immersed in a defined electrolyte with the steel polarized to a defined voltage.

3.1.1 *Method A*—The specimens are immersed in an electrolyte immersion bath. A specified metallic anode is used to polarize the specimen with no electrical monitoring during the test period.

3.1.2 *Method B*—The specimens are immersed in an electrolyte immersion bath. Polarization of the specimen is conducted using an impressed current potentiostat at a specified DC voltage with electrical monitoring during the test period.

3.1.3 *Method C*—The specimens shall have a cell containing the electrolyte attached to the surface of the specimen. Polarization of the specimen is conducted using an impressed current potentiostat at a specified DC voltage with electrical monitoring during the test period.

3.2 Upon completion of immersion exposure, a physical examination is conducted by comparing the extent of loosened

² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

or disbanded coating at the holiday in the immersed area with extent of loosened or disbanded coating at a new holiday in the coating made in an area that was not immersed. Test specimens are also examined for any other visible defect.

4. Significance and Use

4.1 Breaks or holidays in a coating applied over steel exposes the substrate to a potential corrosion cell. When the steel is subjected to cathodic protection by the polarization of the steel via sacrificial anodes or impressed current, the exposed steel at the holiday becomes the cathode in the corrosion cell. When the electrolyte is neutral or slightly alkaline, hydroxyl ions form from the reduction of oxygen and, when paired with a suitable cation from the electrolyte, form an alkaline solution. Depending on the strength of this alkaline solution and the concentration of the alkaline compound, this alkalinity may disrupt the adhesion between the coating and the steel, disbonding the coating from the steel.

4.2 Current density of the cathodic cell also can affect the degree of cathodic disbondment. The greater the current density generated by the concentration of electrons at the anode, the greater the number of hydroxyl ions formed, thus increasing the alkalinity available for disrupting the adhesion between the coating and the steel substrate. Likewise, the concentration of oxygen in the electrolyte will affect the concentration of hydroxyl ions formed at the cathode.

4.3 For these reasons it is often useful to measure pH, oxygen, and current density when conducting a cathodic disbondment test.

5. Apparatus

5.1 *Apparatus for All Three Methods—Method A, Method B, and Method C:*

5.1.1 *Connectors*—Wiring from anode to test specimen shall be 4107 cmil (14 gauge AWG), minimum, insulated copper. Attachment to the test specimen shall be by soldering, brazing, or bolting to the non-immersed end, and the place of attachment shall be coated with an insulating material. A junction in the connecting wire is permitted, provided that it is made by means of a bolted pair of terminal lugs soldered or mechanically crimped to clean wire ends.

5.1.2 *Holiday Tools*—Holidays shall be made with conventional drills of the required diameter. For use in preparing small-diameter pipe specimens, the use of a flat end mill has been found effective in preventing perforation of the metal wall of the pipe.

5.1.3 *Disbondment Evaluation Tools*—A sharp-pointed thin blade knife with a safe handle is required for use in removing disbanded coating from the specimen.

5.1.4 *Reference Electrode*—A reference electrode Ag/AgCl in saturated KCl with double junction, or a saturated Cu/CuSO₄ reference electrode shall be used. The accuracy of the Ag/AgCl reference electrode shall be checked before starting the test. The Ag/AgCl reference electrode can be checked against another Ag/AgCl reference electrode which is only used for accuracy checkup only without routine usage. The two Ag/AgCl reference electrodes can be inserted into the same

electrolyte solution (for example, 3 % NaCl solution). The voltage differential shall be within 5 mV. If over 5 mV, the subject Ag/AgCl reference electrode shall be discarded.

5.1.5 *Thickness Gauge*, for measuring coating thickness in accordance with Practice D7091.

5.1.6 *Holiday Detector*, for locating holidays in the coating of the test specimen in accordance with Practice D5162, Test Method A – Low Voltage Wet Sponge Testing.

5.1.7 *Thermometer*, for measuring electrolyte temperature, general lab type, 1° subdivisions, 76.2 mm (3 in.) immersion.

5.1.8 *High-Resistance Voltmeter*, for direct current, having an internal resistance of not less than 10 MΩ and capable of measuring as low as 10 μV potential drop across a shunt in the test cell circuit.

5.2 *Additional Apparatus for Methods, Method A and Method B:*

5.2.1 *Test Vessel*—A nonconducting material shall be used for the vessel or as a lining in a metallic vessel. Dimensions of the vessel shall permit the following requirements:

5.2.1.1 Test specimens shall be suspended vertically in the vessel with at least 25.4 mm (1.0 in.) clearance from the bottom.

5.2.1.2 Each test specimen shall be separated from the other specimens, from the anodes and from the walls of the test vessel by at least 38.1 mm (1.5 in.).

5.2.1.3 The depth of electrolyte shall permit the test length of the specimen to be immersed such that a minimum of 23 227 mm² (36 in.²) shall be immersed in the electrolyte.

5.2.1.4 Plywood or plastic material has been found suitable for the construction of test vessel covers and for the support through apertures of test specimens and electrodes. Wood dowels introduced through holes in the top ends of test specimens have been found suitable for suspending test specimens from the vessel cover.

5.3 *Additional Apparatus for Method A:*

5.3.1 *Sacrificial Anodes*—Anodes shall be made as specified in Table 1. It shall have a surface area not less than one third that of the total specimen area exposed to electrolyte (for flat panels, the area containing the artificial holiday only and for pipe outside area exposed only). The anode shall be provided with a factory-sealed, 4107 cmil (14 gauge AWG), minimum, insulated copper wire for connecting to the test specimen. Anodes without a factory seal may be used if the alloy extends above the cover or if the connection of the wire to the anode is coated with an insulating material. Anodes, alternatively, may be directly bolted to the test specimen ensuring that there is positive electrical contact between the anode and the test specimen. If pre-used anodes are to be used, the anodes shall be cleaned by wire brushing or by immersion in dilute acid to remove corrosion products to ensure they are active.

TABLE 1

Metal Alloy	Potential (Ag/AgCl reference electrode)	Potential (Cu/CuSO ₄ reference electrode)
Magnesium	-1.33 to -1.43 V	-1.45 to -1.55 V
Zinc	-0.88 to -0.98 V	-1.00 to -1.10 V
User specified alloy	User specified	User specified

5.4 Additional Apparatus for Method B:

5.4.1 Precision Wire-Wound Resistor; $1 \Omega \pm 1 \%$, 1 W (minimum), shall be used in the test cell circuit as a shunt for current.

5.4.2 Metallic Electrode, used temporarily with the high-resistance voltmeter to determine apparent initial holiday status of the test specimen.

5.4.3 Additional connecting wires shall be 4107 cmil (14 gauge AWG), minimum, insulated copper.

5.4.4 Brass Studs, used at a terminal board, together with alligator clips or knife switches, for making and breaking circuits may be used. Alligator clips shall not be used to connect to electrodes or specimens at the top location of test cells.

5.4.5 Direct-Current Rectifier or Power Supply, capable of supplying constant voltage at a voltage of up to $5.0 \text{ V} \pm 0.05 \text{ V}$, as measured between the test specimen and reference electrode.

5.4.6 Impressed-Current Anode Assembly (Fig. 1):

5.4.6.1 Filter Tube—Anode assembly shall be inserted into a glass tube. Length of the tube shall be a minimum of 180 mm (7 in.) and 6 mm (0.25 in.) in diameter. A removable glass or plastic (for example, polyester) wool plug shall be fitted at the bottom of the tube. The plug shall be removed after testing and disposed.

5.4.6.2 Impressed-Current Anode—The anode shall be of corrosion-resistant metal wire 0.51 mm (0.020 in. – 24 gauge AWG) diameter. A titanium wire coated with mixed metal oxide $\text{IrO}_2/\text{Ta}_2\text{O}_5$ or a platinum coated wire has been used with good results.

5.4.7 Voltage Divider, 100 Ω , 25 W rheostat, to be used if more than one specimen is to be tested as shown in Fig. 6.

5.5 Additional Apparatus for Method C:

5.5.1 Test Vessel—The test vessel shall be a transparent plastic or glass tube that is centered over the intentional holiday and sealed to the test sample surface with a waterproof sealing material. The cylinder shall be 101.6 mm (4.0 in.) nominal diameter and of sufficient height to contain 127.0 mm (5.0 in.) of electrolyte. Size of vessel shall remain unchanged. Sealing procedure must be altered to accommodate specimen having a diameter less than 101.60 mm (4 in.).

5.5.2 Impressed-Current Anode Assembly (Fig. 1):

5.5.2.1 Filter Tube—Anode assembly shall be constructed utilizing an immersion tube. Length of the tube shall be a minimum of 180 mm (7 in.) and 6 mm (0.25 in.) in diameter. A removable glass or plastic (for example, polyester) wool plug shall be fitted at the bottom of the tube. The plug shall be removed after testing and disposed.

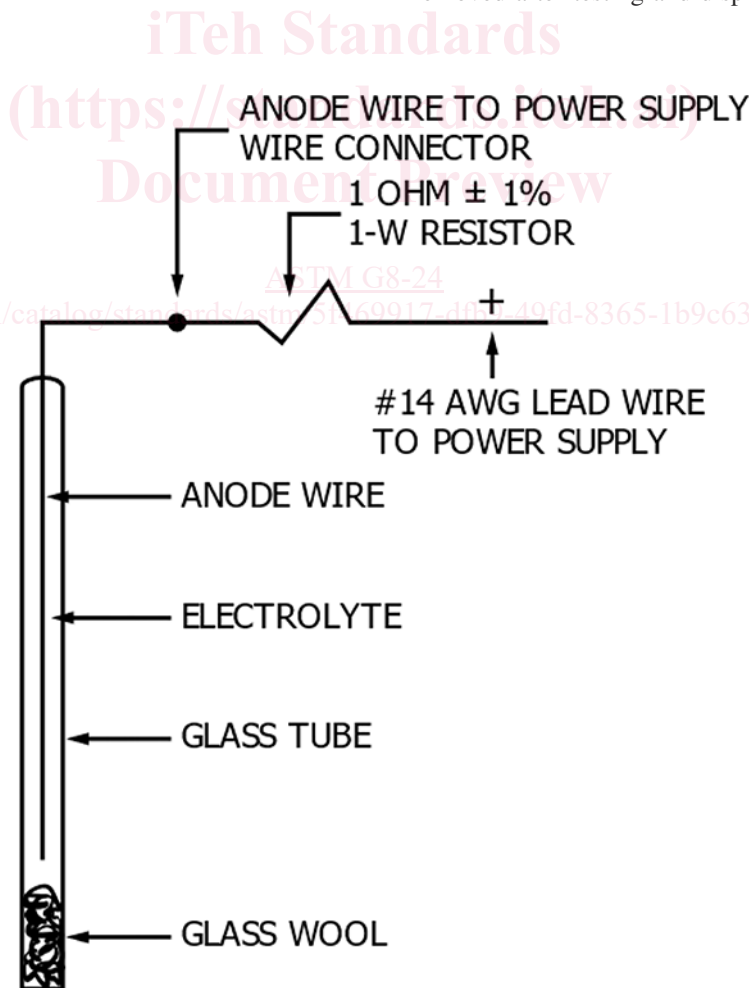


FIG. 1 Anode Assembly for Methods B and C

5.5.2.2 *Impressed-Current Anode*—The anode shall be of corrosion-resistant metal wire 0.51 mm (0.020 in. – 24 gauge AWG) diameter. A titanium wire coated with mixed metal oxide IrO₂/Ta₂O₅ or a platinum coated wire has been used with good results.

5.5.3 *High-Impedance Multimeter*—For making direct-current and voltage measurements, the multimeter must have an internal resistance of not less than 10 M Ω and be capable of measuring current as low as 1 mA, and voltage up to 10 V.

5.5.4 *Direct-Current Rectifier or Power Supply*, capable of supplying constant voltage at a voltage of up to 3.00 V ± 0.05 V, as measured between the test specimen and reference electrode.

5.5.5 *Precision Wire-Wound Resistor*, 1 Ω ± 1 %, 1 W (minimum), shall be used in the test cell circuit as a shunt for current (Fig. 1).

6. Reagent and Materials

6.1 The electrolyte employed shall be one of those found in Table 2:

TABLE 2

Electrolyte Designation	Ionic Composition	Preparation
I	Aqueous solution of 1 % sodium chloride, 1 % sodium sulfate, 1 % sodium carbonate	Using technical grade salts, add to distilled or deionized water, and mix until dissolved.
II	Aqueous solution of 3% sodium chloride	Using technical grade sodium chloride, add to distilled or deionized water, and mix until dissolved.
III	Synthetic seawater	Practice D1141 (without heavy metals)
IV	Specified by the user	Specified by the user

6.1.1 Use freshly prepared solution for each test.

6.2 Materials for sealing edges of coated panels or the ends of coated pipe specimens shall consist of non-conducting protective materials.

7. Test Specimen

7.1 Test specimens shall be of the following types, unless otherwise specified by the end user:

7.1.1 *Applicable for Methods A, B, and C*—Coated flat panels or coupons shall have minimum dimensions of 150 mm × 300 mm (6 in. × 12 in.) with a minimum thickness 3.2 mm (1/8 in.). Unless otherwise specified, the grade of steel shall be Specification A36 or equivalent. Uncoated edges shall have a protective edging applied to the panels when used with Method A and Method B.

7.1.2 *Applicable for Methods A and B*—Coated pipe shall have an outside diameter of 50.8 mm (2 in.) with a wall thickness of 6.4 mm (0.25 in.) and a minimum length of 300 mm (12 in.). The end of the pipe to be immersed shall be plugged or capped, and sealed.

7.1.3 *Applicable for Method C*—Coated pipe or curved plate of a diameter that the test vessel can be fitted and sealed to the surface. The recommended wall thickness of the test specimen shall be 6.4 mm (0.25 in.) or greater.

8. Test Specimen Preparation

8.1 Three single holiday specimens or one, three holiday pipe specimen shall be tested for each coating/test condition unless otherwise specified.

8.2 Preparation of Artificial Holiday:

8.2.1 Prior to making the artificial holiday, the continuity of the coating shall be verified by using a low-voltage wet-sponge holiday detector (Practice D5162) with sufficient water on the sponge to ensure electrical connection in case a holiday is encountered. Specimens with holidays shall be removed and not tested and replaced with holiday free specimens.

8.2.2 For flat panels, curved panels, and large diameter pipe specimens, one intentional holiday shall be made in each specimen to be tested at the center of the immersion area. The holiday shall be drilled so that the angular cone point of the drill will fully enter the steel where the cylindrical portion of the drill meets the steel surface. The specimen shall not be perforated by the drill. The drill shall be for Methods A and B, 6.4 mm (0.25 in.) in diameter and for Method C, 3.2 mm (0.125 in.) in diameter, unless otherwise specified.

8.2.3 For 50.8 mm (2.0 in.) pipe specimens, three holidays with diameters of 6.4 mm (0.25 in.) shall be drilled with a flat end mill or a regular drill bit and the angular cone point of the drill will fully enter the steel where the cylindrical portion of the drill meets the steel surface. The specimen shall not be perforated by the drill. One holiday shall be drilled in the center of the immersion area of the pipe. One holiday shall be drilled halfway above the center holiday to the upper immersion level on the pipe, offset 120° to the right the center holiday. One holiday shall be drilled halfway below the center holiday to the bottom on the pipe, offset 120° to the left the center holiday.

8.3 Measure and record the dry film thickness of the coating in accordance with Practice D7091, and the dry film thickness immediately adjacent to where each holiday is made.

8.4 For Methods A and B, the end of the specimen which will protrude above the immersion line shall be provided with suitable supporting means and a separate wire connection for electrical purposes, soldered, brazed, or bolted to the specimen. The protruding end, including hanger and wire connections, shall be protected and sealed with an insulating coating material. The specimen test area shall consist of the area between the edge of the bottom end of the specimen and the immersion line and shall be not less than 23 227 mm² (36 in.²).

9. Procedure for Method A

9.1 Immerse the test specimen in the electrolyte and connect it to the anode as shown in Fig. 2. Position the middle or single holiday so that it faces away from the anode. Space the anode with respect to test specimens as described in 5.2. Mark the correct immersion level of the test specimen with a grease pencil or other suitable marker and maintain by daily additions of distilled or deionized water as required. Perform the test at electrolyte temperature of 21 °C to 25 °C (70 °F to 77 °F) and aerate the electrolyte solution throughout the length of the immersion period unless otherwise specified. An aquarium air

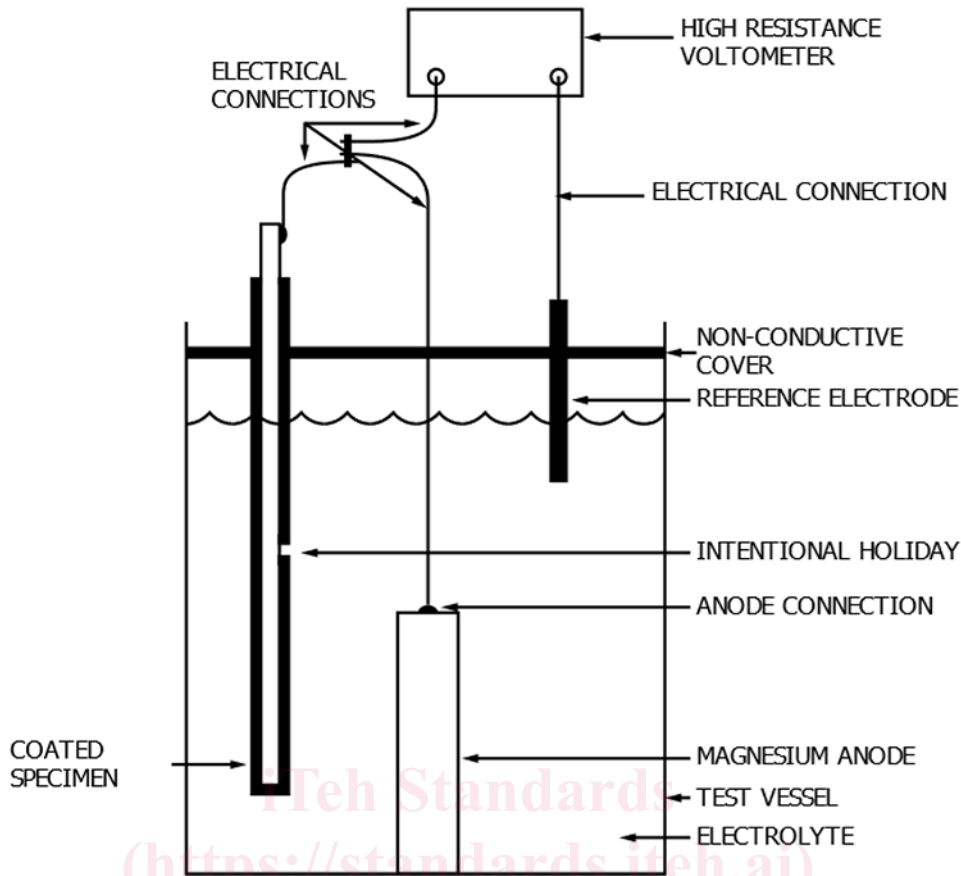


FIG. 2 Test Assembly for Method A Using a Magnesium Anode

pump with a hose and air stone has been shown to be adequate for aerating the electrolyte. Check the temperature daily and adjust as necessary.

9.1.1 In order to ascertain that the test cell is functioning, measure the potential between test specimen and a reference electrode immediately after starting the test and immediately before terminating it. The potential measured shall be as specified in Table 1 with respect to an Ag/AgCl in saturated KCl reference electrode or a CuCuSO₄ reference electrode. If the test cell is not functioning properly at the termination of the test, the test shall not be considered valid.

9.2 Duration of the immersion period shall be 30 days. Optionally, other test periods such as 60 or 90 days may be used, or as specified by the end user.

9.3 Optionally, during the immersion period, measure the pH and oxygen content of the electrolyte at the beginning, at the end, and at least on a weekly basis and record.

9.4 An examination shall be performed immediately upon termination of the test period as follows:

9.4.1 At the end of the test period, remove the test specimen from the electrolyte bath and rinse the test area with warm tap water. Immediately wipe the sample dry and visually examine the entire test area for any evidence of unintentional holidays and loosening of coating at the edge of all holidays, including the intentional holiday, and record coating condition, for example, color change, blisters, cracking, crazing, adhering deposits, etc.

9.4.2 Drill a new reference holiday in the coating in an area that was not immersed. Follow the same drilling procedure as described in 8.2.

9.4.3 For both the intentional holiday and the reference holiday, make radial 45° cuts at eight compass points through the coating intersecting at the centers of the holiday with a sharp, thin-bladed knife (see Fig. 3). Take care to ensure that coating is cut completely through to the steel substrate.

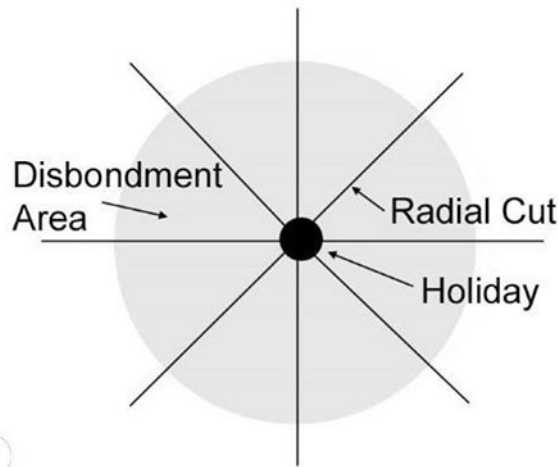


FIG. 3 Radial Cuts

9.4.4 Attempt to lift the coating at both the reference holiday and the intentional holiday with the point of a sharp, thin-bladed knife. Insert the flat blade of the knife between the substrate and the coating, then pry the disbonded coating away from the steel substrate. Keep prying away disbonded coating until a boundary of tightly adhered coating is encountered (see Fig. 4).

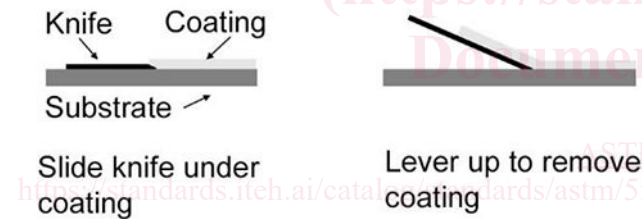


FIG. 4 Removal of Disbonded Coating

9.4.5 Optionally, if any liquid is found beneath the disbonded coating, using pH paper, determine the pH of said liquid.

9.4.6 For both the reference holiday and the intentional holiday, at four disbondment diameters measured at the radial cuts around the coating disbondment area, measure the diameter length of disbondment through the center of the holiday. Report the following as specified:

9.4.6.1 *Radial Disbondment Length (RDL)*:

$$RDL = (\text{Average diameter length of disbondment} - \text{Diameter of holiday})/2$$

9.4.6.2 *Area of Disbondment (AOD)*:

$$AOD = (\pi * (\text{Average diameter length of disbondment}/2))^2 - (\pi * (\text{diameter of holiday}/2))^2$$

9.4.6.3 *Equivalent Circle Diameter (ECD)*:

$$ECD = \sqrt{\frac{AOD}{0.785}}$$

10. Method A Report

10.1 The report for Method A shall include the following information:

10.1.1 Complete identification of the test specimen, including:

10.1.1.1 Product name and batch or lot number(s) of the coating;

10.1.1.2 Dimensions of the test specimen(s);

10.1.1.3 Description of the surface preparation of the steel substrate.

10.1.2 Minimum-maximum coating thickness, average coating thickness, and the coating thickness at the holiday;

10.1.3 Size and number of initial holidays;

10.1.4 Verification of coating continuity prior to immersion;

10.1.5 Anode type and voltage measured;

10.1.6 Immersion conditions, including:

10.1.6.1 Identification of the electrolyte used;

10.1.6.2 If electrolyte was not aerated during immersion period;

10.1.6.3 Immersed area of specimen(s);

10.1.6.4 Start and end dates of immersion;

10.1.6.5 Temperature of immersion bath.

10.1.7 Radial disbondment length (*RDL*), Area of Disbondment (*AOD*), and Equivalent Circle Diameter (*ECD*) as specified;

10.1.8 Any visual defects such as color change, blisters, cracking, crazing, adhering deposits, etc.;

10.1.9 Any other pertinent observations or data.

10.2 The report for Method A shall optionally include the following information if measured:

10.2.1 pH of the electrolyte at the measured time intervals;

10.2.2 Oxygen content of the electrolyte at the measured time intervals;

10.2.3 pH of any liquid found beneath disbonded coating.

11. Procedure for Method B

11.1 Conduct the procedure in accordance with Method A as described in Section 9, except use Fig. 5 for the equipment