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# Standard Practice for Continuity Verification of Liquid or Sheet Linings Applied to Concrete Substrates[1]

This standard is issued under the fixed designation D 4787; 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 This practice covers procedures that may be used to allow the detection of discontinuities in nonconductive linings applied to concrete substrates.

1.2 Discontinuities may include pinholes, internal voids, holidays, cracks, and conductive inclusions.

1.3 This practice describes detection of discontinuities utilizing a low voltage wet sponge holiday detector and a high voltage pulsating or continuous dc spark tester. Linings with thickness in excess of 20 mils must be tested utilizing high voltage spark testing equipment.

NOTE 1—For further information on discontinuity testing refer to NACE Standard RP0188-88 or Practice D 5162.

1.4 This practice describes procedures both with and without the use of a conductive underlayment.

1.5 The values stated in the inch-pound units are to be regarded as the standard. The values given in parentheses are for information only.

1.6 *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 and health practices and determine the applicability of regulatory limitations prior to use.* For a specific hazard statement, see Section 7.

## 2. Referenced Documents

2.1 *ASTM Standards:*

D 149 Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies[2]

D 5162 Practice for Discontinuity (Holiday) Testing of Nonconductive Coating on Metallic Substrates[3]

2.2 *NACE Standards:*[4]

RP0188-88 Discontinuity (Holiday) Testing of Protective Coatings

## 3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *discontinuity*—a localized lining site that has a dielectric strength less than a determined test voltage.

3.1.2 *conductive underlayment*—a continuous layer applied to the prepared concrete surface prior to the application of a nonconductive lining layer(s) that will allow high voltage spark testing for discontinuities in the lining.

3.1.3 *spark-over*—the distance a spark, from a high voltage tester, will jump across a space from a grounded surface at a specific electrical voltage.

3.1.4 *high voltage spark tester*—an electrical device (in excess of 800 V) used to locate discontinuities in a nonconductive protective coating applied to a conductive substrate.

3.1.5 *low voltage tester*—a low voltage wet sponge electrical detector used to locate discontinuities in nonconductive linings applied to conductive substrates.

3.1.5.1 *Discussion*—This test instrument is not suitable for testing linings in excess of 20 mils.

3.1.6 *test voltage*—that electrical voltage established which will allow a discontinuity at the thickest lining location site to be tested, but which will not damage the lining.

3.1.6.1 *Discussion*—The test voltage must always be set well below the dielectric breakdown strength of the lining. This voltage should be recommended by the lining manufacturer. The dielectric breakdown voltage strength of a solid can be determined by Test Method D 149.

## 4. Summary of Practice

4.1 This practice allows for high and low voltage electrical detection of discontinuities in new linings applied to concrete substrates through the utilization of a continuous conductive underlayment applied to the prepared concrete surface prior to the application of the nonconductive lining layer(s) or by determining the conductivity of the concrete substrate to be

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[2] *Annual Book of ASTM Standards*, Vol 10.01.

[3] *Annual Book of ASTM Standards*, Vol 06.02.

[4] Available from National Association of Corrosion Engineers, P.O. Box 218340, Houston, TX 77218.

tested. The conductivity of concrete varies, depending on moisture content, type, density, and location of rebars. Test the conductivity of the concrete by attaching the ground wire to rebar or other metallic ground permanently installed in the concrete. If a metallic ground is not available, the ground wire shall be placed directly against the bare concrete surface and weighted with a damp cloth or paper sand-filled bag. If the test indicates the concrete provides an insufficient ground, a conductive underlayment will be required if a continuity test is to be conducted.

## 5. Significance and Use

5.1 The electrical conductivity of concrete is primarily influenced by the presence of moisture. Other factors which affect the continuity of concrete include the following:

5.1.1 Presence of metal rebars,
5.1.2 Cement content and type,
5.1.3 Aggregate types,
5.1.4 Admixtures,
5.1.5 Porosity,
5.1.6 Above or below grade elevation,
5.1.7 Indoor or outdoor location,
5.1.8 Temperature and humidity, and
5.1.9 Age of concrete.

5.2 The electrical conductivity of concrete itself may be successfully used for high-voltage continuity testing of linings applied directly with no specific conductive underlayment installed. However, the voltage required to find a discontinuity may vary greatly from point to point on the structure. This variance may reduce the test reliability.

5.3 Although the most common conductive underlayments are liquid primers applied by trowel, roller, or spray, and which contain carbon or graphite fillers, others may take the form of the following:

5.3.1 Sheet-applied graphite veils,
5.3.2 Conductive polymers,
5.3.3 Conductive graphite fibers,
5.3.4 Conductive metallic fibers, and
5.3.5 Conductive metallic screening.

5.4 Liquid-applied conductive underlayments may be desirable as they can serve to address imperfections in the concrete surface and provide a better base for which to apply the lining.

5.5 This practice is intended for use only with new linings applied to concrete substrates. Inspecting a lining previously exposed to an immersion condition could result in damaging the lining or produce an erroneous detection of discontinuities due to permeation or moisture absorption of the lining. Deposits may also be present on the surface causing telegraphing. The use of a high voltage tester on a previously exposed lining is not recommended because of possible spark through which will damage an otherwise sound lining. A low voltage tester can be used but could produce erroneous readings.

5.6 The user may consider this practice when performance requirements of the lining in a specified chemical environment require assurance of a lining free of discontinuities.

5.7 Factors affecting the dielectric properties and test voltage shall be considered. Some factors are the curing time of liquid-applied linings; the possible presence of electrically conductive fillers or solvents, or both; the possible presence of air inclusions or voids; and the compatibility of conductive underlayments with the specified lining.

5.8 A continuous dc high voltage tester stresses a lining to a greater degree than the pulsating dc high voltage tester.

## 6. Apparatus

6.1 *High Voltage Spark Tester*—An electrical detector with a voltage rating in excess of 800 V. The detector is to consist of an electrical energy source, an exploring electrode, a ground connection, and ground wire. The detector shall be equipped with a visual or audible indicator, or both.

6.1.1 *Electrical Energy Source*—Either a-c, d-c, or pulsating d-c type with the appropriate test voltage.

6.1.2 *Exploring Electrode*—The full length shall be capable of maintaining continuous contact with the surface being inspected.

6.1.3 *Ground Wire*, stranded 14 to 16 gage copper wire.

6.1.4 *Visual or Audible Indicators*, or both, to signal a closed electrical circuit. Such signals shall be essential for testing the underlayment for electrical conductivity and for exposing discontinuities in the lining after it has been applied.

6.1.5 *High Voltage Pulsating DC Spark Tester*—A device used to locate discontinuities where electrical pulses are generating between 20 and 60 cps. Each pulse is on for a period of time between 20 and 200 µs.

6.1.6 *High Voltage Continuous DC Spark Tester*—A device used to locate discontinuities where the voltage is continuously present on the surface of the protective coating.

6.2 *Low Voltage Tester*—An electrical device powered by a 5 to 90 volt battery. The detector consists of an electrical energy source, an open-cell sponge electrode, a ground wire, and an audible indicator. The device may contain a variable range selector that has no effect on the sensitivity of the detector which must range between 80 000 and 100 000 Ω.

## 7. Hazards

7.1 Solvents retained in the applied underlayment or lining may create an explosive environment with the high voltage testers as well as produce an erroneous result.

## 8. Conductive Underlayments

8.1 The conductive underlayment shall not rely on the concrete substrate's electrical properties.

8.2 The specified lining shall be compatible with the specified conductive underlayment.

8.3 *Application*:

8.3.1 The finished conductive underlayment surface shall be relatively smooth. The conductive underlayment shall be considered part of the lining system and must be installed in accordance with the manufacturer's latest published instructions.

8.3.2 Visually verify that the conductive underlayment covers the entire area to be lined. Breaks at expansion joints and construction joints are allowable unless otherwise specified.

8.4 *Verification of Underlayment Conductivity*:

8.4.1 The surface of the applied conductive underlayment shall be clean, dry, free of oil, grease, dirt, or other contaminants and be sufficiently cured in accordance with the manufacturer's latest published instructions at the time the conductivity testing is performed. ( **Warning**—See Section 7.)

8.4.2 Verify the operation of the test instrument in accordance with Section 9.

8.4.3 Adjust the high-voltage test instrument in accordance with Section 12.

8.4.4 Ground the test instrument to the installed underlayment or other appropriate ground. If electrical isolation across an expansion joint is encountered, the ground wire must be moved to an appropriate ground in the same section being tested.

8.4.5 Place the exploring electrode on a nonconductive spacer so that an air gap between the surface of the underlayment and the electrode is equal to the maximum thickness of the lining.

8.4.6 The underlayment is conductive if the visual or audible indicator, or both, on the test instrument is activated.

8.5 *Test Sampling*:

8.5.1 A minimum of four test points shall be used for the first 100 $ft^2$ (9.2 $m^2$). Test points shall be approximately equally spaced within the test area. At least one additional test point shall be used for every 500 $ft^2$ (46.45 $m^2$) thereafter.

8.5.2 Test points most distant from the ground connection shall be included in the test sampling.

8.5.3 The specified lining shall not be applied until the conductivity of the underlayment or concrete has been verified.

## 9. Verifying Operation of High and Low Voltage Testers

9.1 Test electrical source for proper voltage output of high voltage testers.

9.2 Check battery for proper operation of low voltage testers.

9.3 Follow the equipment manufacturer's operating instructions for verifying the operation of the tester.

9.4 If the testers fail to signal, they shall be considered defective.

## 10. Adjustment of High-Voltage Spark Tester for Verifying Conductivity of Underlayment

10.1 Establish the test voltage based on the maximum specified thickness of the nonconductive lining, its dielectric strength, and the lining manufacturer's recommendations.

10.2 Following the equipment manufacturer's instructions, set and check the test voltage established in 10.1.

## 11. Procedures For Using Low Voltage Wet Sponge Tester

11.1 Attach the ground wire from the instrument ground output terminal to the conductive substrate and ensure positive electrical contact.

11.2 Attach the exploring sponge lead to the other output terminal.

11.3 Saturate the sponge with a solution consisting of tap water and a low sudsing wetting agent (such as used in photographic film development), combined at a ratio of 1 fluid oz (29.5 mL) wetting agent to 1 gal (3.785 L) water. The sponge shall be wetted sufficiently to barely avoid dripping of the solution while the sponge is moved over the coating.

11.4 Sodium chloride (salt) shall not be added to the wetting solution because of the potential erroneous indications of discontinuities. The salt, after drying on the coated surface, may form a continuous path of conductivity. It will also interfere with intercoat adhesion of additional coats.

11.5 Contact a bare spot on the conductive substrate with the wetted sponge to verify that the instrument is properly grounded. This procedure shall be repeated periodically during the test.

11.6 Move the sponge over the surface of the coating at a moderate rate approximately 1 ft/s (0.3 m/s), using a double pass over each area. Apply sufficient pressure to maintain a wet surface. If a discontinuity is detected, turn the sponge on end to determine the exact location of the discontinuity.

11.7 Discontinuities that require repair shall be identified with a marker that is compatible with the repair coating or one that is easily removed.

11.8 To prevent telegraphing (current traveling through a moisture path to a discontinuity, giving an erroneous indication), take care to ensure that the solution is wiped dry from a previously detected discontinuity before continuing the test.

11.9 The wetting agent must be completely removed by rinsing the holiday area prior to repair.

11.10 When a test is conducted between coats of a multicoat system, a wetting agent shall not be used.

## 12. Adjustment of High Voltage Spark Tester for Verifying Conductivity of the Applied Lining

12.1 Select the proper test voltage to provide reliable spark-over to locate a holiday under normal test conditions. The voltage selected must jump an air gap equal to the maximum specified dry film thickness of the lining being tested and not arc through the lining at the minimum specified dry film thickness.

12.2 Adjust the tester to the test voltage established in 12.1 as follows:

12.2.1 Connect a high-voltage voltmeter or a spark-gap calibrator between the electrode and the ground wire.

12.2.2 Switch the detector to the ON position.

12.2.3 Perform field checking of the test voltage with the electrode placed against the surface of the lining since the exploring electrode voltage may be reduced by the slight current flow to the lining.

12.2.4 If required, compare measured voltage with the selected test voltage. Depending on the type of tester, adjust to the selected voltage ±5 %.

12.2.5 Switch the detector to the OFF position.

12.2.6 Disconnect the voltmeter or spark-gap calibrator.

## 13. Testing for Verifying Continuity of Applied Lining

13.1 The surface of the applied lining shall be clean, dry, free of oil, grease, dirt, or other contaminants and be sufficiently cured in accordance with the manufacturer's latest published instructions at the time the testing is performed (**Warning**—See Section 7).

13.2 Attach the ground wire from the instrument ground terminal to the conductive underlayment or appropriate ground in the same manner as was required in 8.4.4. Make contact with the exploring electrode at a known discontinuity to verify that the instrument is properly grounded. For each ground location, make contact with a known discontinuity. A discontinuity may be produced by drilling a hole through the lining with a 1⁄16-in.

(1.59-mm) diameter drill bit. Conduct this test periodically during the test.

13.3 With the exploring electrode in continuous contact with the lining surface, move it over the entire surface of the lining at a rate of 1 ft/s (0.3 m/s) maximum in a sweeping motion with overlapping passes to ensure that the entire surface has been subjected to the test.

13.4 Identify discontinuities that require repair with a compatible marker.

13.5 Completely test the lining one time only. Repair all defects found in the lining and retest only those repaired areas.

## 14. Keywords

14.1 conductive underlayment; conductivity; discontinuities; high voltage spark testers; low voltage wet sponge testers