Standard Test Methods for Hookup Wire Insulation[1]

This standard is issued under the fixed designation D3032; 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.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope

1.1 These test methods cover procedures for testing hookup wire.

1.2 For the purposes of these test methods, hookup wire insulation includes all components of the insulation system used on single insulated conductors or an assembly of single insulated conductors such as a cable bundle and harness or flat ribbon cable. The insulating materials include not only the primary insulation over the conductor, but also insulating jackets over shielded constructions.

1.3 The test procedures and their locations are as follows:

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1.4 The values stated in SI units are to be regarded as standard. The values given in parentheses are mathematical conversions to inch-pound units that are provided for information only and are not considered standard.

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 and health practices and determine the applicability of regulatory limitations prior to use.* For specific precaution statements, see 12.2.1, 12.4.1.8, 18.1.3, Note 17, *and* 25.4.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D149 Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies

D150 Test Methods for AC Loss Characteristics and Permittivity (Dielectric Constant) of Solid Electrical Insulation

D257 Test Methods for DC Resistance or Conductance of Insulating Materials

D374 Test Methods for Thickness of Solid Electrical Insulation (Metric) D0374_D0374M

D412 Test Methods for Vulcanized Rubber and Thermoplastic Elastomers—Tension

D471 Test Method for Rubber Property—Effect of Liquids

D543 Practices for Evaluating the Resistance of Plastics to Chemical Reagents

D638 Test Method for Tensile Properties of Plastics

D1711 Terminology Relating to Electrical Insulation

D1868 Test Method for Detection and Measurement of Partial Discharge (Corona) Pulses in Evaluation of Insulation Systems

D2303 Test Methods for Liquid-Contaminant, Inclined-Plane Tracking and Erosion of Insulating Materials

D2307 Test Method for Thermal Endurance of Film-Insulated Round Magnet Wire

D2865 Practice for Calibration of Standards and Equipment for Electrical Insulating Materials Testing

D3183 Practice for Rubber—Preparation of Pieces for Test Purposes from Products

D3636 Practice for Sampling and Judging Quality of Solid Electrical Insulating Materials

[1] These test methods are under the jurisdiction of ASTM Committee D09 on Electrical and Electronic Insulating Materials and are the direct responsibility of Subcommittee D09.07 on Electrical Insulating Materials.

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[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.

D3638 Test Method for Comparative Tracking Index of Electrical Insulating Materials
D5032 Practice for Maintaining Constant Relative Humidity by Means of Aqueous Glycerin Solutions
D5374 Test Methods for Forced-Convection Laboratory Ovens for Evaluation of Electrical Insulation
D5423 Specification for Forced-Convection Laboratory Ovens for Evaluation of Electrical Insulation
D6054 Practice for Conditioning Electrical Insulating Materials for Testing (Withdrawn 2012)[3]
E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications
E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

2.2 *IEEE Standards:*[4]
Standard 98 Guide for the Preparation of Test Procedures for the Thermal Evaluation of Electrical Insulating Materials
Standard 101 Statistical Analysis of Thermal Life Test Data

2.3 *Federal Standard:*
Federal Specification for Tape, Gummed; Paper, Reinforced and Plain, for Sealing and Securing (PPP-T-45C)[5]

3. Terminology

3.1 *Definitions:*For definitions of terms used in these test methods, refer to Terminology D1711.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *capacitance unbalance (of a pair in a shielded cable), n*—the ratio, expressed as a percentage, of the difference in capacitance between each of two insulated conductors and the shield, to the capacitance between that conductor pair.

3.2.1.1 *Discussion*—Capacitance unbalance is also called coefficient of asymmetry or capacitance asymmetry, and is expressed in percent unbalance.

3.2.2 *cold bend test*—a test in which a specimen is slowly wrapped around a mandrel of a specified diameter after conditioning at a specified low temperature to determine that the primary insulation, primary jacket, overall jacket and any other layer of the wire or cable specimen maintains sufficient flexibility to withstand such bending at that low temperature without evidence of cracking.

3.2.3 *relative thermal endurance*—the comparison of the thermal endurance (as described by their Arrhenius plots) of two or more insulated wires designed for the same specific use; this usually implies the same size of conductor, but the insulation is of the thickness required for the particular use of each insulation.

3.2.4 *strip force*—force required to remove a specified length of insulation from an insulated wire specimen as determined by a specified test procedure.

3.2.5 *surface resistance, n*—see Terminology D1711.

3.2.5.1 *Discussion*—For a fixed electrode separation, the measured surface resistance of a given hookup wire decreases as the diameter increases.

3.2.6 *temperature index, n*—see Terminology D1711.

3.2.6.1 *Discussion*—For hookup wire, the symbol TI is used for temperature index and the preferred use of the TI symbol implies a time of 20 000 h obtained by analysis of aging data in which extrapolation is limited to no more than 25°C below the lowest aging temperature (See also Section 14).

3.2.7 *thermal end point time, n*—the time necessary for a specific property of a material, or a simple combination of materials, to degrade to a defined end point when aged at a specified temperature.

3.2.8 *thermal end point curve, n*—a graphical representation of a thermal end point at a specified aging temperature in which the value of a property of a material, or a simple combination of materials, is measured at room temperature and the values plotted as a function of time.

3.2.9 *thermal endurance, n*—see Terminology D1711.

3.2.9.1 *Discussion*—The stability of hookup wire insulation is estimated from changes in the results of voltage withstand tests on hookup wire specimens that have been heat aged, cooled to room temperature, flexed over a mandrel, immersed in salt water, and subjected to a specific applied voltage.

3.2.10 *voltage withstand (proof-voltage)test*—the application of a specified voltage for a specified time to a specified configuration of the insulation. Results are expressed as "pass" or "fail."

4. Sampling

4.1 Refer to the material specification for sampling plan covering specific types of hookup wire insulations.

4.2 Use Practice D3636 as a guide if the material specification does not include a sampling plan.

5. Dielectric Breakdown Voltage

5.1 *Significance and Use:*

5.1.1 A detailed statement of significance is given in Appendix X1 of Test Method D149.

5.2 *Apparatus:*

5.2.1 Use the electrical apparatus described in Test Method D149 for this test.

5.3 *Test Specimens:*

5.3.1 The test specimen shall consist of insulated wire 610 mm (24 in.) in length, or of the length required for the environmental exposure. Remove the insulation for a distance of 25 mm (1 in.) at each end and twist the ends together.

5.4 *Procedure:*

5.4.1 Immerse the test specimen to within 152 mm (6 in.) of the twisted ends in the water bath containing 5 % sodium chloride (NaCl) and 0.05 to 0.10 % wetting agent.[6]

5.4.2 Use the water solution as the ground electrode, and apply the voltage to the twisted end of the conductor.

[3] The last approved version of this historical standard is referenced on www.astm.org.

[4] Available from the Institute of Electrical and Electronics Engineers, Inc., 345 E. 47th St., New York, NY 10017.

[5] Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

[6] Triton X-100 manufactured by Rohm & Haas Co., Philadelphia, PA 19106, has been found satisfactory for this test method.

5.4.3 Raise the voltage from zero at a rate of 500 V/s until the specimen fails. If a flashover between the water solution and the twisted ends of the wire occurs, discard the specimen without retesting. Select longer specimens so that the distance between the water solution and the ends of the wire is sufficient to prevent flashover.

5.5 *Report:*

5.5.1 Report the following information:

5.5.1.1 Description of the specimen,

5.5.1.2 Voltage at which breakdown occurred,

5.5.1.3 Description of any previous environmental exposure given to the specimen before testing, and

5.5.1.4 Conditions under which the test was run.

6. Insulation Resistance

6.1 *Significance and Use:*

6.1.1 In high impedance circuits, insulation resistance is functionally important. In some cases, changes in insulation resistance indicates deterioration of other properties. Insulation resistance is also useful for quality control.

NOTE 1—The term "insulation resistance" is a standard term used in the hookup wire industry to designate the resistance of a specified length of insulated wire, normally expressed as ohm-1000 ft. This is not a true insulation resistance since a resistance for a known length can be calculated and, also, the tests are conducted in a manner to eliminate surface conduction. The value obtained in this type of measurement is actually a volume resistance, but will be referred to here as insulation resistance to avoid confusion in the hookup wire industry.

6.2 *Apparatus:*

6.2.1 *Battery Jar,* or other insulated vessel, large enough to immerse the specimen, filled with water containing 0.05 to 0.10 % wetting agent.[6] The water bath shall serve as one electrode.

6.2.2 Use apparatus described in Test Methods D257 for the resistance measurement.

6.3 *Test Specimens:*

6.3.1 The test specimen shall consist of a 8.3-m (or 26-ft) length of the insulated wire. Remove the insulation for a distance of 25 mm (1 in.) at each end and twist the ends together.

6.4 *Procedure:*

6.4.1 Immerse the specimen to within 152 mm (6 in.) of the twisted ends in the water bath, which is maintained at 23 ± 5°C (73 ± 9°F). Make an initial resistance measurement between the conductor and the water bath for the purpose of detecting nontypical values. Discard any specimen with a gross defect (that is, having an insulation resistance less than 1×10^6 Ω between the conductor and the water bath) and replace it with another specimen.

6.4.2 After 4 h, remeasure the resistance between the conductor and the water bath. Make the measurement at 500 (±10 %) d-c V, after an electrification time of 1 min, unless otherwise specified.

6.5 *Calculation:*

6.5.1 Calculate the insulation resistance as ohm-1000 ft as follows:

$$\text{Insulation resistance, } \Omega - 1000\text{ ft} = (R \times L)/1000 \tag{1}$$

where:

R = measured resistance, Ω, and
L = immersed length, 25 ft.

6.5.2 Calculate the insulation resistance as Ω-1000 m as follows:

$$\text{Insulation resistance, } \Omega - 1000\text{ m} = (R \times L')/1000 \tag{2}$$

where:

L' = immersed length, 8 m.

NOTE 2—Do not express insulation resistance as ohm-metre since this unit describes resistivity. It must be used as ohm for some unit of length.

6.6 *Report:*

6.6.1 Report the following information:

6.6.1.1 Description of the specimen,

6.6.1.2 Immersed length of the specimen,

6.6.1.3 Applied voltage,

6.6.1.4 Time of electrification,

6.6.1.5 Immersion time,

6.6.1.6 Measured resistance,

6.6.1.7 The insulation resistance of the specimen calculated inΩ -1000 ft (or in Ω-1000 m), and

6.6.1.8 Number of specimens discarded.

7. Surface Resistance

7.1 *Significance and Use:*

7.1.1 At high humidities, surface conduction is responsible for the largest part of the leakage current in service (for example, at the terminations of bundled hookup wires).

7.1.2 Additional statements on the significance of surface resistance can be found in Test Methods D257.

7.2 *Apparatus:*

7.2.1 *Test Chamber*—A suitable test chamber can be made from a vessel fitted with a cover through which leads have been sealed. The leads can be made from polytetrafluoroethylene (PTFE)-insulated wire, sealed with paraffin wax or silicone grease as they pass through the cover. PTFE-insulated feed-through bushings can also be used in place of the wires (Fig. 1).

7.2.2 As an alternative method, a paraffin wax collar can be fitted to the top of a glass vessel and tin-coated size 1.02 mm (AWG No. 18) solid copper wires can be sealed through the paraffin wax. A glass cover can then be used to seal the top of the test chamber (Fig. 2).

7.2.3 Use the test instruments described in Test Methods D257 for the resistance measurement.

7.2.4 The electrical resistance of the chamber, measured between the lead wires under the conditions given in 7.3 with no specimens in place, shall be greater than 10^{12} Ω.

7.3 *Test Specimens:*

7.3.1 Measure five specimens.

7.3.2 The specimens shall consist of 152-mm (6-in.) lengths of finished wire, cleaned in accordance with the procedure recommended by the manufacturer. Handle the specimens subsequently with maximum care, preferably with clean lint-free gloves to avoid even the slightest contamination, including direct contact with the fingers. Provide each cleaned specimen near its center with two electrodes spaced 25.4 ± 0.1 mm (1.0 ± 0.005 in.) apart between their nearest edges. Each electrode