Designation: D350 – 21

Standard Test Methods for Flexible Treated Sleeving Used for Electrical Insulation[1]

This standard is issued under the fixed designation D350; 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 electrical insulating sleeving comprising a flexible tubular product made from a woven textile fibre base, such as cotton, rayon, nylon, or glass, thereafter impregnated, or coated, or impregnated and coated, with a suitable dielectric material.

1.2 The procedures appear in the following sections:

Procedures	Section(s)
Selection of Test Material	5
Conditioning	6
Dimensions	7 to 11
Dielectric Breakdown Voltage	12 to 17
Brittleness Temperature	18 to 21
Flammability (See Test Methods D8355)	22 to 23
Dielectric Breakdown Voltage After Short-Time Aging	24 to 28
Oil Resistance	29 to 32
Thermal Endurance	33 to 39
Compatibility of Sleeving with Magnet Wire Insulation	40 to 54
Solvent Resistance	55 to 60
Hydrolytic Stability	61 to 67
Effect of Push-Back After Heat Aging	68 to 73

1.3 The values stated in inch-pound units, except for °C, are to be regarded as the standard. The values in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.4 This is a fire-test-response standard. See Test Methods D8355, which contains procedures for flammability tests.

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.* For specific hazard statements, see 40.2 and 58.1.1.

NOTE 1—This standard resembles IEC 60684-2, Specification for Flexible Insulating Sleeving—Part 2 Methods of Test, in a number of ways, but is not consistently similar throughout. The data obtained using either standard are not necessarily technically equivalent.

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.*

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

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

D471 Test Method for Rubber Property—Effect of Liquids

D746 Test Method for Brittleness Temperature of Plastics and Elastomers by Impact

D876 Test Methods for Nonrigid Vinyl Chloride Polymer Tubing Used for Electrical Insulation

D1711 Terminology Relating to Electrical Insulation

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

D3487 Specification for Mineral Insulating Oil Used in Electrical Apparatus

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

D5423 Specification for Forced-Convection Laboratory Ovens for Evaluation of Electrical Insulation

D6054 Practice for Conditioning Electrical Insulating Materials for Testing (Withdrawn 2012)[3]

D8355 Test Methods for Flammability of Electrical Insulating Materials Used for Sleeving or Tubing

E145 Specification for Gravity-Convection and Forced-Ventilation Ovens

E176 Terminology of Fire Standards

[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.

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

2.2 *IEEE Standard:*[4]
IEEE 101 Guide for the Statistical Analysis of Thermal Life Test Data
2.3 *IEC Standard:*[5]
IEC 60684-2 Specification for Flexible Insulating Sleeving—Part 2 Methods of Test
2.4 *ISO Standard:*[6]
ISO 13943 Fire Safety—Vocabulary

3. Terminology

3.1 *Definitions:*
3.1.1 Use Terminology E176 and ISO 13943 for definitions of terms used in this test method and associated with fire issues. Where differences exist in definitions, those contained in Terminology E176 shall be used. Use Terminology D1711 for definitions of terms used in this test method and associated with electrical insulation materials.
3.2 *Definitions of Terms Specific to This Standard:*
3.2.1 *size, n*—a numerical designation which indicates that the inside diameter of the sleeving lies within the limits prescribed in Table 1.

3.2.2 *wall thickness, n*—one half the difference between the outside diameter of the sleeving mounted on a loosely fitting gauge rod and the diameter of the gauge rod when measured in accordance with 9.2.

4. Apparatus and Materials

4.1 Ovens used in these test methods shall meet the requirements of Specification D5423.

5. Selection of Test Material

5.1 In the case of sleeving on spools or in coils, not less than three turns of the product shall be removed before the selection of material from which test specimens are to be prepared.

5.2 In the case of sleeving offered in cut lengths, test specimens shall not be prepared from material closer than 1 in. (25 mm) from each end.

5.3 Specimens for test shall not show obvious defects unless the purpose of the test is to determine the effect of such defects.

5.4 Specimens shall be prepared from samples selected in accordance with Practice D3636. The sampling plan and acceptance quality level shall be as agreed upon between the user and the producer.

6. Conditioning

6.1 Unless otherwise specified, a standard laboratory atmosphere of 50 ± 5 % relative humidity and 23 ± 2 °C (73.4 ± 3.6 °F) shall be used in conducting all tests and for conditioning specimens for a period of at least 18 h prior to testing.

TABLE 1 ASTM Standard Sizes for Flexible Sleeving

Size	Inside Diameter, in. (mm)	
	Max	Min
1 in.	1.036 (26.3)	1.000 (25.4)
⅞ in.	0.911 (23.1)	0.875 (22.2)
¾ in.	0.786 (20.0)	0.750 (19.1)
⅝ in.	0.655 (16.6)	0.625 (15.9)
½ in.	0.524 (13.3)	0.500 (12.7)
7/16 in.	0.462 (11.7)	0.438 (11.1)
⅜ in.	0.399 (10.1)	0.375 (9.5)
No. 0	0.347 (8.8)	0.325 (8.3)
No. 1	0.311 (7.9)	0.289 (7.3)
No. 2	0.278 (7.1)	0.258 (6.6)
No. 3	0.249 (6.3)	0.229 (5.8)
No. 4	0.224 (5.7)	0.204 (5.2)
No. 5	0.198 (5.0)	0.182 (4.6)
No. 6	0.178 (4.5)	0.162 (4.1)
No. 7	0.158 (4.0)	0.144 (3.7)
No. 8	0.141 (3.6)	0.129 (3.3)
No. 9	0.124 (3.1)	0.114 (2.9)
No. 10	0.112 (2.8)	0.102 (2.6)
No. 11	0.101 (2.6)	0.091 (2.31)
No. 12	0.091 (2.31)	0.081 (2.06)
No. 13	0.082 (2.08)	0.072 (1.83)
No. 14	0.074 (1.88)	0.064 (1.63)
No. 15	0.067 (1.70)	0.057 (1.45)
No. 16	0.061 (1.55)	0.051 (1.30)
No. 17	0.054 (1.37)	0.045 (1.14)
No. 18	0.049 (1.24)	0.040 (1.02)
No. 20	0.039 (0.99)	0.032 (0.81)
No. 22	0.032 (0.81)	0.025 (0.64)
No. 24	0.027 (0.69)	0.020 (0.51)

6.2 In the case of dielectric breakdown voltage tests after humidity conditioning, specimens shall be conditioned for 96 h in an atmosphere of 93 ± 3 % relative humidity and 23 ± 2 °C (73.4 ± 3.6 °F) before testing. If a conditioning cabinet is used, specimens shall be tested for dielectric breakdown voltage within 1 min after removal from the cabinet.

6.3 For details regarding conditioning, refer to Practice D6054.

DIMENSIONS

7. Apparatus

7.1 *Gauge Rods*—Standard gauge rods shall be made of steel and shall have smooth surfaces and rounded edges. One rod is required for each of the maximum and minimum diameters shown in Table 1 for each size. Each rod shall be within ±0.005 in. (±6.012 mm) of the values shown in Table 1.

8. Test Specimens

8.1 Five test specimens of at least 7 in. (180 mm) in length shall be cut from material obtained in accordance with Section 5.

9. Procedure

9.1 *Inside Diameter*—Pass the minimum gauge rod for the size sleeving under test into the specimen for a distance of 5 in.

[4] Available from Institute of Electrical and Electronics Engineers, Inc. (IEEE), 445 Hoes Ln., Piscataway, NJ 08854-4141, http://www.ieee.org.
[5] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.
[6] Available from International Organization for Standardization (ISO), ISO Central Secretariat, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, https://www.iso.org.

(127 mm) without expanding the wall of the sleeving. If the rod has a snug fit, then consider the specimen as having an inside diameter equal to the diameter of the rod. If the minimum gauge rod fits loosely, insert the maximum gauge rod into the specimen. If the maximum gauge rod passes freely into the specimen for a distance of 5 in. with a snug fit, or if it expands the wall of the specimen, then consider the sleeving to be of that size which falls within the limits of the maximum and minimum inside diameters as represented by the gauge rods.

9.2 *Wall Thickness*—Insert in the specimen the largest standard gauge rod that will pass freely into the sleeving. Apply a micrometer over the specimen and make thickness measurements as specified in Method C of Test Methods D374 except that the force on the pressor foot shall be 3 oz (85 g). Obtain the average of five thickness readings taking the micrometer readings at approximately 90° intervals about the circumference of the specimen and spaced lineally approximately 0.25 in. (6 mm). Methods A and B of Test Methods D374 can be used as alternative methods where agreed upon between the manufacturer and purchaser. Compute wall thickness as half the distance between the outside diameter of the mounted sleeving and the diameter of the gauge rod.

10. Report

10.1 Report the following information:
10.1.1 Identification of the sleeving,
10.1.2 Method of measurement if other than Method C,
10.1.3 Size of sleeving, and
10.1.4 Wall thickness.

TABLE 2 Estimated Precision of Wall Thickness Measurement

Sleeving Type	Nominal Value, in. (mm)		$(Sr)_j$, in. (mm)		$(SR)_j$, in. (mm)	
Acrylic	0.0213	(0.54)	0.0007	(0.018)	0.0017	(0.043)
PVC	0.0237	(0.60)	0.0007	(0.018)	0.0021	(0.053)
Silicone Rubber	0.0331	(0.84)	0.0012	(0.030)	0.0019	(0.048)

11. Precision and Bias

11.1 *Precision*—The overall estimates of the precision within laboratories $(Sr)_j$ and the precision between laboratories $(SR)_j$ for the determination of wall thickness are given in Table 2 for three selected materials. These estimates are based on a round robin of the three materials with six laboratories participating.[7]

11.2 *Bias*—This test method has no bias because the value for wall thickness is determined solely in terms of this test method itself.

DIELECTRIC BREAKDOWN VOLTAGE

12. Significance and Use

12.1 The dielectric breakdown voltage of the sleeving is of importance as a measure of its ability to withstand electrical stress without failure. This value does not correspond to the dielectric breakdown voltage expected in service, but is of value in comparing different materials or different lots, in controlling manufacturing processes or, when coupled with experience, for a limited degree of design work. The comparison of dielectric breakdown voltage of the same sleeving before and after environmental conditioning (moisture, heat, and the like) gives a measure of its ability to resist these effects. For a more detailed discussion, refer to Test Method D149.

13. Apparatus

13.1 *Inner Electrode*—A straight suitable metallic conductor which fits snugly into the sleeving, without stretching the wall, in such a manner that one end of the wire is exposed and can be used to support the specimen.

13.1.1 For specimens having an inside diameter greater than about size 8, the use of stranded conductors or of a bundle of wires of smaller size, is recommended, instead of using a solid conductor.

13.2 *Outer Electrode*—Strips of soft metal foil 1-in. (25 mm) wide and not more than 0.001 in. (0.03 mm) in thickness.

14. Procedure A—Straight Specimens

14.1 *Test Specimens*—Ten specimens 7 in. (180 mm) long shall be prepared for each conditioning test (see Section 6) from material selected in accordance with Section 5.

14.2 *Procedure:*

14.2.1 After conditioning in accordance with 6.1, determine the dielectric breakdown voltage in accordance with Test Method D149 except as specified in 14.2.2 and 14.2.3.

14.2.2 Mount a sleeving specimen on the inner electrode. Wrap the outer electrode tightly on the outside of the sleeving at a distance of not less than 1 in. (25 mm) from the ends of the specimens. Snugly wrap the foil over the sleeving. Wind two more turns of foil over the first turn, leaving a free end of about 0.5 in. (13 mm) to which an electrical contact can be made.

14.2.3 Determine the breakdown voltage, in accordance with Test Method D149 by the short time method, increasing the voltage from zero at a rate of 0.5 kV/s. Calculate the average breakdown voltage for the ten tests.

15. Procedure B—90° Bent Specimens

15.1 *Test Specimens*—Ten specimens 4 in. (100 mm) long shall be prepared for each conditioning test (see Section 6) from material selected in accordance with Section 5.

15.2 *Procedure:*

15.2.1 Mount a sleeving specimen on the inner electrode.

15.2.2 Bend the specimen through an angle of 90 ± 2° over a smooth mandrel having a diameter of ten times the nominal inside diameter of the specimen. Arrange the bend so that it is centrally located on the specimen.

15.2.3 Condition the samples as specified in 6.1.

15.2.4 Determine the dielectric breakdown voltage of the bent specimen using the following procedure:

15.2.4.1 Carefully wrap a strip of metal foil as in 14.2.2 snugly over the specimens at the bend. In accordance with Test Method D149 apply a voltage starting at zero and increasing at

[7] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D09-1024. Contact ASTM Customer Service at service@astm.org.