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An American National Standard

Standard Test Methods for Flexible Composite Materials Used for Electrical Insulation[1]

This standard is issued under the fixed designation D 2381; 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.

ε[1] NOTE—Editorial changes were made throughout in November 1999.

1. Scope

1.1 These test methods cover procedures for testing flexible materials consisting of two or more insulating components combined to form a composite to be used as an electrical insulation.

1.2 The procedures appear in the following order:

Procedure	Section	ASTM Reference Method
Breaking Strength	24 to 30	D 202, D 1458
Conditioning	4	...
Dielectric Breakdown Voltage	9 to 15	D 149, D 295
Tearing Resistance	31 to 36	D 689, D 827, D 1004
Thickness	5 to 8	D 374
Volume Resistivity	16 to 23	D 257

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

1.4 *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.* A specific warning statement is given in 13.2.

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 202 Test Methods for Sampling and Testing Untreated Paper Used for Electrical Insulation[2]

D 257 Test Methods for DC Resistance or Conductance of Insulating Materials[2]

D 295 Test Methods for Varnished Cotton Fabrics Used for Electrical Insulation[2]

D 374 Test Methods for Thickness of Solid Electrical Insulation[2]

D 689 Test Method for Internal Tearing Resistance of Paper[3]

D 827 Test Method for Edge Tearing Strength of Paper[4]

D 1004 Test Method for Initial Tear Resistance of Plastic Film and Sheeting[5]

D 1458 Test Methods for Fully Cured Silicone Rubber-Coated Glass Fabric and Tapes for Electrical Insulation[2]

D 1711 Terminology Relating to Electrical Insulation[2]

D 6054 Practice for Conditioning Electrical Insulating Materials for Testing[6]

3. Terminology

3.1 *Definitions:*

3.1.1 For definitions of terms used in these test methods see Terminology D 1711.

4. Conditioning

4.1 Unless otherwise specified in the individual specification, condition test specimens for the time specified in 4.1.1 or 4.1.2 in the standard laboratory atmosphere of Practice D 6054 at the tightened tolerances of ±2 % relative humidity and ±1°C. Conduct tests immediately after removal from the conditioning room or chamber. In matters of dispute, 4.1.1 shall be considered the referee procedure.

4.1.1 Condition for 96 h.

4.1.2 Condition for 48 h.

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[1] These test methods are under the jurisdiction of ASTM Committee D-9 on Electrical and Electronic Insulating Materials and are under the jurisdiction of Subcommittee D09.19 on Dielectric Sheet and Roll Products.

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

[3] *Annual Book of ASTM Standards*, Vol 15.09.

[4] Discontinued, see 1981 *Annual Book of ASTM Standards*, Vol 15.09.

[5] *Annual Book of ASTM Standards*, Vol 08.03.

[6] *Annual Book of ASTM Standards*, Vol 10.02.

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THICKNESS

5. Significance and Use

5.1 The importance of space factor, particularly in slot cell design and in other electrical equipment, makes proper determination of thickness essential.

5.2 Some properties, such as dielectric breakdown, vary with the thickness of the material; and certain properties such as volume resistivity cannot be determined without a knowledge of thickness.

6. Test Specimens

6.1 In the case of rolls or sheets, across the entire width cut a specimen 1 in. (25.4 mm) wide.

6.2 In the case of tapes, the specimens shall be 36 in. (920 mm) long.

7. Procedure

7.1 Measure the thickness in accordance with Test Methods D 374, with the following modifications:

7.1.1 Raise the presser foot the distance necessary to allow free movement of the specimen from measurement to measurement position. Carefully lower the presser foot this distance.

7.1.2 Use Methods C or D unless otherwise agreed upon between the user and supplier.

7.1.3 In the case of rolls and sheets, take ten measurements equally spaced across the width of the specimen. The thickness of the material shall be the average of the ten measurements.

7.1.4 In the case of tapes, unless otherwise specified, take ten measurements equally spaced along the length of each specimen. The thickness of the tape shall be the average of the ten measurements.

7.1.4.1 Test Method D 374 prohibits the measurement of thickness within 6 mm of a specimen edge. Users of Test Methods D 2381 may ignore this directive if narrow tape specimens are being tested for thickness.

8. Report

8.1 Report the average, maximum, and minimum thickness in inches (millimetres).

DIELECTRIC BREAKDOWN VOLTAGE

9. Significance and Use

9.1 See the general statement on the significance of the dielectric breakdown voltage test as prescribed in Test Method D 149.

9.2 Flexible composite materials are frequently treated with a resin or varnish in the completed assembly of electrical equipment. The dielectric breakdown voltage of the untreated composite may therefore be of less significance than that of the assembly after treatment.

10. Apparatus

10.1 *Electrical Apparatus*—The apparatus described in Test Method D 149 shall be used.

10.2 *Electrodes*:

10.2.1 Cylindrical electrodes, ¼ in. (6.3 mm) in diameter with edges rounded to a radius of 1/32 in. (0.8 mm) (Type 3 of Test Method D 149) shall be used to determine dielectric breakdown voltage of tapes, also rolls and sheet materials to be compared with tape.

10.2.2 Cylindrical electrodes, 2 in. (50.8 mm) in diameter and 1 in. (25.4 mm) in length with the edges rounded to a radius of ¼ in. (Type 1) shall be used to determine dielectric breakdown voltage of rolls and sheet materials.

10.2.3 The ¼-in. electrodes shall be mounted in a test assembly that permits clamping the specimen between pressure gaskets to eliminate voltage flashover, as described in the Appendix to Test Methods D 295.

10.2.4 The 2-in. electrodes may be mounted in a test assembly that permits clamping the specimen between pressure gaskets, but this is not mandatory. Specimen size shall be increased when flashover occurs with ungasketed 2-in. electrodes.

11. Test Specimens

11.1 In the case of rolls and sheets, cut specimens at least 6 in. (150 mm) wide or of adequate width and suitable length to prevent flashover.

11.2 In the case of tape, cut specimens the width of the tape with a maximum width of 2 in. (50.8 mm) and a suitable length.

12. Conditioning

12.1 Condition specimens in accordance with Section 4.

13. Procedure

13.1 Determine the dielectric breakdown voltage in accordance with Test Method D 149, except as modified in Sections 10-12 of this test method.

13.2 **Warning**—*Lethal voltages are a potential hazard during the performance of this test. It is essential that the test apparatus, and all associated equipment electrically connected to it, be properly designed and installed for safe operation. Solidly ground all electrically conductive parts which it is possible for a person to contact during the test. Provide means for use at the completion of any test to ground any parts which were at high voltage during the test or have the potential for acquiring an induced charge during the test or retaining a charge even after disconnection of the voltage source. Thoroughly instruct all operators as to the correct procedures for performing tests safely. When making high voltage tests, particularly in compressed gas or in oil, it is possible for the energy released at breakdown to be sufficient to result in fire, explosion, or rupture of the test chamber. Design test equipment, test chambers, and test specimens so as to minimize the possibility of such occurrences and to eliminate the possibility of personal injury. If the potential for fire exists, have fire suppression equipment available.*

13.3 Make tests in air at standard laboratory conditions unless otherwise agreed upon between the user and supplier.

13.4 Make tests using the short-time test with the voltages increased at the rate of 500 V/s.

14. Report

14.1 Report the following information:

14.1.1 Test method used for determining the dielectric breakdown voltage,

14.1.2 Thickness, average value as reported in 7.1,

14.1.3 Average, minimum, and maximum dielectric breakdown voltage, in volts, and

14.1.4 Room temperature and relative humidity in the test area.

15. Precision and Bias

15.1 This test method has been in use for many years, but no information has been presented to ASTM upon which to base a statement of precision. No activity has been planned to develop such information.

15.2 *Bias*—A statement of bias is not applicable in view of the unavailability of a standard reference material for this property.

VOLUME RESISTIVITY AT ELEVATED HUMIDITY

16. Significance and Use

16.1 See Test Methods D 257.

16.2 Flexible composite materials are commonly used as insulation of slot cells in armatures of rotating electrical equipment. Exposure to moisture may be of significance in applications where the slot cell liners are not completely covered by a resin or varnish. In such cases, the adsorption or absorption of water may lower the effectiveness of the slot liner. Therefore, this test is of value in the comparison and selection of materials for use as slot liners.

17. Apparatus

17.1 Apparatus used shall conform to those described in Test Methods D 257. Electrode systems employing flat, circular guarded electrodes have been found to be useful.

18. Test Specimens

18.1 Prepare and test at least five specimens from each sample. The specimens shall be 4 by 4 in. (100 by 100 mm).

19. Conditioning

19.1 Condition the specimens for 72 h at 23 ± 1°C and 90 ± 1 % relative humidity without electrodes being applied (unless silver paint electrodes are used). The humidity chamber shall be a closed desiccator type or other closed chamber with electrical connections installed that meets the stated temperature and relative humidity conditions.

20. Procedure

20.1 After conditioning, open the humidity chamber and install the electrodes as rapidly as feasible. Reclose the chamber and maintain at 23 ± 1°C and 90 ± 1 % relative humidity for an additional 24 h (see Note 1). Measure the volume resistance in accordance with the general procedures of Test Methods D 257, using an applied voltage of 500 V and electrification time of 1 min.

NOTE 1—If silver paint electrodes are used, omit these steps and condition for 96 h with electrodes.

21. Calculation

21.1 Calculate the volume resistivity in ohm/centimetres in accordance with Test Methods D 257.

22. Report

22.1 Report the following information:

22.1.1 Voltage stress,

22.1.2 Type and size of electrodes,

22.1.3 Description of the instrumentation,

22.1.4 Average thickness of each specimen,

22.1.5 Measured volume resistance of each specimen,

22.1.6 Description of the material tested, and

22.1.7 The volume resistivity calculated in 21.1.

23. Precision and Bias

23.1 This test method has been used for many years, but no information has been presented to ASTM upon which to base a statement of precision. No activity has been planned to develop such information.

23.2 *Bias*—A statement of bias is not applicable in view of the unavailability of a standard reference material for this property.

BREAKING STRENGTH

24. Significance and Use

24.1 The breaking strength of flexible composite material is a measure of the ability of the material to withstand pulling while being applied in service.

25. Apparatus

25.1 A power-driven testing machine as described in Test Method D 202 shall be used. The machine shall be graduated to read 1 lb or ½ kg or less per scale division for testing specimens breaking at 50 lb (22.7 kg) or over, and to 0.5 lb or ¼ kg or less for testing specimens breaking under 50 lb. The machine shall be equipped with specimen-gripping devices as described in 25.2 or 25.3.

25.2 Two flat-jawed clamps fitted with crocus cloth facings shall be used for clamping the specimen between the jaws.

25.3 Two gripping devices of the drum type as described in Fig. 1 of Test Methods D 1458, shall be provided, in which case pins as indicated will be required for securing the specimen on the cylinders.

26. Test Specimens

26.1 Cut five 1-in. (25-mm) width specimens from the sheet in the machine direction (parallel to length) and five 1-in. width specimens from the sheet in the cross-machine direction (perpendicular to the length). Specimens shall have a minimum length of 10 in. (250 mm).

26.2 Cut five specimens 10 in. in length from the rolls. Maximum width shall not exceed 1 in. (25.4mm).

27. Conditioning

27.1 Condition specimens in accordance with 4.1.

28. Procedure

28.1 Adjust the distance between jaws or drum axes to 6 in. (150 mm). Carefully align the specimen to make the breaking force parallel to the length of the specimen.

28.2 Set the movable jaw speed to 12 ± ½ in./min (300 ± 12 mm/min).

28.3 In the case of flat jaws, clamp the specimen between two pieces of crocus cloth, the abrasive side facing the metal jaw.

28.4 In the drum-type gripping device, loop the specimen around a binding pin and insert in the hole provided in such a manner that the fit is neither too tight nor too loose.

29. Report

29.1 Report the following information:

29.1.1 The average, maximum, and minimum breaking strengths in pounds per inch width or newtons per metre,

29.1.2 The width and nominal thickness, and

29.1.3 The breaking strengths in the machine and cross-machine directions separately.

30. Precision and Bias

30.1 This test method has been used for many years, but no information has been presented to ASTM upon which to base a statement of precision. No activity has been planned to develop such information.

30.2 *Bias*—A statement of bias is not applicable in view of the unavailability of a standard reference material for this property.

TEARING RESISTANCE

31. Scope

31.1 This test method covers the determination of resistance to initial tearing using a procedure commonly referred to as the Graves test. It is applicable to a variety of flexible composite materials.

32. Significance and Use

32.1 A high level of resistance to tearing stresses is often desirable in flexible composite materials used, for example, in slot cell lining and in dry-type transformer insulation applications. Such stresses as may initiate rupture by tearing are often of greater importance than stresses that cause tear propagation.

33. Test Specimens

33.1 Cut five specimens in each of the following directions using the die described in Test Method D 1004:

33.1.1 *Machine Direction*—Cut with the longest dimension parallel to the cross-machine direction of the material and label MD.

33.1.2 *Cross-Machine Direction*—Cut with the longest dimension parallel to the machine direction of the material and label CMD.

34. Procedure

34.1 Test the specimens using the procedure described in Test Method D 1004 except that the rate of jaw separation shall be within the limits of 2 to 4 in./min (50 to 100 mm/min).

34.2 Record the value for tearing resistance in newtons or pounds-force for each specimen. Calculate the average of the five specimens as the Graves tear resistance.

35. Report

35.1 Report the following information:

35.1.1 Identification of the material tested, and

35.1.2 Average Graves tear resistance in newtons or pounds-force.

36. Precision and Bias

36.1 No activity has been planned to develop information to assess the precision of this test method. The techniques used and the properties measured in this test method are similar to those measured in Test Method D 1004 and it is expected that the precision will also be similar.

36.2 *Bias*—A statement of bias is not applicable in view of the unavailability of a standard reference material for this property.

37. Keywords

37.1 breaking strength; dielectric breakdown voltage; flexible composite materials; tearing resistance

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