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An American National Standard

Standard Test Methods for Nonmetallic Semi-Conducting and Electrically Insulating Rubber Tapes[1]

This standard is issued under the fixed designation D 4325; 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 Department of Defense.

1. Scope

1.1 These test methods cover the methods and procedures for testing electrically insulating and semi-nonmetallic conducting rubber tapes designed for splicing, terminating, and sheath repair of electrical wire and cable.

1.2 The test methods appear in the following sections:

	Section
Referenced Documents	2
Conditioning	5-6
Dielectric Strength	35-40
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1.3 The SI values are the standard. The inch-pound values given in parentheses are for information purposes only.

NOTE 1—There is no IEC equivalent to these methods.

1.4 Unless otherwise stated, measurements are made on tapes from which the removable separator has been removed.

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 43.1.

1.6 This is a fire-test response standard.

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 150 Test Methods for AC Loss Characteristics and Permittivity (Dielectric Constant) of Solid Electrical Insulating Materials[2]

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

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

D 412 Test Methods for Vulcanized Rubber and Thermoplastic Rubbers and Thermoplastic Elastomers—Tension[3]

D 470 Test Methods for Crosslinked Insulations and Jackets for Wire and Cable[2]

D 750 Test Method for Rubber Deterioration in Carbon-Arc Weathering Apparatus[3]

D 4388 Specification for Nonmetallic Semi-Conducting and Electrically Insulating Rubber Tapes[4]

D 4496 Test Method for DC Resistance or Conductance of Moderately Conductive Materials[4]

E 591 Practice for Safety and Health Requirements Relating to Occupational Exposure to Ozone[5]

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *fusion, n*—that property of rubber tape which causes adjacent layers of tape to become bonded (amalgamated) or adhered together when the tape is stretched and wound upon itself in layers.

SAMPLING

4. Sample and Specimen Requirements

4.1 Unless otherwise required by the detailed product specifications, take the rubber tapes at random from each shipment as follows:

Number of Rolls in Shipment	*Number of Sample Rolls*
50 to 200	2

[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 Flexible and Rigid Insulating Materials.

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

[3] *Annual Book of ASTM Standards*, Vol 09.01.

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

[5] Discontinued, see *1991 Annual Book of ASTM Standards*, Vol 11.03.

201 to 500	3
501 to 1000	4
1001 to 5000	5

4.2 For shipments in excess of 5000 rolls, take one additional roll for each additional 1000 rolls or fraction thereof.

4.3 A shipment consists of material shipped or intended for shipment to a customer and covered by one bill of lading.

4.4 Test each sample roll in conformance to all requirements of the specification.

4.5 All test methods in this standard are intended to produce a single value for a single roll. Any reference to averaging of measurements refers to test averaging on a single roll and not to the average of all sample rolls.

4.6 Remove and discard at least 610 mm (24 in.) of the outer layer of each roll before taking test specimens.

4.7 Remove the test specimen from the roll at a slow, uniform rate without jerking.

CONDITIONING

5. Significance and Use

5.1 The physical and electrical properties, including break strength, elongation, dielectric strength, dissipation factor, permittivity, fusion, etc., will vary with temperature and moisture content. Control the temperature and moisture content of the sample for these test methods to yield consistent and reproducible results.

6. Procedure

6.1 For referee purposes, subject the rolls to standard atmospheric conditions of 23 ± 2°C (73.4 ± 3.6°F) and 50 ± 2 % relative humidity for a minimum period of 16 h before specimens are removed for test.

6.2 Unless otherwise specified, condition all test specimens for a period of 1 h and conduct the tests in a standard laboratory atmosphere at 23 ± 2°C (73.4 ± 3.6°F) and 50 ± 2 % relative humidity.

FUSION

7. Significance and Use

7.1 Fusion is responsible for holding the tape in place to form a permanent compressive force about a conductor or insulator in actual application.

8. Apparatus

8.1 *Winding Fixture*—The winding fixture is designed to hold a metal rod at each end and is fitted with a crank or other device to rotate the rod so that the specimen may be wound thereon. Attach the fixture to a rigid support with the rod held in a horizontal position.

8.2 *Rods*—Any suitable metal of 3-mm (0.125-in.) diameter and a minimum of 229 mm (9.0 in.) in length.

8.3 *Rule*, graduated in inches, 762-mm (30-in.) minimum length.

8.4 *Rule*, graduated in 0.4 mm (1⁄64 in.).

8.5 *Razor Blades*.

8.6 *Board*, with 3-mm (0.125-in.) diameter holes spaced about 50 mm (2 in.) apart on its surface to provide a base for supporting the rods in a near-vertical position.

9. Procedure

9.1 Prepare three specimens by cutting three strips of tape 280 mm (11 in.) in length from the sample roll selected and conditioned in accordance with Sections 4-6. Prepare and wind specimens in a manner that prevents oils or other contaminants from getting on the bonding surface of the tape.

9.2 Mount the rod horizontally in the winding fixture.

9.3 Attach the strip of tape near one end of the rod by winding the strip upon itself using 25 mm (1 in.) of the tape. Place the 762-mm (30-in.) rule next to the 254-mm (10-in.) tape strip. Stretch the tape strip to the desired length corresponding to percent elongation as specified in the product specification (Specification D 4388, Table 1).

9.4 Move the tape to the proper angle and rotate the rod so that the tape is wrapped on the rod with a one-half lap for a length of 178 mm (7.0 in.).

9.5 Change the angle of the tape and repeat the procedure in 9.4 winding back toward the start of the first wrap so that the second one-half overlap wrap is wound over the first wrap to provide a four layer build-up of tape.

9.6 After the final wrap, maintain constant pressure on the tape strip and score the tape with a new razor blade at the top of the rod, parallel to the rod. Break the tape on the score line, removing the tab. Remove the test specimen from the fixture and roll the specimen so formed between the palm of the hands. This completes the preparation of the test specimen.

9.7 Insert the wrapped specimen in the holes in the base of the board and allow them to condition at 23.0 ± 2°C (73.4 ± 3.6°F) and 50 ± 2 % relative humidity for 24 h. At the end of this period, if there is any flagging (end-lifting) of the tape, measure the length of the flag to the nearest 0.4 mm (1⁄64 in.), taking care not to cause additional unwrapping in the measuring operation Record the maximum, minimum and average length of the flag.

10. Report

10.1 Report the following information:

10.1.1 Identification of the tape tested, and

10.1.2 Pass or fail depending on the requirements outlined in the product specification (see Specification D 4388).

DIMENSIONS—LENGTH, WIDTH, AND THICKNESS

11. Significance and Use

11.1 Measurements of length, width, and thickness are necessary to ensure a customer is receiving the correct quantity of tape. The thickness measurement is of particular value in controlling uniformity and providing design criteria, as well as being used in the measurement of physical and electrical properties.

12. Apparatus

12.1 *Steel Rule*, capable of measuring to the nearest 0.4 mm (1⁄64 in.).

12.2 *Thickness Gage*—A dead weight dial micrometer as prescribed in Method C of Test Methods D 374, with the following modifications:

12.2.1 A micrometer with graduations to 0.01 mm (0.001 in).

12.2.2 A micrometer with a presser foot 6.35 ± 0.25 mm (0.25 ± 0.01 in.) in diameter exerting a total force of 2.50 ± 0.03 N (10.0 ± 0.1 oz) force.

12.2.3 Calibrate the gage for the actual load exerted by the presser foot.

13. Test Specimen

13.1 Select and condition the tape and specimen in accordance with Sections 4-6.

14. Procedure

14.1 *Length Determination*—Unwind the tape and separator from the roll, place it on a hard smooth surface, and measure the length to the nearest 0.4 mm (1⁄64 in.).

14.2 *Thickness*—Place the insulation surface against the anvil of the gage with the separator side up holding the sample in a manner such that it is smooth, yet not under tension. Lower the presser foot onto the tape in accordance with Test Methods D 374, allowing it to rest upon the tape for 2 s, and observe the reading on the dial. Take five measurements uniformly distributed over the length of the tape specimen. Report the average thickness to the nearest 0.005 mm (0.0002 in.).

14.3 *Width*—Place the test specimen, after conditioning, on a hard smooth surface. Measure the width perpendicular to the edge with the steel scale to the nearest 0.40 mm (1⁄64 in.).

15. Report

15.1 Report the following information:

15.1.1 Identification of the tape tested, and

15.1.2 Report the thickness, length, and width measured in accordance with the procedures outlined above.

16. Precision and Bias

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

16.2 *Bias*—This test method has no bias because the values are determined solely in terms of this test method itself.

TENSILE STRENGTH AND ELONGATION

17. Significance and Use

17.1 The tensile strength of the tape is an important measure of uniformity, quality, and ability to withstand stress in service.

17.2 The elongation of a tape is important as a measure of uniformity and quality and provides a rough indication of how much a workman may stretch the tape in use for splicing, terminating, and repairing of wires and cables.

18. Test Specimen

18.1 The test sample consists of a single layer of tape that is approximately 610 mm (24 in.) long, with the removable separator removed. Select and condition in accordance with Sections 4-6.

19. Procedure

19.1 Perform the tests for tensile strength and elongation in accordance with Test Methods D 412, with the following exceptions:

19.1.1 Cut five test specimens from a single ply of tape (rubber and separator) that is free from visible defects using the ASTM standard die, as shown in Fig. number 1 (Die A) of Test Methods D 412, except that the ends of the specimen cut from a 19-mm (0.75-in.) tape need not be full width. Place bench marks on the specimens as directed in Test Methods D 412.

19.1.2 Measure the thickness in accordance with 14.2, removing the separator where it is not an integral part of the tape. Record the appropriate thickness.

19.1.3 Where jaw breaks occur, discard the results and retest.

20. Report

20.1 Report the following information:

20.1.1 Average breaking strength expressed in MPa (psi), and

20.1.2 Average percent elongation.

21. Precision and Bias

21.1 See precision and bias statements of Test Methods D 412 for general discussion of precision and bias of this test.

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

21.3 *Bias*—This test method has no bias because the values for tensile strength and elongation are determined solely in terms of this test method itself.

DISSIPATION FACTOR AND PERMITTIVITY

22. Significance and Use

22.1 The dissipation factor and permittivity of an electrically insulating rubber tape are properties of the material which are important when it is used as high-voltage insulation.

22.2 Measurements of dissipation factor and permittivity are nondestructive tests that are helpful in determining the product uniformity, moisture absorption, and changes in composition.

23. Conditioning

23.1 Unless otherwise specified, use the following conditions in preparing specimens and conducting measurements:

23.1.1 *As received*—Condition a set of specimens at 23 ± 2°C (73.4 ± 3.6°F) for 1 h at 50 ± 5 % relative humidity prior to testing at temperatures of 23± 2°C.

23.1.2 *Elevated temperature*—Condition a set of specimens at some specified temperature (for example, 90 ± 2°C [194 ± 3.6°F]) for 1 h prior to testing at temperature specified (for example, 90 ± 2°C).

23.1.3 *After water immersion*—Condition a set of specimens in distilled water at a temperature of 23 ± 2°C (73.4 ± 3.6°F) for a period of 24 h. Remove from water, pat dry, and test immediately at 23 ± 2°C.

23.1.4 *After hot water immersion*—Condition a set of specimens in distilled water at a temperature of 70 ± 2°C (158 ± 3.6°F) for a period of 24 h. Allow the immersed specimens to come to room temperature by conditioning in distilled water at 23 ± 2°C (73.4 ± 3.6°F) for 4 h. Remove from water, pat dry, and test immediately at 23 ± 2°C.

24. Procedure

24.1 Prepare three specimens that are free from defects from each roll that has been selected and conditioned in accordance with Sections 4-6. It is desirable to test tapes that are 38 mm (1.5 in.) or wider. In place of testing narrower widths, the manufacturer may provide certified test results performed on samples taken from the master roll from which the rolls were prepared.

24.2 Determine the thickness of the specimen in accordance with 14.2.

24.3 Perform the measurements at 1.6 kV/mm (40 V/mil) 60 Hz in accordance with Test Methods D 150 using a guarded electrode. Average the test results.

25. Report

25.1 Report the following information:
25.1.1 Average tape thickness,
25.1.2 Conditioning method,
25.1.3 Average dissipation factor, and
25.1.4 Average permittivity.

26. Precision and Bias

26.1 See precision and bias statements of Test Methods D 150 for general discussion of precision and bias of this test.

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

26.3 *Bias*—This test method has no bias because the values for dissipation factor and permittivity are determined solely in terms of this test method itself.

VOLUME RESISTIVITY

27. Significance and Use

27.1 Volume resistivity measurements are useful as indicators of product uniformity, moisture sensitivity, and changes in composition.

27.2 Semi-conducting tapes are used in the splicing of electrical cables to minimize electrical stresses. Volume resistivity may be used to compare tapes as well as to provide a measure of product uniformity.

28. Electrodes

28.1 For the measurement of the volume resistivity of insulating tapes, utilize the guarded electrodes designated for flat sheets (Fig. number 4) in Test Methods D 257.

28.2 Determine the volume resistivity of the nonmetallic semi-conducting rubber tape using strip electrodes for tape and the solid specimen as shown in Fig. number 2 of Test Method D 4496.

29. Voltage Stress

29.1 For electrically insulating tapes apply a direct voltage of 500 ± 5 V using the time of electrification of 60 s.

29.2 For nonmetallic conducting rubber tapes apply a direct voltage of 5 ± 0.5 V using an electrification time as specified in Test Method D 4496.

30. Test Specimen

30.1 Select the tape rolls for test in accordance with Section 4.

31. Conditioning

31.1 Condition the electrically insulating tapes as follows:

31.1.1 Condition one set of specimens at 23 ± 2°C (73.4 ± 3.6°F) and 50 ± 5 % relative humidity for 96 h.

31.1.2 Condition one set of specimens at 23 ± 2 °C (73.4 ± 3.6°F) and 96 ± 2 % relative humidity for 96 h.

31.2 Condition the semi-conducting tapes as follows:

31.2.1 Condition one set of specimens at 90 ± 2°C (194 ± 3.6°F) for 168 h.

32. Procedure

32.1 For the electrically insulating tapes, test five specimens for each condition in accordance with Test Methods D 257, except as modified in 32.1.1.

32.1.1 Remove the specimens from the chamber, assemble in electrodes, and test within 2 min.

32.2 Test tapes that are 38 mm (1.5 in.) wide or wider. In place of testing narrower width tapes, the manufacturer may provide or furnish certified test results performed on samples taken from the master roll from which these rolls were prepared.

32.3 For the nonmetallic semi-conducting tapes, test five specimens for each condition and measure in accordance with Test Methods D 257 except as follows:

32.3.1 Remove the specimens from the chamber or oven, assemble in electrodes, and test within 2 min.

33. Report

33.1 Report the following information:
33.1.1 Sample identification,
33.1.2 Conditioning and test, and
33.1.3 Average volume resistivity.

34. Precision and Bias

34.1 See precision and bias statements of Test Methods D 257 and Test Method D 4496 for general discussion of precision and bias of this test.

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

34.3 *Bias*—This test method has no bias because the value for volume resistivity is determined solely in terms of this test method itself.

DIELECTRIC STRENGTH

35. Significance and Use

35.1 The dielectric strength of insulating tape provides a measure of its ability to withstand electrical stress. See Test Method D 149. This test is not applicable to semi-conductive tapes.

36. Test Specimen

36.1 Select and condition the tape rolls in accordance with Sections 4-6.

37. Electrodes

37.1 Use Type 3 electrodes as described in Table number 1 of Test Method D 149. Exercise special care in maintaining the surfaces of the electrodes to obtain accurate results.

38. Procedure

38.1 Determine the thickness of the test specimens in accordance with 14.2.

38.2 In order to prevent flash-over, the preferred technique is to place the specimen in an insulating fluid. See the section on Surrounding Medium of Test Method D 149 about flash-over. Another alternative to prevent flash-over is to test tapes that are 38 mm (1.5 in.) wide or wider. Even then, it will probably be necessary to increase the width of the specimen by attaching to each side of the tape specimen an added piece of tape making at least a 6-mm (0.25-in.) lap seam carefully rolled down. In place of testing narrower widths of tape, the manufacturer may provide or furnish certified test results performed on samples taken from the master roll from which these rolls were prepared.

38.3 Measure and calculate the dielectric strength in volts per mil in accordance with Test Method D 149 using the short time test increasing the voltage at a uniform rate of 500 V/s. Make all breakdown measurements in air. Make five measurements for each roll.

39. Report

39.1 Report the following information:

39.1.1 Thickness, and

39.1.2 Average dielectric strength in kV/mm (Volts/mil).

40. Precision and Bias

40.1 See precision and bias statements of Test Method D 149 for general discussion of precision and bias of this test.

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

40.3 *Bias*—This test method has no bias, because the value for the dielectric strength is determined solely in terms of this test method itself.

OZONE RESISTANCE

41. Significance and Use

41.1 Ozone resistance testing, properly interpreted, provides information with regard to the resistance of insulation to ozone attack which may be encountered in connection with the operation of high-voltage cable. Ozone resistance tests may provide data for research and development, engineering design, quality control, and acceptance or rejection under specifications.

42. Test Specimen

42.1 The test specimen consists of a single layer of tape that is approximately 305 mm (12 in.) long, removed from a 19-mm (0.75-in.) wide or wider roll of tape which has been selected and conditioned in accordance with Sections 4-6.

43. Procedure

43.1 Special precautions are necessary for handling ozone. See Practice E 591 for safety and health requirements regarding occupational exposure to ozone.

43.2 Prepare one specimen from each roll selected as follows:

43.2.1 Die cut the specimen with the ASTM standard die as shown in Fig. number 1 (Die A) of Test Methods D 412 except that the ends of the specimen cut from 19-mm (0.75-in.) width tape need not be full width.

43.2.2 Mark the specimen with 51-mm (2-in.) gage marks taking care not to cut the stock as described in Test Methods D 412.

43.2.3 Clamp one end in suitable apparatus while drawing the other end through another clamp until the 51-mm (2-in.) gage marks are 76 mm (3 in.) apart. Clamp this end, which will provide a specimen that is elongated 50 %.

43.2.4 Condition the specimen for 3 h at an ozone concentration between 0.010 and 0.015 % in accordance with the ozone resistance test described in Test Methods D 470.

43.2.5 Examine the specimens for cracking or surface checking discernible without magnification.

44. Report

44.1 Report the following information:

44.1.1 The ozone concentration used,

44.1.2 Whether there are visible signs of deterioration after being subjected to the test, and

44.1.3 Pass or fail depending on the requirements established in the product specification (see Specification D 4388).

45. Precision and Bias

45.1 No statement is made about either the precision or bias of this test method for ozone resistance since the result merely states whether there is conformance to the criteria for success specified in the procedure.

HEAT EXPOSURE

46. Significance and Use

46.1 The wrapped mandrel heat exposure test measures changes to the physical condition of the tape when exposed to elevated temperatures under physical conditions similar to those encountered in service. This test is not intended to establish a maximum operating temperature or a temperature index.

47. Procedure

47.1 Remove approximately 914 mm (36 in.) from a roll of tape selected and conditioned in accordance with Sections 4-6. Half-lap the tape around a 51- to 76-mm (2- to 3-in.) mandrel for a distance of 127 to 152 mm (5 to 6 in.) with minimum elongation, taking care to reduce the air space between the adjacent layers to a minimum. Build the specimen to a four layer thickness by applying the tape smoothly and evenly, maintaining the 50 % overlay. Support the entire assembly in a circulating air oven for 7 days at the temperature specified in the product specification. Examine for and record evidence of porosity, blistering, delamination, cracking, or sagging.

48. Report

48.1 Report the following information:

48.1.1 Pass or fail depending on the requirements established in the product specification (see Specification D 4388).

49. Precision and Bias

49.1 No statement is made about either the precision or bias of this test method for heat resistance since the result merely states whether there is conformance to the criteria for success specified in the procedure.

ULTRAVIOLET AND WEATHER RESISTANCE

50. Significance and Use

50.1 The carbon-arc and weathering tests assess the effects of light and moisture on the rubber tape. The light exposure assesses the effect of light having essentially the same wave lengths as are found in natural sunlight, but with increased intensity in the ultraviolet range. The changes in the conditions of the surface of the tapes after exposure in the weatherometer does not correspond directly to a prescribed condition that may actually occur in service, but it does describe a condition which may be used for purchase by specification as an indication of quality for comparison of different tapes or different lots of tape. In some instances rubber tapes are covered by other layers of material and, in that case, the test has no significance.

51. Test Specimen

51.1 The test specimen consists of a single layer that is approximately 152 mm (6 in.) long that was removed from a roll of tape selected and conditioned in accordance with Sections 4-6.

52. Procedure

52.1 Expose the five test specimens in accordance with Test Method D 750 for 750 h in the weather exposure apparatus using a cycle of 18 min distilled water spray and 102 min dry with ultraviolet light at a constant temperature of 40°C (94°F).

52.2 Examine the specimens after exposure and record signs of cracking, crazing, or physical deterioration of the specimens.

53. Report

53.1 Report the following information:

53.1.1 Identification of the specimen, and

53.1.2 Pass or fail depending on the requirements established in the product specification (see Specification D 4388).

54. Precision and Bias

54.1 No statement is made about either the precision or bias of this test method for ultraviolet and weather resistance since the result merely states whether there is conformance to the criteria for success specified in the procedure.

55. Keywords

55.1 dielectric strength; dissipation factor; elongation; fusion; heat exposure; ozone resistance; permittivity; rubber electrical insulating tape; rubber semi-conducting nonmetallic tape; tensile strength; ultraviolet and weather exposure; volume resistivity