



# Standard Test Methods for Bondable Silicone Rubber Tapes Used for Electrical Insulation<sup>1</sup>

This standard is issued under the fixed designation D 2148; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

## 1. Scope

1.1 These test methods cover tests for bondable silicone rubber tapes which form a sealed structure either with the application of heat (and pressure if needed) or by the process of auto-adhesion (self-fusing).

1.2 The methods appear in the following sections:

Test Method	Section
Adhesion	3-9
Bond Strength	10-17
Dielectric Breakdown Voltage	18-25
Hardness	40
Length	32 and 33
Thickness	26-31
Width	35-39

1.3 The values stated in inch-pound units are to be regarded as the standard except for °C.

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.* For a specific hazard statement see 22.1.1.

## 2. Referenced Documents

### 2.1 ASTM Standards:

- D 149 Test Methods for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies<sup>2</sup>
- D 374 Test Methods for Thickness of Solid Electrical Insulation<sup>2</sup>
- D 618 Practice for Conditioning Plastics and Electrical Insulating Materials for Testing<sup>2,3</sup>
- D 1000 Test Methods for Pressure-Sensitive Adhesive Coated Tapes Used for Electrical and Electronic Applications<sup>2</sup>
- D 1458 Test Methods for Fully Cured Silicone Rubber-Coated Glass Fabric and Tapes for Electrical Insulation<sup>2</sup>

<sup>1</sup> These methods are under the jurisdiction of ASTM Committee D-9 on Electrical and Electronic Insulating Materials and are the responsibility of Subcommittee D 09.07 on Flexible and Rigid Insulating Materials.

Current edition approved Jan. 15, 1995. Published March 1995. Originally published as D 2148 – 63 T. Last previous edition D 2148 – 90.

<sup>2</sup> *Annual Book of ASTM Standards*, Vol 10.01.

<sup>3</sup> *Annual Book of ASTM Standards*, Vol 08.01.

D 2240 Test Method for Rubber Property—Durometer Hardness<sup>4</sup>

## ADHESION

### 3. Scope

3.1 This test method covers the determination of the self-adhesion of unsupported, self-fusing silicone rubber rectangular and taper-edge (Note 1) tape designed for use as electrical insulation.

NOTE 1—Taper-edge tape includes such cross sections as triangular, lens, etc.

### 4. Significance and Use

4.1 Self-adhesion is a primary initial property since it affects layer-to-layer bonding. The integrity of the bond can significantly affect the electrical and physical performance of the insulation system. Therefore, the degree of self-adhesion is directly related to apparatus performance.

4.2 A high degree of self-adhesion is desirable for most electrical applications. In this test, a short unwinding length indicates a high degree of self-adhesion.

4.3 This test method has been found useful as a quality control test for lot acceptance.

### 5. Apparatus

5.1 *Inclined Mandrel Tack Test Fixture*— A suggested fixture is shown in Fig. 1.<sup>5</sup> The mandrel shall consist of a 5/8-in. (15.9-mm) diameter aluminum rod mounted in low-friction bearings. Good alignment of bearings is necessary for accurate results. When properly assembled, the mandrel shall turn freely when loaded with a 30-g weight suspended from a cotton thread wound in a single layer at the center of the mandrel.

5.2 *Weights*, as specified in Section 7 and means for attachment.

### 6. Test Specimen

6.1 A test specimen shall consist of two pieces of tape 12 to 15 in. (25 to 38 mm) long. Divisions spaced 1 in. (25.4 mm) apart shall be marked off on one piece of tape. If tapes contain

<sup>4</sup> *Annual Book of ASTM Standards*, Vol 09.01.

<sup>5</sup> A detailed drawing of a suggested fixture is available at a nominal cost from ASTM Headquarters, 100 Barr Harbor Drive, West Conshohocken, PA 19428. Request Adjunct No. ADJD2148.

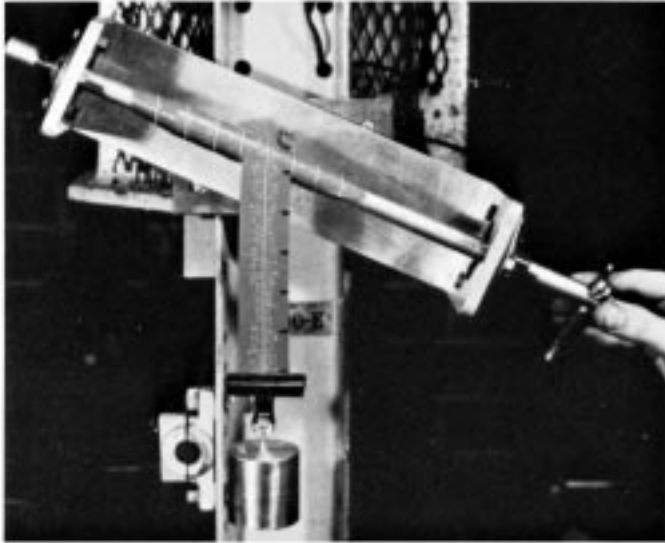


FIG. 1 Inclined Mandrel Tack Test Fixture

an interliner, the interliner shall be removed just prior to wrapping the mandrel. Dirt and other forms of contamination shall be avoided.

**7. Procedure**

7.1 *Winding*—Half lap the unmarked specimen perfectly on the mandrel of the test fixture, using the suggested weight as shown in Table 1. These weights are not critical. However, they are necessary to get intimate contact and conformability of the tape. To obtain perfect half lapping, tilt the tack tester at an appropriate angle as shown in Fig. 1. Wrap the tape on the mandrel at a speed of approximately 18 in. (450 mm)/min. Using the winding procedure and weights just described, half lap the marked tape sample on the mandrel over the first piece of tape. With the winding weight attached, return the test fixture to a horizontal position and allow the tape to bond for 1 min. Remove the winding weight from the tape and the handle from the fixture and proceed with the unwinding test.

7.2 *Unwinding*—After the tape has bonded for 1 min, attach a load of 600 g/in. of the original tape width (Note 2). Attach the weight to the free end of the tape by means of a bulldog paper clamp or other suitable device. Release the weight and

TABLE 1 Suggested Winding Weights For 1-in. Wide Tapes

NOTE 1—Winding weights are based on cross-sectional area and have been selected to produce approximately the same unit stress on all cross-sections. For tapes of dimensions not listed, use a winding weight of approximately 300 g/0.01 in.<sup>2</sup> (6.3 mm<sup>2</sup>)

Tape Thickness, in. (mm)		Weight, g
Triangular	Rectangular	
0.020 (0.51)	0.010 (0.25)	300
0.030 (0.76)	0.015 (0.38)	450
0.040 (1.02)	0.020 (0.51)	600
0.050 (1.27)	0.025 (0.64)	750
0.060 (1.52)	0.030 (0.76)	900
0.070 (1.78)	...	1050
0.080 (2.03)	...	1200

record the length of tape unwound in 3 min. Although the original 1-in. dimensions will elongate due to the unwind weight, consider each division as one unit. While the winding weights are not critical, the use of proper unwinding weights is mandatory. Consistent and comparable results depend upon accurate width measurements and the use of the proper unwinding weight.

NOTE 2—Commercial tapes are usually made to a ±1/16-in. (±1.59-mm) tolerance. Therefore a 600-g weight shall be used for tapes varying in width from 15/16 to 1 1/16 in. (23.8 to 27 mm); a 750-g weight shall be used for tapes varying in width from 1 3/16 to 1 5/16 in. (30.2 to 33.3 mm) and a 900-g weight shall be used for tapes varying in width from 1 7/16 to 1 9/16 in. (36.5 to 39.7 mm). Tapes with widths outside these ranges shall be tested in accordance with their width (determined to the nearest 1/16 in. (1.59 mm)). For example, a 1 1/8-in. (28.6 mm) wide tape shall be tested with a 675-g weight. The unwinding weights shall be made to a tolerance of ± 2 %.

**8. Report**

- 8.1 Report the following information:
  - 8.1.1 Description of material, type of cross-section, tape width and thickness,
  - 8.1.2 Winding weight, in grams,
  - 8.1.3 Unwinding weight, in grams, and
  - 8.1.4 Length of unwind, to the nearest 1/4 unit.

**9. Precision and Bias**

9.1 The precision of this test method has not been determined. Since there is no accepted reference material, no statement on bias is being made.

**BOND STRENGTH**

**10. Terminology**

- 10.1 *Definitions of Terms Specific to This Standard:*
  - 10.1.1 *bond strength, of unvulcanized and semivulcanized supported silicone rubber tapes*—the strength of chemical linkages achieved between successive layers of tape under controlled vulcanizing conditions.

**11. Significance and Use**

11.1 The bond strength is an indication of the physical integrity that can be expected under end use conditions in which the insulating tapes are applied with an overlap.

**12. Apparatus**

- 12.1 *Bonding Press*—A platen press having the following characteristics:
  - 12.1.1 A temperature range to 205°C (400°F).
  - 12.1.2 A thermostat that will allow a set temperature to be maintained ±9°F (±5°C).
  - 12.1.3 A pressure regulator to allow setting and control of the platen pressure.
  - 12.1.4 A pressure indicator to show the pressure being exerted between the platen faces.
  - 12.1.5 A timer to allow measurement of bonding time. It is preferred that a controller-type timer be used which will both indicate bonding time and also cause the platen pressure to be released and the platens separated at the end of the bonding period.

12.2 *Temperature-Measuring Device(s)* to indicate face temperature of the platen(s).

12.3 *Silicone Rubber Pad*, approximately 1/8 in. (3.20 mm) thick, 60 to 70 Shore A durometer hardness, larger in dimension than the specimens to be tested. This is used as a pressure-equalizing device, compensating for irregularities in either the specimen or the platens.

12.4 *Polytetrafluoroethylene* or suitable release film, three sheets, approximately 2 to 4 mils (0.05 to 0.10 mm) thick. One sheet is placed on each side of the specimens as a release sheet, the third sheet being used to separate the ends of the two test specimens.

12.5 *Testing Machine*—A power-driven testing machine of either the cross head or dead-weight pendulum type. The machine shall be equipped with a tension weighing device having a maximum capacity of 50 lb (22.7 kg) graduated to read 0.1 lb (50 g) or less per scale division.

**13. Test Specimen**

13.1 The test specimen shall be selected to be representative of the material to be tested. The size of sample shall be sufficient to give six strips at least 1.25 to 1.5 in. (32 to 38 mm) wide and 6 in. (150 mm) long. Care should be taken to prevent contamination.

**14. Conditioning**

14.1 The specimen shall not be exposed to temperatures above 85°F (30°C) before bonding. The tests shall be conducted in the Standard Laboratory Atmosphere as described in Practice D 618.

**15. Procedure**

15.1 Cut the strips of material to 1.25 to 1.5 in. (32 to 38 mm) wide and at least 6 in. (150 mm) long, the length being measured in the warp or machine direction of the backing.

15.2 Remove any interliner material.

15.3 Superimpose one strip on another, front side to back side, to form a specimen.

15.4 Separate the two strips at one end for a distance of about 1 in. (25 mm) and insert a strip of release film.

15.5 Preheat the press to 177°C (350°F).

15.6 Assemble the test specimens between two sheets of release film. Place the assembly on the unheated silicone rubber pad and insert in the press.

15.7 Close the press and apply 50 psi (345 kPa) pressure to the specimens for 5 min.

15.8 Release the pressure, remove the specimens, and allow them to cool for at least 5 min.

15.9 Remove the release film and trim the specimens to a 1-in. (25-mm) width.

15.10 Clamp one separated end in the upper jaw of the testing machine; peel the other separated end back 180 deg and clamp it in the lower jaw.

15.11 Adjust the testing machine to provide a jaw separation rate of 20 in. (500 mm) per min. If the pendulum-type machine is used, disengage the pawls during the test. Record the average observed force for each specimen using the technique described for adhesion strength in Test Methods D 1000.

**16. Report**

16.1 Report the following information:

16.1.1 Bond strength of each specimen and the average in pounds per inch or newtons per metre of width, and

16.1.2 Bonding time, pressure, and temperature used, if other than as specified.

**17. Precision and Bias**

17.1 The precision of this test method has not been determined. Since there is no accepted reference material, no statement on bias is being made.

**DIELECTRIC BREAKDOWN VOLTAGE**

**18. Scope**

18.1 This test method covers determination of the breakdown voltage of unsupported bondable silicone rubber tapes with tapered edges (Note 3) for use as electrical insulation.

18.2 The method to be used for rectangular cross section tapes is described in Test Methods D 1458.

NOTE 3—Tapes with tapered edges include such cross sections as triangular and lens-shaped.

**19. Significance and Use**

19.1 The level of dielectric breakdown voltage as determined by this test is one measure of the quality of both material and fabrication methods used in producing the tape. This voltage value should not be compared directly with the results of tests made on rectangular cross section tapes. For further details, refer to Test Method D 149.

**20. Apparatus**

20.1 *Test Fixture*, designed to support a removable mandrel 1/8 in. (15.9 mm) in diameter and about (20 in.) (500 mm) in length. This fixture may be a modification of the one described in 5.1.

20.2 *Voltage Source*, capable of applying alternating voltage and increasing it at the rate of 500 V/s. This equipment shall conform to the requirements of Test Method D 149.

**21. Test Specimen**

21.1 The test specimen shall consist of lengths of bondable tape about 0.75 to 2 in. (19 to 50 mm) wide and of sufficient length to cover the entire mandrel.

21.2 Adjust the mandrel to such an angle as will provide a half-lapped tape on winding. Wrap the tape on the mandrel at a linear speed of 18 in./min using the winding weight shown in Table 2.

**TABLE 2 Winding Weights**

Nominal Thickness of Tape		Winding Weight, g
in.	mm	
0.02	0.5	300
0.03	0.75	450
0.04	1.0	600
0.05	1.25	750
0.06	1.5	900
0.07	1.75	1050
0.08	2.0	1200

NOTE 4—Winding weights are based on cross sectional area and have been selected to approximate the same unit stress for all cross sections. For tapes of dimensions other than listed, use a winding weight of about 300 g/0.01 in.<sup>2</sup> (6.3 mm<sup>2</sup>).

21.3 Apply foil electrodes 0.0005 to 0.002 in. (0.013 to 0.050 mm) thick by 1 in. (25 mm) wide over the tapes, allowing approximately 4 in. (100 mm) between electrodes and from electrodes to the end of the mandrel (Note 5). For example, in evaluating 0.030-in. (0.75-mm) tapes, three electrodes shall be placed on a 20-in. (500-mm) long mandrel. Thicker tapes which require higher voltage to failure may require more distance between electrodes in order to avoid flashover.

NOTE 5—Intimate contact between electrodes and tape surface is required for accurate results. Hand-tightening the foil is ordinarily adequate.

## 22. Procedure

22.1 Attach a high-voltage lead to one foil electrode and electrically ground the mandrel. Increase the voltage starting at zero and at a rate of 500 V/s until breakdown occurs. Repeat this procedure for all electrodes and record the breakdown voltages. Obtain at least six breakdown values.

22.1.1 **Caution**—*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.*

22.2 Remove the foil electrodes and measure the thickness of the tape at the point of failure on the mandrel. Take care not to compress the insulation wall during this measurement. A machinist's micrometer having a 1/4-in. (6.4-mm) presser foot is suitable. Calculate the net insulation thickness by subtracting the mandrel diameter from the micrometer reading and dividing the remainder by two.

## 23. Interpretation of Results

23.1 Inspect each breakdown for presence of a puncture. Areas showing evidence of surface flashover or interlayer creepage shall be noted but not considered in the calculation of breakdown voltage.

23.2 Dielectric breakdown voltage is dependent on thickness. Correct the breakdown voltage values to nominal thickness using the following equation (Note 6):

$$V_2 = V_1(t_2/t_1)^m \quad (1)$$

where:

- $V_1$  = actual breakdown voltage for measured thickness,  $t_1$ ,
- $V_2$  = corrected breakdown voltage for nominal thickness,  $t_2$ , and
- $m$  = constant (approximately 0.60 for bondable silicone rubber tape).

NOTE 6—This expression is an equation for a straight line using log-log graph paper. The exponential constant  $m$  is the slope of this line as plotted, and has been determined empirically.

## 24. Report

24.1 Report the following information:

- 24.1.1 Description of the material, including type of cross section, tape width, and nominal thickness,
- 24.1.2 Observed breakdown voltage readings for all tests,
- 24.1.3 Observed breakdown voltage values corrected to nominal thickness,
- 24.1.4 Average corrected breakdown voltage, and
- 24.1.5 Insulation thickness for each breakdown measurement.

## 25. Precision and Bias

25.1 The precision of this test method has not been determined. Since there is no accepted reference material, no statement on bias is being made.

## THICKNESS

### 26. Significance and Use

26.1 The determination of tape thickness is frequently necessary for the satisfactory production of electrical equipment. Some properties, such as dielectric strength, vary with the thickness; and other properties, such as dielectric constant, cannot be calculated without a proper determination of thickness.

### 27. Apparatus

27.1 *Thickness Gage*—A dead-weight dial micrometer as prescribed in Method C of Test Methods D 374, with the following modification: The presser foot shall be  $0.24 \pm 0.4$  in. ( $6 \pm 1$  mm) in diameter, and the anvil surface upon which the specimen rests shall be at least 2 in. (50 mm) in diameter. The pressure of the presser foot on the specimen shall be  $4 \pm 1$  psi ( $27.6 \pm 6.9$  kPa).

### 28. Test Specimen

28.1 The test specimen shall consist of a single thickness of tape approximately 18 in. (500 mm) long.

### 29. Procedure

29.1 Remove any interliner from the test specimen carefully to prevent distortion. Make five measurements at the center (or peak) of the width using Test Methods D 374 with the following modifications: Allow the presser foot to remain on the test specimen for 2 s, (or until dial stops moving) at which time read the dial gage.

**30. Report**

30.1 The report shall include the five thickness measurements and their average to the nearest 0.001 in. (0.025 mm).

**31. Precision and Bias**

31.1 The precision of this test method has not been determined. Since there is no accepted reference material, no statement on bias is being made.

**LENGTH****32. Procedure**

32.1 Determine the length of a roll as in Methods D 1000, with the exception that the test specimen shall consist of a single thickness of tape and interliner approximately 18 in. (500 mm) long, removed from the roll of tape as received.

**33. Report**

33.1 Report the following information:

33.1.1 Length of tape in each roll measured, calculated to the nearest 0.01 yd (1 cm), and

33.1.2 Average weight (including interliner) in ounces per yard or kilogram per square metre.

**34. Precision and Bias**

34.1 The precision of this test method has not been determined. Since there is no accepted reference material, no statement on bias is being made.

**WIDTH****35. Apparatus**

35.1 *Steel Scale* having 0.01-in. (1-mm) divisions.

**36. Test Specimen**

36.1 The test specimen shall consist of an 18-in. (500-mm) length of tape.

**37. Procedure**

37.1 Remove any interliner from the test specimen carefully to prevent distortion. Place the test specimen without tension on a hard smooth surface. Measure the width perpendicular to the edge with the steel scale at five approximately equally-spaced points along the length.

**38. Report**

38.1 Report the following information:

38.1.1 Nominal width of the tape, and

38.1.2 The five width measurements and their averages.

**39. Precision and Bias**

39.1 The precision of this test method has not been determined. Since there is no accepted reference material, no statement on bias is being made.

**HARDNESS****40. Procedure**

40.1 Determine the hardness of unsupported bondable silicone rubber tape as prescribed in Test Method D 2240, with the following addition in preparing the test specimens: Remove any interliner from the tape. Stack up the required number of layers to obtain the proper thickness. When nonrectangular shapes are to be tested, lay up sufficient short lengths of tape to make a section approximately 2 by 3 by 0.25 in. (50 by 80 by 6 mm) thick using the center line of the tape as a guide to form a solid specimen free of voids.

**41. Keywords**

41.1 bond strength; bondable silicone rubber tape; dielectric breakdown voltage; durometer hardness; electrical insulation; self-fusing tape; taper edge tape

*The American Society for Testing and Materials takes no position respecting the validity of any patent rights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, are entirely their own responsibility.*

*This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, at the address shown below.*

*This standard is copyrighted by ASTM, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959, United States. Individual reprints (single or multiple copies) of this standard may be obtained by contacting ASTM at the above address or at 610-832-9585 (phone), 610-832-9555 (fax), or service@astm.org (e-mail); or through the ASTM website (www.astm.org).*