Designation: D2148 – 22

Standard Test Methods for Bondable Silicone Rubber Tapes Used for Electrical Insulation[1]

This standard is issued under the fixed designation D2148; 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.

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 These test methods appear in the following sections:

Test Method	Section
Adhesion	3 – 10
Bond Strength	11 – 18
Dielectric Breakdown Voltage	19 – 26
Hardness	41
Length	33 and 34
Thickness	27 – 32
Width	36 – 40

1.3 *Units*—The values stated in SI units are the standard. The inch-pound units in parentheses are for information only. The values stated in each system are not necessarily exact equivalents; therefore, to ensure conformance with the standard, each system shall be used independently of the other, and values from the two systems shall not be combined.

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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.* For a specific hazard statement see 23.1.1.

1.5 *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/D374M Test Methods for Thickness of Solid Electrical Insulation

D618 Practice for Conditioning Plastics for Testing

D1000 Test Methods for Pressure-Sensitive Adhesive-Coated Tapes Used for Electrical and Electronic Applications

D1458 Test Methods for Fully Cured Silicone Rubber-Coated Glass Fabric and Tapes for Electrical Insulation (Withdrawn 2019)[3]

D2240 Test Method for Rubber Property—Durometer Hardness

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. Hazards

4.1 *High Voltage:*

4.1.1 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.

[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.

***A Summary of Changes section appears at the end of this standard**

4.1.2 Solidly ground all electrically conductive parts which it is possible for a person to contact during the test.

4.1.3 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.

4.1.4 Thoroughly instruct all operators as to the correct procedures for performing tests safely.

4.1.5 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. See 23.1

5. Significance and Use

5.1 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.

5.2 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.

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

6. Apparatus

6.1 *Inclined Mandrel Tack Test Fixture*—A suggested fixture is shown in Fig. 1. Tack tester assembly and details are included as Appendix X1. The mandrel shall consist of a 16 mm (0.625 in.) 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 28 g (1-oz) weight suspended from a cotton thread wound in a single layer at the center of the mandrel.

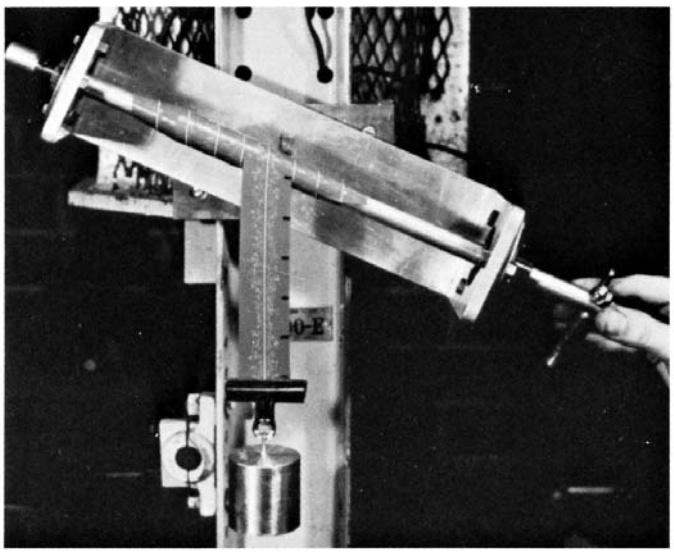

FIG. 1 Inclined Mandrel Tack Test Fixture

6.2 *Weights,* as specified in Section 8 and means for attachment.

6.3 Calibrated stopwatch capable of measuring accurately to one second.

7. Test Specimen

7.1 A test specimen shall consist of two pieces of tape 305 mm to 380 mm (12 to 15 in.) long. Divisions spaced 25 mm (1 in.) apart shall be marked off on one piece of tape. If tapes contain an interliner, the interliner shall be removed just prior to wrapping the mandrel. Dirt and other forms of contamination shall be avoided.

8. Procedure

8.1 *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 460 mm (18 in.)/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.

8.2 *Unwinding*—After the tape has bonded for 1 min, attach a load of 600 g (21 oz)/25 mm (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 record the length of tape unwound in 3 min. Although the original 25 mm (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 ±1.6 mm (±0.06 in.)

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

Note—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 (10.5 oz)/6 mm^2 (0.01 $in.^2$).

Tape Thickness, mm (in.)		Weight, g (oz)
Triangular	Rectangular	
0.50 (0.020)	0.25 (0.010)	300 (10.5)
0.75 (0.030)	0.4 (0.015)	450 (15.8)
1.02 (0.040)	0.5 (0.02)	600 (21.0)
1.27 (0.050)	0.64 (0.025)	750 (26.4)
1.52 (0.060)	0.76 (0.030)	900 (31.7)
1.78 (0.070)	...	1050 (37.0)
2.03 (0.080)	...	1200 (42.3)

tolerance. Therefore a 600-g weight shall be used for tapes varying in width from 24 mm to 27 mm (0.94 to 1.06 in.); a 750-g weight shall be used for tapes varying in width from 30 mm to 33 mm (1.19 to 1.31 in.) and a 900-g weight shall be used for tapes varying in width from 37 mm to 40 mm (1.44 to 1.56 in.). Tapes with widths outside these ranges shall be tested in accordance with their width (determined to the nearest 1.6 mm (0.06 in.). For example, a 29 mm (1.125 in.) wide tape shall be tested with a 675-g weight. The unwinding weights shall be made to a tolerance of ±2 %.

9. Report

9.1 Report the following information:

9.1.1 Description of material, type of cross-section, tape width and thickness,

9.1.2 Winding weight, in grams,

9.1.3 Unwinding weight, in grams, and

9.1.4 Length of unwind, to the nearest ¼ unit.

10. Precision and Bias

10.1 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.

10.2 This test method has no bias because the value for adhesion is determined solely in terms of this test method itself.

BOND STRENGTH

11. Terminology

11.1 *Definitions of Terms Specific to This Standard:*

11.1.1 *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.

12. Significance and Use

12.1 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.

13. Apparatus

13.1 *Bonding Press*—A platen press having the following characteristics:

13.1.1 A temperature range to 205 °C (400 °F).

13.1.2 A thermostat that will allow a set temperature to be maintained ± 5 °C (± 9 °F).

13.1.3 A pressure regulator to allow setting and control of the platen pressure.

13.1.4 A pressure indicator to show the pressure being exerted between the platen faces.

13.1.5 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.

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

13.3 *Silicone Rubber Pad,* approximately 3.2 mm (0.125 in.) 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.

13.4 *Polytetrafluoroethylene* or suitable release film, three sheets, approximately 0.05 mm to 0.10 mm (2 to 4 mils) 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.

13.5 *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 22.7 kg (50 lb) graduated to read 50 g (0.1 lb) or less per scale division.

14. Test Specimen

14.1 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 32 mm to 38 mm (1.25 to 1.5 in.) wide and 150 mm (6 in.) long. Care shall be taken to prevent contamination.

15. Conditioning

15.1 The specimen shall not be exposed to temperatures above 30 °C (85 °F) before bonding. The tests shall be conducted in the Standard Laboratory Atmosphere as described in Practice D618.

16. Procedure

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

16.2 Remove any interliner material.

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

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

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

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

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

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

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

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

16.11 Adjust the testing machine to provide a jaw separation rate of 500 mm (20 in.) 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 D1000.

17. Report

17.1 Report the following information:

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

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

18. Precision and Bias

18.1 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.

18.2 This test method has no bias because the value for bond strength is determined solely in terms of this test method itself.

DIELECTRIC BREAKDOWN VOLTAGE

19. Scope

19.1 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.

19.2 The method to be used for rectangular cross section tapes is described in Test Methods D1458.

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

20. Significance and Use

20.1 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. It is not appropriate to make direct comparisons between this voltage value and the results of tests made on rectangular cross section tapes. For further details, refer to Test Method D149.

21. Apparatus

21.1 *Test Fixture,* It shall be designed to support a removable mandrel 16 mm (0.625 in.) in diameter and about 500 mm (20 in.) in length. One example of the type of fixture is a modification of the one described in 6.1.

21.2 *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 D149.

22. Test Specimen

22.1 The test specimen shall consist of lengths of bondable tape about 20 mm to 50 mm (0.75 to 2 in.) wide and of sufficient length to cover the entire mandrel.

22.2 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 460 mm (18 in.)/min using the winding weight shown in Table 2.

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/0.25 mm (0.01 in.^{2}).

TABLE 2 Winding Weights

Nominal Thickness of Tape		Winding Weight, g (oz)
in.	mm	
0.02	0.5	300 (10.5)
0.03	0.75	450 (15.8)
0.04	1.0	600 (21.0)
0.05	1.25	750 (26.4)
0.06	1.5	900 (31.7)
0.07	1.75	1050 (37.0)
0.08	2.0	1200 (42.3)

22.3 Apply foil electrodes 0.013 mm to 0.050 mm (0.0005 to 0.002 in.) thick by 25 mm (1 in.) wide over the tapes, allowing approximately 100 mm (4 in.) between electrodes and from electrodes to the end of the mandrel. For example, in evaluating 0.75 mm (0.030 in.) tapes, three electrodes shall be placed on a 500 mm (20 in.) long mandrel.

22.3.1 If thicker tapes, which require higher voltage to failure, are tested, they will often require more distance between electrodes in order to avoid flashover.

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

23. Procedure

23.1 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.

23.1.1 **Warning—**This test involves the use of high voltage (see 4 – 4.1.1, "Hazards").

23.2 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 6.4 mm (0.25 in.) presser foot is suitable. Calculate the net insulation thickness by subtracting the mandrel diameter from the micrometer reading and dividing the remainder by two.

24. Interpretation of Results

24.1 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.

24.2 Dielectric breakdown voltage is dependent on thickness. Correct the breakdown voltage values to nominal thickness using the following equation (Note 5):

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

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 5—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.