Designation: D 1000 – 04

An American National Standard

Standard Test Methods for Pressure-Sensitive Adhesive-Coated Tapes Used for Electrical and Electronic Applications[1]

This standard is issued under the fixed designation D 1000; 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 procedures for testing pressure-sensitive adhesive-coated tapes to be used as electrical insulation. These tapes are classified as follows:

1.1.1 *Class 1*—Non-elastomeric backings made from materials such as:

Paper, flat or creped,
Fabric, uncoated or coated,
Cellulose ester films,
Polyethylene terephthalate (polyester) films,
Fluorocarbon polymer films,
Composite filament films,
Polyamide films,
Polyimide films, and
Combinations thereof.

1.1.2 *Class 2*—Elastomeric backings that are characterized by both high stretch and substantial recovery. These backings are made from materials such as:

Vinyl chloride and co-polymers,
Vinylidene chloride and co-polymers, and
Polyethylene and co-polymers.

1.2 Laminates of Class 1 and Class 2 backings should be tested according to Class 1 test methods.

1.3 *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 hazards see Section 3.

1.4 The procedures appear in the sections indicated below and in alphabetical order:

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NOTE 1—These procedures apply to both Class 1 and Class 2 tapes except as noted above.

1.5 The values stated in SI units are the standard, unless otherwise noted. If a value for measurement is followed by a value in inch-pound or English units in parentheses, the second value may only be approximate and is for information only. The first stated value is the preferred unit.

NOTE 2—These test methods are similar to IEC 60454–3, but may differ sometimes in some details.

1.6 This is a fire–test response standard.

2. Referenced Documents

2.1 *ASTM Standards:* [2]

A 167 Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip

D 149 Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies

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

D 295 Test Methods for Varnished Cotton Fabrics Used for Electrical Insulation

[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] 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.

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D 374 Test Methods for Thickness of Solid Electrical Insulation
D 1711 Terminology Relating to Electrical Insulation
D 3487 Specification for Mineral Insulating Oil Used in Electrical Apparatus
D 5032 Practice for Maintaining Constant Relative Humidity by Means of Aqueous Glycerin Solutions
E 691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method
2.2 *IEC Standard:*
IEC 60454-3 Specification for Pressure-Sensitive Adhesive Tapes for Electrical Purposes[3]

3. Hazards

3.1 The following specific substances are flammable liquids. Do not use them in the vicinity of open flames or electrical contacts: *acetone* (see 50.1 and 94.1), *heptane* (see 50.1 and 94.1), and *toluene* (see 70.6). They must be stored in closed containers, and it is imperative to clean apparatus in a well-ventilated area.

3.2 As a toxic substance, toluene should be used only where adequate ventilation is provided and in such manner as to avoid any absorption through the skin (see 70.6).

3.3 **Warning**— *Lethal voltages may be present during test methods which evaluate electrical properties. It is essential that the test apparatus, and all associated equipment that may be electrically connected to it, be properly designed and installed for safe operation. Solidly ground all electrically conductive parts that any person might come in contact with 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; may have acquired an induced charge during the test; may retain a charge even after disconnection of the voltage source. Thoroughly instruct all operators in the proper way to conduct tests safely. When making high voltage tests, particularly in compressed gas or in oil, the energy released at breakdown may 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.*

SAMPLING

4. Sample and Specimen Requirements

4.1 The producer and consumer shall agree upon the number of rolls selected. Unless otherwise specified a minimum of three rolls per lot shall be selected.

4.2 For sampling purposes, a lot consists of identifiable materials of the same type, manufactured in one production run and offered for delivery at the same time.

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

4.4 See Table 1 for a summary of standard requirements for the number of test specimens to select from each sample roll, the number of test measurements to make per test specimen, and the value to be reported.

4.5 Include in every report the complete identification of the tape tested.

SPECIMEN PREPARATION

5. Test Specimen Preparation

5.1 Place any roll of tape to test on a freely revolving mandrel. Except for determination of length of tape in a roll, remove and discard a minimum of three layers before removing tape for preparation of test specimens.

5.2 Remove sufficient length of tape, at the rate of approximately 50 mm/s (2 in./s), to provide the specimens required for all tests. Cut the tape with a sharp razor blade or scissors, unless otherwise specified. Place the tape on a smooth clean surface, adhesive side up, or suspend it from one end in free air. Protect the adhesive surface from dust. Do not allow the adhesive surface to contact the operator's fingers or other foreign objects. From this tape material, prepare specimens as required in the individual test methods. See also Table 1.

5.3 Use test specimens that are the width of the tape as received, if possible. If it is necessary to prepare narrower specimens as prescribed in the test method, use extreme care since hand trimming may materially affect the test results. Two recommended procedures are (*1*) to slit the specimen with a sharp razor blade free of nicks while the specimen is held down with a pattern of the desired width, or (*2*) to slit with mounted parallel sharp razor blades free of nicks to the desired width.

CONDITIONING

6. Terminology

6.1 *Definitions:*

TABLE 1 Testing and Reporting

Test	Section	Tests per Specimen[A]	Specimens per Roll[A]	Report[B]
Width	14, 19	3	1	avg
Thickness	26	3	1	avg
Length of tape in a roll	35	1	1	value
Breaking strength	44	1	3	avg
Elongation	44	1	3	avg
Adhesion strength	52	1	3	avg
Unwind force				
Fast rate of removal	64	1	1	value
Slow rate of removal	64	3	1	avg
Flagging				
Class 1 Tape	71	3	1	avg
Class 2 Tape	75	1	3	avg
Thermosetting properties	81	1	3	avg
Dielectric breakdown voltage	89	3	3	avg
Insulation resistance at high humidity	95	5	1	med
Effect of accelerated aging	102	3	2	avg
Flammability	108	1	3	avg
Bond strength after solvent immersion	114	1	3	avg
Oil resistance	121	1	4	avg
Puncture resistance	127	1	5	avg
Resistance to accelerated aging	129, 133	1	6	avg
Curling and twisting	140	1	3	avg

[A] When referee testing is involved, use an average of 5 determinations wherever 1 or 3 are specified above.
[B] Minimum and maximum values may also be required when average values are reported.

[3] Available from American National Standards Institute, 11 W. 42nd St., New York, NY 10036.

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6.1.1 *conditioning*, *n*—the exposure of a material to the influence of a prescribed atmosphere for a stipulated period of time or until a stipulated relation is reached between material and atmosphere.

7. Significance and Use

7.1 The physical and electrical properties such as adhesion, elongation, breaking strength, and dielectric breakdown will vary with temperature and moisture content. Actual service results are influenced by these factors. In order that test methods yield consistent and reproducible results, control the temperature and moisture content of the sample or specimen.

8. Conditioning for Room Temperature Measurements

8.1 Condition all rolls of tape for a minimum of 24 h to a temperature of 23 ± 5 °C (73 ± 9 °F) before removing specimens for test.

8.2 Condition all test specimens for a period of 1 h in a controlled atmosphere at 23 ± 5 °C (73 ± 9 °F) and 50 ± 10 % relative humidity prior to testing.

8.3 Unless otherwise specified, testing shall be conducted at 23 ± 5 °C (73 ± 9 °F) and 50 ± 10 % relative humidity.

8.4 For referee testing purposes, subject all sample rolls to a controlled laboratory temperature of 23 ± 1°C (73.4 ± 1.8 °F) for a minimum period of 24 h before removing specimens for test.

8.5 Unless otherwise specified, condition all referee test specimens for a period of 1 h in a controlled laboratory atmosphere at 23 ± 1°C (73.4 ± 1.8 °F) and 50 ± 2 % relative humidity.

8.6 Unless otherwise specified, referee testing shall be conducted at 23 ± 1°C (73.4 ± 1.8 °F) and 50 ± 2 % relative humidity.

9. Conditioning for Low Temperature Measurements

9.1 Elastomeric backings of Class 2 tapes may be subject to cold temperature tests. In these cases, place prepared specimens or rolls of tape in a cold room and condition for at least 2 h at the desired temperature (for example, 10 °C, 0 °C, –10 °C, –18 °C, etc.).

10. Apparatus for Low Temperature Conditioning

10.1 Cold room or cold chamber capable of maintaining the desired cold temperatures during testing.

WIDTH OF TAPE

Method A—Steel Ruler

11. Apparatus

11.1 A steel scale having divisions at 0.5 mm or 1/64-in. intervals.

12. Test Specimens

12.1 Select test specimens of approximately 450 mm (18-in.) lengths of tape taken from each sample roll in accordance with 5.2 and conditioned in accordance with Section 8.

13. Procedure

13.1 Place the test specimen, after conditioning, without tension or pressure, adhesive side down on a hard smooth surface. Measure the width perpendicular to the edge with the steel scale at three approximately equally-spaced points along the length.

14. Report

14.1 Report the average width in millimetres or inches, plus the maximum and minimum, if specified.

15. Precision and Bias

15.1 This test method has been in use for many years, but no statement of precision has been made and no activity is planned to develop such a statement.

15.2 This test method has no bias because the value for width is defined in terms of this test method.

Method B—Caliper

16. Apparatus

16.1 A pair of calipers with a scale length larger than width of the roll of tape, having divisions at 0.5-mm or 1/64-in. intervals.

17. Test Specimen

17.1 One roll of tape, conditioned in accordance with Section 8. Unless damaged, no outer layers need to be removed.

18. Procedure

18.1 The outer turns of the roll must have clean and sharp edges. Discard any damaged or crushed edges. After conditioning the roll of tape, place it on a table in a vertical position. Open the jaws of the calipers and slide them over the cut edges of the tape so that the scale shaft is parallel to the table. Close the caliper jaws slowly so as to just touch the sides of the tape roll. Be careful not to crush the edges and keep the caliper jaws perpendicular to the edges of the tape. Measure the width perpendicular to the edges in mm (in.) to the nearest 0.5 mm (1/64 in.) at three approximately equally-spaced points along the circumference of the roll.

19. Report

19.1 Report the average width in millimetres or inches, plus the maximum and minimum, if specified.

20. Precision and Bias

20.1 This test method has been in use for many years, but no statement of precision has been made and no activity is planned to develop such a statement.

20.2 This test method has no bias because the value for width is defined in terms of this test method.

THICKNESS

21. Terminology

21.1 *Definitions of Terms Specific to This Standard:*

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21.1.1 *thickness, n*—the perpendicular distance between the opposite surfaces of pressure-sensitive adhesive tape as determined in accordance with this test method.

22. Significance and Use

22.1 The thickness is of value in controlling uniformity and providing design data, as well as for use in determining physical and electrical properties.

23. Apparatus

23.1 *Thickness Gage*—A dead weight thickness gage as prescribed in Apparatus C of Test Methods D 374, with the following modifications:

23.1.1 *Presser Foot Diameter*—6 mm (¼ in.).

23.1.2 *Anvil Diameter*—6 mm to 50 mm (¼ to 2 in.).

23.1.3 A weighted presser foot so that the total pressure applied to a specimen is equal to 50 ± 5 kPa (7.6 ± 0.5 psi). Calibrate the gage for the actual load exerted by the presser foot.

NOTE 3—Any commercial instrument, including hand-held micrometer, that satisfies 23.1.3 may be use for the thickness measurement.

24. Test Specimens

24.1 In accordance with 5.2 and Section 8, prepare and condition specimens of tape of a single thickness a minimum length of 450 mm (18 in.). Let flexible specimens relax for at least 2 min before testing.

25. Procedure

25.1 Place the test specimen upon the anvil of the gage, smoothly, with adhesive side down, but without tension. Lower the presser foot onto the tape gradually to minimize any impact force, allowing it to rest upon the tape for 2 s, and then observe the reading to the nearest 0.0025 mm (0.0001 in.) of the thickness gage scale. Make sure no air bubbles are trapped.

25.2 Take three measurements uniformly distributed over the surface of the test specimen.

26. Report

26.1 Report the following information:

26.1.1 The average thickness to the nearest 0.0025 mm (0.0001 in.) plus the maximum and minimum, if specified.

27. Precision and Bias

27.1 Data obtained from a round-robin investigation on several types of pressure-sensitive adhesive tape indicate that thickness measurements within a single laboratory can be expected to fall within ±5 % of the mean value, and that measurements between laboratories can be expected to fall within ±10 % of the overall mean value.[4]

27.2 A statement of bias is not applicable in view of the unavailability of a standard reference material for this property.

LENGTH OF TAPE IN A ROLL

28. Terminology

28.1 *Definitions of Terms Specific to This Standard:*

28.1.1 *length of tape in a roll, n*—the number of linear metres or yards of tape wound into a roll as measured in accordance with these test methods.

29. Significance and Use

29.1 Measurement of the length of tape in a roll is necessary to ensure receiving correct quantities.

Method A—Balance Method

30. Apparatus

30.1 *Balance*—Two required, one capable of weighing to the nearest 0.1 g, the other capable of weighing to 1 mg.

30.2 *Steel Rule*—Capable of measuring to the nearest 2 mm (0.1 in.).

31. Test Specimen

31.1 A test specimen is a single thickness of pressure-sensitive adhesive tape approximately 1 m (3 ft) long removed from a full roll of tape as received from the manufacturer. Condition each specimen as described in Section 8.

32. Procedure

32.1 Determine the number of rolls to be tested for length in accordance with the schedule described in Section 4.

32.2 Remove the core from the roll. Weigh each roll to the nearest 0.1 g (Note 4). Remove a specimen of tape approximately 1 m (3 ft) long from the roll in accordance with the procedure described in Section 5, except DO NOT DISCARD the first three layers. After conditioning, measure the relaxed length of the specimen to the nearest 2 mm or 0.1 in. and weigh to the nearest mg.

NOTE 4—If it is desired to run additional tests on the tape in the roll, it is permissible to first weigh the roll with the core in place and then subtract the weight of the core after all test specimens are removed.

32.3 Calculate the metres per roll as follows:

$$\text{Metres per roll} = \frac{\text{weight of roll less core} \times \text{length of specimen, mm}}{\text{weight of specimen} \times 1000} \quad (1)$$

32.4 Calculate the yards per roll as follows:

$$\text{Yards per roll} = \frac{\text{weight of roll less core} \times \text{length of specimen, in.}}{\text{weight of specimen} \times 36} \quad (2)$$

Method B—Length Sensor Method

33. Apparatus

33.1 *Length Sensor*—A device to measure length by using a benchmarked rotating wheel which rolls, with low torque and contact pressure, against the circumference of the roll as it unwinds. The apparatus includes a spindle for mounting the tape, the length sensor mechanism, and a read-out and rotating wind-up roll that can be used to either manually or automatically unwind the roll of tape. See Fig. 1.

34. Procedure

34.1 Determine the number of rolls to be tested for length in accordance with the schedule described in Section 4. Use only full rolls of tape. Do not remove any outer layer.

[4] Supporting data are available from ASTM Headquarters. Request RR: D09:1008.

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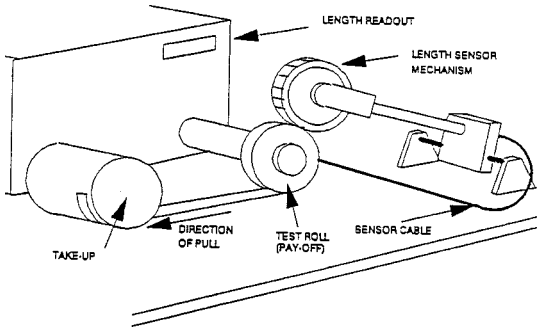


FIG. 1 Measuring Device for Determination of Length of Tape in a Roll (Length Sensor Method)

34.2 Mount the roll on the shaft adjacent to the sensor. Position the roll and length sensor so that the sensor is in contact with the circumference of the roll and the leading end of the roll is directly under the sensor. Zero the sensor and manually pull the leading edge of the tape and fix it to the wind-up roll. At the start of the unwinding, make sure that the length sensor maintains good contact with the roll and does not slip or bind. After unwinding is completed, take the reading of the length sensor.

35. Report

35.1 Report the following information:

35.1.1 The length of tape in each roll to the nearest 0.1 m (0.1 yd).

36. Precision and Bias

36.1 These test methods have been in use for many years, but no statement of precision has been made and no activity is planned to develop such a statement.

36.2 These test methods have no bias because the value for length is defined in terms of these test methods.

BREAKING STRENGTH AND ELONGATION

37. Terminology

37.1 *Definitions of Terms Specific to This Standard:*

37.1.1 *breaking strength of pressure-sensitive adhesive tape, n*—the force required, per unit width, to break the tape when tested under prescribed conditions.

37.1.2 *elongation of pressure-sensitive adhesive tape, n*—the increase in length at break when the tape is tested under prescribed conditions.

37.1.2.1 *Discussion*—In the case of Class 1 tapes, the elongation may include creep in the jaws which is often partially compensated for by "necking" of the specimen.

38. Significance and Use

38.1 *Breaking Strength*—Breaking strength of tape is important as a measurement of its uniformity, quality, and ability to withstand tensile stress in application and service.

38.2 *Elongation*—Elongation of tape is important as a measurement of its uniformity and quality, as well as a rough indication of its ability to conform to contours of uneven surfaces.

38.3 In the case of Class 2 tapes, testing at low temperature is necessary to ensure that the tape performs well at cold winter temperatures.

NOTE 5—Values obtained in dry ice chambers and walk-in cold rooms may not be equivalent.

39. Apparatus

39.1 *Testing Machine*—A testing machine of the constant-rate-of-extension (CRE) type is preferred. Equip the machine with a device for recording the tensile load and the amount of separation of the grips (Note 6) such that both of these measuring systems are accurate to ±2 % of the breaking load or the amount of separation of the grips. The apparatus must be capable of providing smooth, uniform jaw movement during testing, and the rate adjustable in increments necessary to produce strain rates that are specified for the materials under test. Equip the machine with a load cell with a capacity such that the breaking load of the material under test falls between 10 and 90 % of the maximum capacity of the load cell.

NOTE 6—A high response speed in the recording system is desirable, particularly when relatively high strain rates are employed. The speed of pen response for recorders is supplied by manufacturers of this equipment. Take care to conduct tests at conditions such that response time (ability of recorder to follow actual load) will produce less than 2 % error.

39.2 *Extension Indicator*—A suitable instrument for determining the distance between two fixed points located within the gage length of the test specimen at any time during the test. It is desirable, but not essential, that this instrument automatically record this distance as a function of the load on the test specimen, or of the elapsed time for the start of the test, or both. If only the latter is obtained, also take load-time data. The extension indicator will usually have a separation of 25 mm (1 in.) between points and be a minimum of 25 mm (1 in.) from both the top and bottom jaws.

39.3 *Holding Fixtures*—The holding fixtures may be any of the following types, provided that the fixture does not cut the specimen or cause slippage:

39.3.1 *Air Jaws*—A device that can be fitted with various types of grips that will clamp onto a specimen through lever arms actuated by compressed air cylinders built into the body. The design provides a high gripping force with standard air pressure. Increased air pressure raises the gripping force to accommodate materials that are often difficult to hold in other types of grips.

39.3.2 *Drum Jaws*—Two smooth cylindrical metallic drums, 50 mm (2 in.) in diameter with a minimum length of 38 mm (1½ in.), suitably marked to aid in proper specimen alignment.

NOTE 7—While drum jaws are permissible, they are not preferred. The design of drum jaws makes it extremely difficult to identify accurately the gage length between jaws.

39.3.3 *Manual Jaws*—A device that can be fitted with various types of grips that will clamp onto a specimen through a manually operated lever.

39.3.4 *Grips*—For manual jaws.

39.3.4.1 *Line Contact* grips have faces designed to concentrate the entire gripping force along a single line perpendicular to the direction of testing stress. This is usually done by

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combining one standard flat face with an opposing face from which protrudes a half-round.

39.3.4.2 *Flat Faced* grips have their surfaces finished in order to give the best clamping force on the material for test. The choice is determined largely by practical experience with the materials tested. The faces may be smooth-ground, rubber-coated, or serrated. In general, the smooth-ground surface offers high gripping efficiency with most flat materials. The rubber-coated surface is of value with materials that tend to be weakened by pinching at the edge of the jaw face. The serrated surface is recommended for stronger materials that require the greatest gripping action.

NOTE 8—Double coated tape may be used to reinforce gripping, by applying a thin piece of tape on each side of the flat grips.

39.3.4.3 *Cold Chamber*—For cold temperatures testing, if a cold chamber is used for conditioning, it must be equipped with a slot suitable for inserting the tape.

39.3.4.4 *Gloves*—White cotton for handling very cold samples.

40. Conditioning

40.1 Condition rolls of tape or specimens according to Sections 6-10 for either room or low temperature testing.

41. Test Specimens

41.1 Select specimens in accordance with 5.2 and Section 8. Use specimens that are the width of the tape as received if possible. If it is necessary to trim the specimens due to the machine or jaw width limitations, take extreme care since hand trimming may materially affect the test results. See 5.3 for recommended procedures to slit narrower widths. Put benchmarks on the specimens, if needed.

42. Procedure

42.1 *Air Jaws or Manual Jaws*—Position the crosshead at the desired gage length and insert the specimen in the grips. Tighten the movable grip first. If this process applies a preload on the specimen, do not change the balance adjustment to compensate for it. Adjust the initial length of the specimen between contact points to 100 mm (4 in.).

42.2 *Drum Jaws*—Hold the test specimen in place by placing approximately three quarters of a turn of the tape around each holding fixture with the adhesive side in contact with the drum. Place the tape in the center of the drums with the edges parallel to the scribed lines. Adjust the initial length of the specimen between contact points to 100 mm (4 in.).

42.3 Use a constant jaw speed of 300 ± 13 mm/min (12 ± ½ in./min), unless otherwise specified.

42.4 Discard breaks that occur at the jaws. Make a minimum of three acceptable determinations.

43. Calculation

43.1 Read the breaking strength directly from the recording chart or digital readout.

43.2 Read the percent elongation from the chart or digital readout or record the distance between benchmarks at the instant of break or rupture, and note the jaw separation or the distance between benchmarks at the instant of break or rupture, and calculate the percent elongation as follows:

$$\text{Elongation, \%} = [(D_2 - D_1)/D_1] \times 100 \quad (3)$$

where:

D_1 = original distance between jaws or benchmarks, and
D_2 = distance at instant of break or rupture between jaws or benchmarks.

44. Report

44.1 Report the following information:

44.1.1 Temperature conditions,

44.1.2 Average breaking strength expressed in newtons per 10 mm of width (N/10 mm) or in pounds-force per inch of width, plus the maximum and minimum, if specified, and

44.1.3 Average percent elongation, plus the maximum and minimum, if specified.

45. Precision and Bias

45.1 Data obtained from a round-robin investigation on several types of pressure-sensitive adhesive tape indicate that breaking-strength measurements within a single laboratory can be expected to fall within ±15 % of the mean value, and elongation measurements to within ±25 % of the mean value. Among different laboratories they can be expected to fall within ±20 % and ±30 %, respectively, of the overall mean value.[4]

45.2 A statement of bias is not applicable in view of the unavailability of a standard reference material for these properties.

ADHESION STRENGTH TO STEEL AND BACKING

46. Terminology

46.1 *Definitions of Terms Specific to This Standard:*

46.1.1 *adhesion strength of pressure-sensitive adhesive tape*, *n*—the force necessary to remove the tape from a prescribed surface when measured in accordance with this test method.

47. Significance and Use

47.1 In many applications the use of a pressure-sensitive adhesive tape depends upon adhesion strength to give satisfactory performance. The adhesion property is also important in determining the uniformity of quality.

48. Apparatus

48.1 *Testing Machine*—A crosshead type (constant rate of extension) testing machine, with two clamps with centers in the same plane, parallel with the direction of the motion of the stressing clamp, and so aligned that the clamps will hold the specimen entirely in the same plane, and with a graduated tension weighing device having an accuracy of at least 45 g (0.1 lb) or less per scale division, and preferably 23 g (0.05 lb) or less per scale division. Equip the machine with a device that allows a head separation of a minimum of 250 mm (10 in.).

48.2 *Test Panel*[5]—A flat steel sheet having a bright annealed finish, 50 by 125 by 1.5 mm (2 by 5 by 1/16 in.). Use stainless

[5] Test panels meeting these requirements are available from Chemsultants International, 9349 Hamilton Drive, Mentor, OH 44061-1118.

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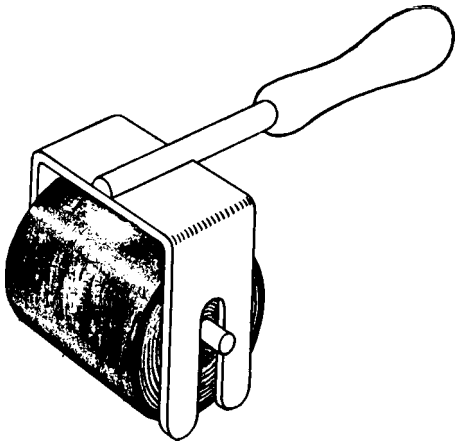


FIG. 2 Suggested Construction of Roller for Adhesion Strength Test

steel Type 302 or 304 as prescribed in Specification A 167 with surface roughness height of 0.050± 0.025 µm (2.0 ± 1.0 µin.) arithmetic average deviation from the mean line.

48.3 *Rubber Covered Steel Roller*—A steel roller, Fig. 2, 80 ± 2.5 mm (3.25 ± 0.1 in) in diameter and 45 mm ± 1 mm (1.75 ± 0.05 in.) wide, covered with rubber approximately 6 mm (¼ in.) in thickness having a durometer hardness of 80 ± 5 Shore A. To apply pressure to the specimen, use a roller weighing 2000 ± 50 g (4.5± 0.1 lb). Construct the roller so that the weight of the handle is not added to the weight of the roller during use.

49. Test Specimens

49.1 Use test specimens that are 250 mm (10 in.) long and no more than 25 mm (1 in.) wide. Remove each specimen from the roll in accordance with 5.2 so that neither surface in the test area contacts the operator's fingers nor any other foreign object.

49.2 Prepare three test specimens from each roll.

50. Procedure

50.1 *Adhesion to Steel Panel*—Prepare the polished surface of the steel panel by scrubbing it thoroughly, using a clean piece of surgical gauze saturated with any solvent capable of facilitating the removal of adhesive residue (**Caution:** see 3.1). Scrub the panel again using a clean piece of surgical gauze saturated with heptane or any other appropriate solvent (**Caution:** see 3.1). Discard the gauze after each cleaning step. After all traces of solvent evaporate, wipe the surface of the panel with a clean dry piece of surgical gauze.

NOTE 9—For referee testing, use new cleaned steel panels.

50.2 Remove the specimen from the roll. Let it relax for about 2 min or more. Apply it, adhesive side down, to the polished surface of the panel. Apply the specimen so that a 125-mm (5-in.) length extends beyond one end of the panel.

50.3 For tapes less than 25 mm (1 in.) wide, cut other strips from the same sample roll and apply parallel and adjacent to the test specimen to provide a total width of approximately 25 mm (1 in.) for rolling purposes only. Then, pass the roller, without application of additional pressure, over the backing of the tape lengthwise, once in each direction at the rate of approximately 300 mm/min (12 in./min). After the tape is on the panel for 20 min (Note 10), double back the free end of the test specimen at an angle of 180° and peel 25 mm (1 in.) of the tape off the panel at the doubled end. Clamp this portion of the exposed panel in the lower jaw of the testing machine and place the free end of the tape in the upper jaw. Use a jaw travel rate of 300 mm/min (12 in./min). After the first 25 mm (inch) of tape is removed from the panel, read the specimen adhesion over approximately the next 50 mm (2 in.) at approximately 13-mm (½ in.) intervals. Do not take any readings during the removal of the last 25 mm (inch) of tape from the panel.

NOTE 10—In order to expedite testing, the adhesion may be measured immediately after application of the tape to the panel, except for referee testing. This procedure results in slightly lower and more variable values.

50.4 Test double-sided tapes by removing the liner material and covering the adhesive surface not under test with soft tissue paper, such as facial tissue.

50.5 Reinforce glass cloth tapes which may break on 180° pullback with another thickness of the same tape. Report this modification.

50.6 *Adhesion to Backing*—Conduct the test of the adhesion of a tape to its own backing in a similar manner, except first affix a strip of the tape under test to each test panel with both ends wrapped around the ends of the panel. Use clean steel plates. Follow the procedure described in 50.1-50.3 except apply the test specimen to the tape backing rather than to the steel panel. Both test specimen and tape backing are to be used once.

51. Procedure for Low Temperatures Testing

51.1 For low temperature measurements, specimens prepared in Section 49 will be conditioned for 2 h according to Sections 9 and 10 before testing. Use white cotton gloves for handling very cold samples.

52. Report

52.1 Report the following information:

52.1.1 Testing temperatures,

52.1.2 Kind of test (to steel or to backing), and

52.1.3 Average of the three test values for each kind of test expressed in newtons per 10 mm of width (N/10 mm) or in ounces-force per inch of width, plus the maximum or minimum, if specified.

53. Precision and Bias

53.1 For adhesion to steel, in a round-robin investigation involving two laboratories and several types of pressure-sensitive adhesive tapes (plastic, cloth, and paper-backed tapes), data generated utilizing the procedures described in Practice E 691 indicate that the coefficient of variation within a single laboratory, (Vr %) *j*, is expected to be as much as 7 % whereas the coefficient of variation between laboratories, (VL %) *j*, is expected to be as much as 10 %.[6]

[6] Supporting data are available from ASTM Headquarters. Request RR: D-9-1023.

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FIG. 3 Test Machine for Unwind Force Test (Method A)

53.2 For adhesion to backing, in a round-robin investigation involving two laboratories and several types of pressure-sensitive adhesive tapes (plastic, cloth, and paper-backed tapes), data generated utilizing the procedures described in Practice E 691 indicate that the coefficient of variation within a single laboratory, (Vr %) *j*, is expected to be as much as 7 % whereas the coefficient of variation between laboratories, (VL %) *j*, is expected to be as much as 11 %.[6]

53.3 These test methods have no bias because the values for adhesion to steel and adhesion to backing are defined solely in terms of these test methods.

UNWIND FORCE

54. Terminology

54.1 *Definitions of Terms Specific to This Standard:*

54.1.1 *unwind force of pressure-sensitive adhesive tape, n*—the force required to remove the tape from the roll when measured in accordance with this test method.

55. Significance and Use

55.1 The unwind force at the specified rate gives information on the combined effects of the interlayer adhesion in the roll and of the physical condition of the backing and adhesive mass. This unwind force is useful as a measure of the effects of natural, shelf or accelerated aging, and the unwind force determined at the fast rate of removal is useful as a measure of the ease of unwinding in mechanized or hand dispensers. A tape width of 25 mm (1 in.) is considered optimum for this test method. The unwind force for widths other than 25 mm (1 in.) may not be proportional to the width.

Method A—Fast Rate of Removal

56. Apparatus

56.1 *Testing Machine*[7]—A power-driven testing machine, similar to that shown in Fig. 3, that can rewind a roll of tape at 45 m/min (150 ft/min) from a specimen roll that is mounted upon a free-turning roller assembly. By suitable means, attach this assembly to a scale or other measuring device. The driven roll of the machine operates at the test speed while the wind-up mandrel may be operated through a slip clutch.

56.2 *Test Jig*[8]—A free-turning roller assembly similar to that shown in Fig. 4. The free-turning wheel or drum of the assembly should fit snugly into the core of the tape.

57. Conditioning

57.1 Condition rolls of tape or specimens according to Sections 6-10 for either room or low temperature testing, as needed.

[7] A variable-speed unwind machine meeting these requirements is available from Chemsultants International, 9349 Hamilton Drive, Mentor, OH 44061-1118.

[8] A test jig for 3-in. (75 mm) cores meeting these requirements is available from Chemsultants International, 9349 Hamilton Drive, Mentor, OH 44061-1118.

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FIG. 4 Test Jig for Unwind Force Test

58. Test Specimen

58.1 Use a roll of pressure-sensitive adhesive tape as received and a minimum length of 18 m (20 yd) as the test specimen. Discard the first three layers of tape before making the measurement.

59. Procedure

59.1 Place the roll of tape on the free-turning roller assembly. Thread the tape over the pull roll and attach it to a core on the wind-up mandrel. Check the zero reading on the scale. Operate the machine from the scale. Run off approximately 10 m (10 yd) for each test. Conduct one test on each roll.

Method B—Slow Rate of Removal

60. Apparatus

60.1 Use the testing machine and fixtures described in 56.1 and 56.2.

61. Conditioning

61.1 Condition rolls of tape or specimen according to Sections 6-10 for either room or low temperature testing, as needed.

62. Test Specimen

62.1 Use a roll of pressure-sensitive adhesive tape as received and a minimum length of 5 m (5 yd) as a test specimen. Discard the first three layers of tape before making the measurement.

63. Procedure

63.1 Place the roll of tape on the free-turning roller assembly. Clamp the roller assembly in the lower jaw of the tension testing machine. Unwind sufficient tape so that the free end of the tape can attach to the upper jaw of the machine. Operate the machine at 300 mm/min (12 in./min) and take readings as described in 50.3. After 25 mm (1 in.) has been run off, record the average load required for unrolling the tape. Run off approximately 300 mm (1 ft) of tape for each determination. Conduct three tests on each roll.

63.1.1 Observe the tape for adhesive transfer to backing and breaking during unrolling, especially at low temperatures.

64. Report

64.1 Report the following information:

64.1.1 Testing temperatures,

64.1.2 Rate of removal (fast or slow),

64.1.3 Average unwind force in newtons per 10 mm of width (N/10 mm) or in ounces-force per inch of width, plus the maximum and minimum, if specified, and

64.1.4 Any adhesive transfer to the backing, delamination on composites, or breaking of the tape during unrolling, especially at low temperatures.

65. Precision and Bias

65.1 These test methods have been in use for many years, but no statement of precision has been made and no activity is planned to develop such a statement.

65.2 These test methods have no bias because the value for unwind force is defined in terms of these test methods.

FLAGGING

66. Terminology

66.1 *Definitions of Terms Specific to This Standard:*

66.1.1 *flagging, n*—the lifting of an end of pressure-sensitive adhesive tape that has been applied to a curved surface, thus forming a flag or tab tangent to the surface.

67. Significance and Use

67.1 Knowledge of the flagging characteristics of tape is useful in determining whether such properties as thickness, stiffness, and adhesion have been properly balanced for applications where flagging may occur.

Method A—For Class 1 Tape

68. Apparatus

68.1 *Winding Fixture*—A device designed to hold a metal rod at each end and 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.

68.2 *Rods*—Any suitable metal of 3 mm (⅛ in.) or 6 mm (¼ in.) in diameter and 125 mm (5 in.) long. Rods of other diameters may be acceptable if agreed upon between the manufacturer and the purchaser.

68.3 *Weight*—A mass of 500 ± 1 g provided with a hook or other means of attaching to the specimen.

68.4 *Rule*, graduated in millimetres.

68.5 *Board or Block*, a device made of wood or aluminum to hold the wrapped rods in a near-vertical position.

69. Test Specimens

69.1 Select test rolls specimens and condition them in accordance with Sections 5 and 8, except unwind the tape at approximately 300 mm/s (12 in./s) in order to select three strips of tape about 125 mm (5 in.) long at intervals of 300 mm (12 in.) along the length. Protect the adhesive surface from dust. Do not allow the adhesive surface to contact the fingers or any other foreign objects. If the strip of tape is wider than 14 mm (9⁄16 in.), use a sharp razor to trim the tape to a width of 13 mm

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(½ in.). See 5.3 for recommended procedures. Use tape 14 mm (9⁄16 in.) in width or narrower without trimming.

70. Procedure

70.1 Mount a rod of the required size horizontally in the winding fixture. For tapes of 0.025 mm (0.001 in.) or less of backing thickness, use a 3-mm (⅛-in.) diameter rod. For tapes having a backing thickness greater than 0.025 mm (0.001 in.), use a 6-mm (¼-in.) diameter rod.

70.2 Attach a 500-g weight to one end of a 125-mm (5-in.) strip of tape. Holding the opposite end of the strip, drape the strip over the rod with the adhesive side contacting and adhering to the rod (see Fig. 5(a)). Rotate the rod so that the contact point is at the top of the rod (see Fig. 5(b)) and use a sharp razor blade to trim the leading edge of the strip of tape flush with the rod.

70.3 Wind the tape on itself one and one-quarter turns (see Fig. 5(c)). Remove the weight and cut the tape at point D by tearing against the blade edge, taking care not to cut the lower layer of tape.

NOTE 11—As the tape is being wound up rely only on the weight to get smooth overlap. Avoid juggling or touching the tape to direct it during the wind up.

70.4 *Flagging (as received)*—Insert the specimen assembly in holes in the base of the board with the flag at the upper end and allow them to condition at 23 ± 1°C (73.4 ± 1.8 °F) and 50 ± 2 % relative humidity for 24 h unless a period of 7 days is specified.

70.5 *Flagging (after thermosetting)*— Cure the specimen assembly as described in 80.1. Remove the assembly from the oven and cool to room temperature.

70.6 *Flagging (after immersion)*—Prepare specimen assembly as described in 70.4 or 70.5. With assembly at room temperature, totally immerse the specimens vertically in a specified varnish solvent or cleaning solvent such as toluene (**Caution:** see 3.1 and 3.2) for 15 min. Allow assembly to dry before measuring the unwound length.

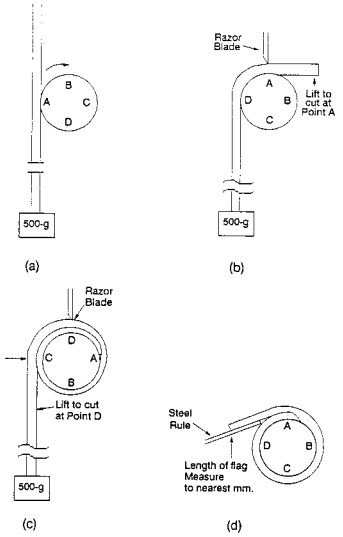


FIG. 5 Flagging Test—Preparation of Test Specimen (Method A) for Class 1 Tape

70.7 Measure the length of the unwound tape (flag) from the end of the tape to the point of tangent of the rod (see Fig. 5(d)). If an uneven flag occurs, record the greatest length. Calculate the average length of flag in millimetres to the nearest millimetre.

71. Report

71.1 Report the following information:

71.1.1 Rod diameter used,

71.1.2 Conditioning procedure used, including solvent type, if used, and

71.1.3 Pass or fail depending on the requirements of the reference specification.

Method B—For Class 2 Tape

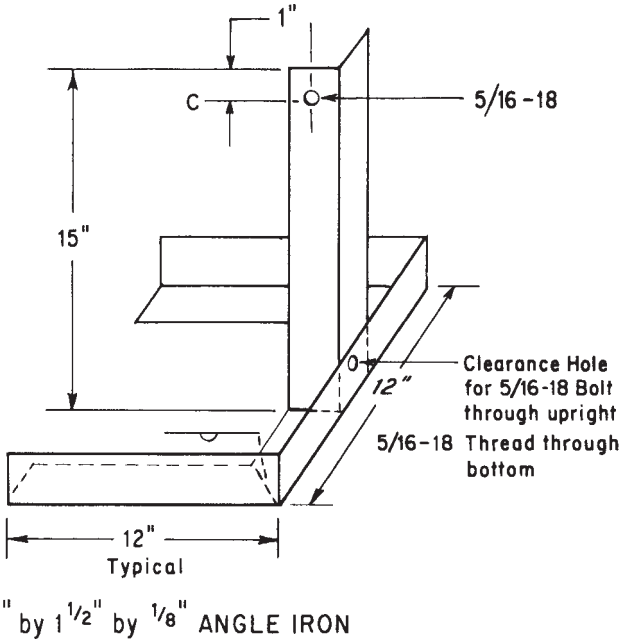
72. Apparatus

72.1 *Brass Rod*, clean, smooth, 3 mm (⅛ in.) in diameter by 125 mm (5 in.) in length.

72.2 *Winding Fixture*—A device designed to support the brass rods at each end and a crank or other device to wind the tape specimens on the rod. Attach the fixture to a rigid support to allow rotation while tilting the rod to an angle of approximately 35° with the horizontal (see Fig. 6).

72.3 *Weights*, such that 50 ± 1 g for each 0.025 mm (0.001 in.) of nominal overall thickness of tape can be attached to the lower end of the tape to provide winding tension.

72.4 *Board*, a device to hold the wrapped rods in a near-vertical position.



NOTE 1—The SI equivalents for the dimensions shown are:

5⁄16 in. = 8 mm
1 in. = 25 mm
12 in. = 305 mm
15 in. = 380 mm
1½ × 1½ × ⅛ in. = 38 × 38 × 3.2 mm

FIG. 6 Test Fixture—Flagging Test (Method B) for Class 2 Tape

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73. Test Specimens

73.1 Cut six strips of tape 6 mm (¼ in) wide and 200 mm (8 in.) long from the sample roll. Take care to ensure that the adhesive does not contact the hands or other foreign object. See 5.2 for recommended procedures.

74. Procedure

74.1 Secure a strip of tape to a rod held in the winding fixture and tilted approximately 35° to the horizontal position. Attach the weight specified in 72.3 to the lower end of the tape. After 1 min under tension, slowly rotate the rod and tilt the fixture so that the strip of tape wraps for the length of the rod with successive turns closely butted without overlapping. It may be necessary to adjust the angle of the rod by successive trials until the proper angle for the particular tape is obtained. After wrapping is complete, secure the lower end of the tape and cut off any remaining length.

74.2 Secure a second strip of tape to the upper end of the rod and apply it under tension over the first layer in the same direction as described in 74.1, with the width of the second layer centered over the butt lap in the first layer. As the winding progresses to the lower end of the rod, insert a short length of lens tissue 3 mm (⅛ in.) wide under the tape across its width and parallel to the axis of the rod to serve as a starting point for the tape to unwind (flag). Remove the winding tension and cut the tape adjacent to the tissue strip that then serves as a benchmark for measurement of the unwind length.

74.3 Insert the wrapped specimens in the holes in the base of the board with the flag at the upper end, and allow them to condition at 23 ± 1°C (73.4 ± 1.8 °F) and 50 ± 2 % relative humidity for 7 days. At the end of this period, measure the length of the flag from the point of tangency to the nearer edge of the tissue, taking care not to cause additional unwrapping in the measuring operation. Calculate the average length of flag in millimetres.

75. Report

75.1 Report the following information:

75.1.1 The average of three values of lengths of flags, in mm, using the greatest distance if the flag is uneven, and

75.1.2 Pass or fail depending on the requirements of the reference specification.

76. Precision and Bias

76.1 No statement is made about either the precision or bias of these test methods since the result merely states whether there is conformance to the criteria for success specified in the procedure.

THERMOSETTING PROPERTIES

77. Scope

77.1 Thermosetting pressure-sensitive adhesive tapes are produced with adhesives that cure after exposure to heat. The curing reaction involved is not reversible, and tapes once heat-cured remain cured. Thermosetting properties are measured by a bond separation test and are reported as the time to failure of a heat-cured adhesive-to-adhesive bond under a prescribed load at a specified temperature.

78. Significance and Use

78.1 This test method offers a means of differentiating between thermosetting and non-thermosetting tapes since application of stress on the bond after cure will result in bond failures within a few minutes for non-thermosetting adhesives, while bonds of true thermosetting adhesive tapes will hold an hour or more before failure.

78.2 The length of time to failure of an adhesive-to-adhesive bond is also a measure of the holding strength of the cured tape at an elevated temperature.

78.3 This test method is suitable for specification acceptance and service evaluation.

79. Test Specimens

79.1 Remove 150-mm (6-in.) long samples from the roll (whose width is more than 13 mm (½ in.)) in accordance with Section 4 so that the adhesive surface in the test area contacts neither the operator's fingers nor any other foreign object. Construct each specimen from two strips of tape fastened together to form a 13-mm (½-in.) long adhesive-to-adhesive lap joint. Take a rubber-covered steel roller as described in 48.3 and, without applying additional pressure, pass the roller at a speed of 300 mm/min (12 in./min) over the joint once in each lengthwise direction. After this application of pressure, cut the tape to a width of 13 mm (½ in.) with a sharp razor blade. See 5.3 for recommended procedures.

NOTE 12—If different width tape specimens with same unit loading must be used, significant differences in test results may result.

80. Procedure

80.1 Set an oven at a temperature and for the time recommended by the manufacturer. If not specified, use Table 2 according to the type of adhesive to be tested:

80.2 Place three assemblies of adhesive-to-adhesive specimens on the shelf of an oven maintained at the thermosetting temperature for the time specified in the preceding table with no stress on the bond. Remove the assemblies from the oven, and allow them to cool for 5 min. Hang the specimens vertically in the oven at the test temperature with a 500-g weight fastened to one end of each specimen. Continue the test for a prescribed time, or until failure occurs by bond separation. Calculate the average time of bond separation. Compare with the prescribed time of failure.

81. Report

81.1 Report the following information:

81.1.1 Pass or fail depending on the requirements of the reference specification.

TABLE 2 Adhesive Type vs. Test Conditions

Adhesive Type	Temperature, °C	Time, h
Natural or synthetic rubber	130	2
Acrylic polymer	130	2
Silicone polymer	200	3

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82. Precision and Bias

82.1 No statement is made about either the precision or bias of these test methods since the result merely states whether there is conformance to the criteria for success specified in the procedure.

DIELECTRIC BREAKDOWN VOLTAGE

83. Terminology

83.1 *Definitions of Terms Specific to This Standard:*

83.1.1 *dielectric breakdown voltage of pressure-sensitive adhesive tape, n*—the potential difference at which dielectric failure occurs under prescribed conditions, in a single layer of pressure-sensitive adhesive tape located between two electrodes.

84. Significance and Use

84.1 The measure of dielectric breakdown voltage of a tape is an indication of its ability to withstand electric stress. This value does not correspond to the dielectric strength expected in service, but is a numerical value which may be used for purchase by specification as an indication of quality and for comparison of different tapes or different lots of the same tape, and to a limited degree for design work when coupled with experience. The comparison of dielectric breakdown voltage of different tapes after exposure to widely differing moisture conditions gives an indication of the quality of the compound used in the tape backing as a moisture resistant dielectric material.

85. Electrodes

85.1 Use a testing device whereby the test specimen is held under pressure between methyl silicone rubber washers (see Note 13) while voltage is applied to prevent flashover around the edges of the specimen tested. Two forms of this tester are fully described in the Appendix to Test Methods D 295. The electrodes which are a part of the test fixture are 6 mm (¼ in.) in diameter and conform to the description of Type 3 electrodes specified for narrow materials (tape) in Test Method D 149.

NOTE 13—To prevent flashover, other types of track resistant rubber can also be used, as described in Test Methods D 295. Use of fluorinet or other electronic liquid will help prevent flashover also.

86. Test Specimens

86.1 Use test specimens that are single thicknesses of tape, each approximately 125 mm (5 in.) long.

87. Conditioning

87.1 Test tapes of Class 1 and Class 2 with no further conditioning than prescribed in Section 8.

87.2 In addition, test all Class 2 tapes after conditioning under the following conditions:

87.2.1 After 24 h immersion in distilled water at 23± 1°C (73.4 ± 1.8 °F), and

87.2.2 After 96 h at 23 ± 1°C and 96 % relative humidity. Practicable methods of maintaining 96 % relative humidity in small enclosures are described in Practice D 5032.

87.2.3 Remove water-immersed test specimens from the water one at a time and dry by placing between layers of cotton toweling and pressing down gently over the entire surface. Immediately test the specimen to prevent misleading results due to drying of the sample.

87.2.4 Remove humidity-conditioned test specimens from the humidity chamber one at a time and test immediately.

88. Procedure

NOTE 14—**Caution:** see 3.3 before commencement of any test.

88.1 Determine the dielectric breakdown voltage in accordance with Test Method D 149 using the short-time test. Increase the voltage from zero to breakdown at a uniform rate of 0.5 kV/s. Make all measurements in air.

88.2 Take three specimens from each roll for each condition and make one breakdown measurement on each specimen.

89. Report

89.1 Report the following information:

89.1.1 Conditioning method, and

89.1.2 Average breakdown voltage, in kV, plus the maximum and minimum, if required.

90. Precision and Bias

90.1 Since this test method involves the testing of a wide variety of materials, it is the consensus that a precision statement in this standard is not practical.

90.2 This test method has no bias because the value for dielectric breakdown voltage is defined in terms of this test method.

INSULATION RESISTANCE AT HIGH HUMIDITY (INDIRECT ELECTROLYTIC CORROSION)

91. Significance and Use

91.1 Electrolytic corrosion can produce open circuit failures in electrical conductors and devices. The initiation and progression of electrolytic corrosion are influenced by temperature, humidity, time exposure, voltage level, whether the applied voltage or current is direct or alternating, and the characteristics of the metals involved. By measuring the insulation resistance of tape samples in contact with specified metal electrodes at high humidity, the presence and influence of electrolytic corrosion is detected (as a decrease in the insulation resistance or as an increase in the leakage current).

92. Apparatus

92.1 *Electrodes*—Use 6-mm (¼-in.) square stainless steel, brass or copper bars having the side in contact with the tape polished smooth and flat and the corners slightly rounded. Mount the electrodes in such a way that the tape under test is clamped between electrode pairs spaced 25 mm (1 in.) from edge to edge. Use a guard so that only the current flowing in the tape is measured.[9] Design the guard circuit in conformance with the requirements of Test Methods D 257. One arrangement, suitable for testing a number of tapes at the same time, has several rows of electrodes mounted on the inside of the cover of the humidity chamber as shown in Fig. 7. A

[9] Holding clips made from heat-treated Brylco 25 were used successfully.

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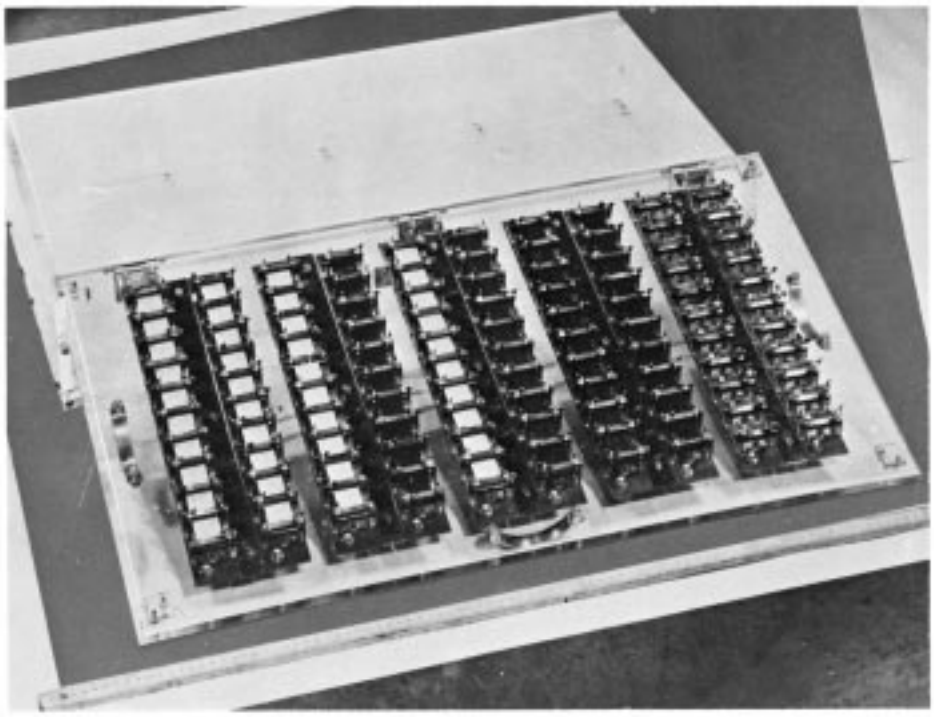


FIG. 7 Electrode Arrangement for Insulation Resistance (Indirect Electrolytic Corrosion) Tests

satisfactory method of attaching guarded electrodes to the cover and bringing out a terminal for each electrode is shown in Fig. 8.

92.2 *Measuring Equipment*—A source of stable direct-voltage potential within the range from 100 to 130 V and a means of measuring currents ranging from 0.001 to 1000 µA. Stable direct-voltage power supplies are satisfactory voltage sources. Recommended meter is any quality, high resistance, solid state measuring instrument, with a suitable resistance range, as described in Test Methods D 257, that will impress the required potential on the sample and cover the required conductance range.

93. Test Specimens

93.1 In accordance with 5.2, take test specimens that are approximately 150-mm (6-in.) long from each sample roll.

93.2 Condition the specimens in accordance with Section 8.

94. Procedure

94.1 *Preparation of Electrodes*—Clean the electrodes by dipping in acetone (**Caution:** see 3.1) and then wiping with a clean, soft cloth saturated with heptane (**Caution:** see 3.1) in a well-ventilated area. Polish the electrodes of brass or copper with No. 0 emery polishing paper, rinse in acetone, and then wipe with a heptane-saturated soft cloth.

NOTE 15—**Caution:** see 3.3 before commencement of any test.

94.2 *Calibration of High Resistance Meter*—Clamp a resistor (of a value within one decade of the anticipated specimen resistance) across the electrodes and measure the resistance with 100 to 130 V dc applied.

94.3 *Specimen Clamping*—Without stretching the test specimen, place it between the bar electrodes evenly. Firmly clamp the tape between the electrodes taking great care to avoid contact between the hands and any tape surfaces between electrodes.

94.4 *Conditioning*—Condition the tape mounted in the electrodes inside the test chamber for 18 ± 0.1 h at a relative humidity of 96 ± 2 % at 23 ± 1°C (73.4± 1.8 °F) (Note 16). Satisfactory means of obtaining this relative humidity are described in Practice D 5032.

NOTE 16—The test chamber must be capable of maintaining 96 ± 2 % at 23 ± 1°C (73.4 ± 1.8 °F). If possible, stabilize the humidity within ±1 %. It is advisable to cover the test chamber with thermal insulation in order to minimize internal temperature fluctuations caused by temperature changes or drafts, or both, in the surrounding air.

94.5 *Measuring*—At the end of the conditioning period, and while the tape is still in the humidity chamber, measure the resistance of the tape between each of five pairs of electrodes. Take readings 15 s after impressing 100 to 130 V dc between the electrodes. Calculate and record all values, and the median resistance of the five specimens.

95. Report

95.1 Report the following information:

95.1.1 All the values and the median, Ω, and

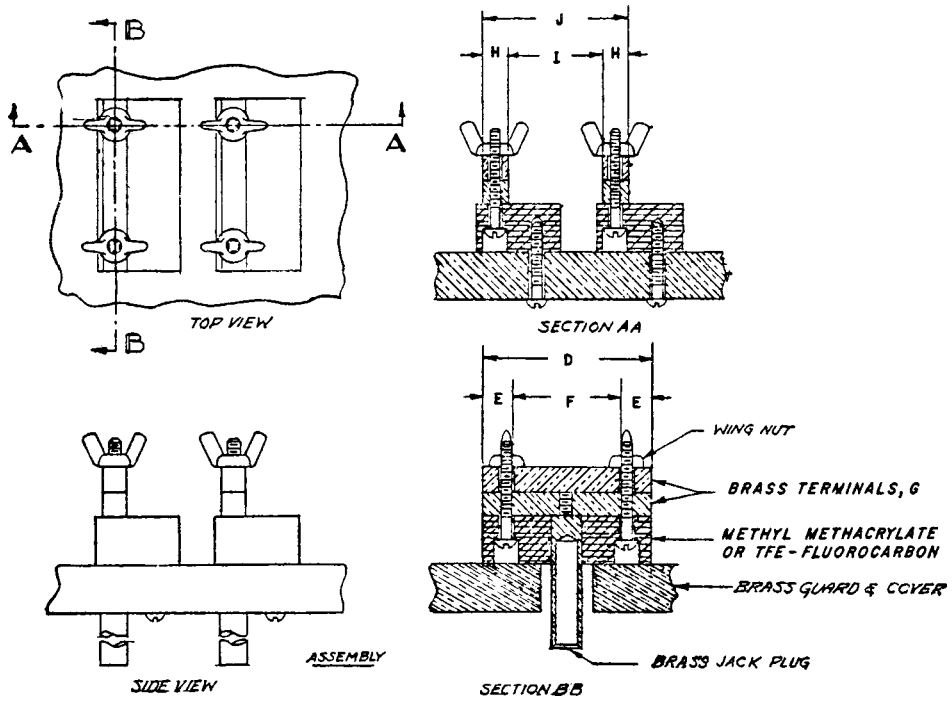
95.1.2 Pass or fail depending on the requirements of the reference specification.

96. Precision and Bias

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

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Metric Equivalents

	D	E	F	G	H	I	J
mm	45	8	29	6 × 6 × 45	6	25	38
in.	1¾	5⁄16	1⅛	¼ × ¼ × 1¾	¼	1	1½

FIG. 8 Method of Attaching Electrodes to Cover for Insulation Resistance (Indirect Electrolytic Corrosion) Tests

EFFECT OF ACCELERATED AGING ON DIELECTRIC BREAKDOWN VOLTAGE FOR HIGH-TEMPERATURE TAPE (THERMAL CLASS 180 AND ABOVE)

97. Scope

97.1 This test method determines the relative resistance of high-temperature tapes to short-time accelerated heat aging while the tape is under tension. The change in dielectric breakdown voltage is used as a measure of this resistance.

98. Significance and Use

98.1 The wrapped-mandrel, heat aging test indicates the relative resistance of a tape to elevated temperatures under physical conditions similar to those encountered in service.

99. Apparatus

99.1 *Brass Rod*, clean, smooth, 13 mm (½ in.) in diameter by 250 mm (10 in.) in length.

99.2 *Weight*, 2.3-kg (5-lb), for applying tension during winding.

99.3 *Oven*, having forced ventilation and capable of maintaining a temperature of 250 ± 3 °C (482 ± 5.2 °F).

100. Test Specimens

100.1 Use tape 13 to 25 mm (½ to 1 in.) wide. Prepare two test specimens by spirally winding a layer of tape on the brass rods using 2.3-kg (5-lb) tension per 25 mm (1 in.) of tape width. Wrap the tape so as to leave a gap between turns of 1 to 1.5 mm (1⁄32 to 1⁄16 in.). Spirally wrap a second layer in the same direction over the first layer, with the center of the second layer positioned over the gaps of the first layer.

101. Procedure

NOTE 17—**Caution:** see 3.3 before starting any test.

101.1 Condition one specimen for 168 h as described in 8.5. Wrap three strips of metal foil not more than 0.0125 mm (0.0005 in.) in thickness and 25 mm (1 in.) wide, tightly on each specimen equally spaced from each other and from the ends of the rod. Using the rod as one electrode and the foil as the other, determine the dielectric breakdown voltage at each foil strip, in accordance with 88.1.

101.2 Age the other specimen for 16 h at 250 ± 3 °C (482 ± 2 °F) in the oven, remove, and allow to cool for 4 h at the conditions described in 8.5. Determine the dielectric breakdown voltage as prescribed in 101.1.

102. Report

102.1 Report the following information:

102.1.1 Average breakdown voltage under each condition plus the maximum and minimum, and

102.1.2 Percent gain or loss in breakdown voltage as a result of heat aging.

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103. Precision and Bias

103.1 No statement is made about either the precision or bias of these test methods since the result merely states whether there is conformance to the required criteria specified in the procedure.

FLAMMABILITY

104. Significance and Use

104.1 The burning characteristics exhibited by a pressure-sensitive adhesive tape wound on a brass rod and ignited in a horizontal position are a measure of flammability. This test method differentiates among tapes having widely different burning characteristics but is less precise in differentiating among tapes within a narrow range of burning characteristics. The usefulness of this test method is primarily for specification purposes as the actual amount of tape used in any specific application and its configuration may alter the burning characteristics.

104.2 *This standard should be used to measure and describe the properties of materials, products, or assemblies in response to heat and flame under controlled laboratory conditions and should not be used to describe or appraise the fire hazard or fire risk of materials, products, or assemblies under actual fire conditions. However, results of this test may be used as elements of a fire risk assessment which takes into account all of the factors which are pertinent to an assessment of the fire hazard of a particular end use*.

105. Apparatus and Materials

105.1 *Brass Rod*—A minimum of three straight clean rods, 3 mm (⅛ in.) in diameter and 300 mm (12 in.) long, free of any burned material.

105.2 *Winding Fixture*—A device designed to support a brass rod by the ends with a crank or other device to rotate the rod from either end to wind the tape specimens on the rod. Attach the fixture to a rigid support to allow tilting to the proper angle needed to achieve the correct lap in winding the tape.

105.3 *Weights*, as required to provide 150 g for each 0.025 mm (0.001 in.) nominal overall thickness of tape, and means for attaching them to the end of the tape to provide winding tension.

105.4 *Bunsen Burner*—The gas flow cylinder shall be 10 mm (⅜ in.) in inside diameter.

105.5 *Timer*, capable of measuring to the nearest second.

105.6 *Stands and Clamps*, arranged to support the test specimens horizontally.

105.7 *Level*.

105.8 *Enclosure*, to provide a draft-free space.

105.9 *Gas Supply*—Public utility gas or propane may be used. For referee tests use commercial grade propane having a nominal heating value of 94 MJ/m^3 (2521 Btu/ft^3) and a specific gravity of 0.508 at 15.6 °C (60.1 °F) at a line pressure of 275-mm (11-in.) water column.

106. Test Specimens

106.1 Cut two strips of tape for each specimen, 19 mm (¾ in.) wide by approximately 375 mm (15 in.) long.

106.2 Prepare three specimens as described under Section 107.

107. Procedure

107.1 Place one of the rods in the fixture while held in a horizontal position. Secure one end of the specimen strip of tape near one end of the rod. Attach a weight as required by the nominal thickness to the lower end of the tape. After 1 min under tension, slowly tilt the fixture to the proper angle and then rotate the rod so that the tape is wrapped on the rod with a one-half lap for a length of 250 ± 10 mm (10 ± ⅜ in.). Remove the weight.

107.2 Reverse the rod in the fixture and repeat the procedure in 107.1 so that a second strip of tape is wound over the first strip in the opposite direction. This completes the preparation of the test specimen.

107.3 Support the specimen in a horizontal position in the draft-free enclosure using the stand and clamps. Check with the level to ensure that the wrapped specimen is horizontal.

107.4 Ignite the Bunsen burner and adjust the flame to produce a 125-mm (5-in.) outer cone and a 38-mm (1.5-in.) inner cone.

107.5 Apply the burner flame vertically to the specimen so that the tip of the blue inner cone touches the center of the specimen. Start the stop watch at the instant the flame is applied to the specimen. Allow the flame to remain in contact with the specimen for 30 s.

107.6 After 30 s, immediately turn off the gas supply. To obtain consistency, the gas must be turned off rapidly, such as by using a spring pinch clamp on the supply hose. If the burner is physically removed, the air flow around the flame may cause a blowout of the burning specimen.

107.7 When the specimen ceases to burn, stop the stop watch. Determine the flammability as the total time of burning noted less 30 s. Record the burning time for each test and calculate the average burning time.

108. Report

108.1 Report the following information:

108.1.1 All the values and the median, and

108.1.2 Pass or fail depending on the requirement of the reference specification.

109. Precision and Bias

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

BOND STRENGTH AFTER SOLVENT IMMERSION

110. Terminology

110.1 *Definitions of Terms Specific to This Standard:*

110.1.1 *bond strength after solvent immersion of a pressure-sensitive adhesive tape, n*—the force required to separate by shear a cured bond after immersion in a typical varnish solvent under designated conditions of test.

110.1.1.1 *Discussion*—It is measured as a tensile load in newtons per 10 mm of width or in pounds per inch of width at bond failure.

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111. Significance and Use

111.1 Bond strength is a measure of the resistance of a cured tape adhesive to action of a specific solvent. In use, variations in tape width will produce varying results due to change in relative edge area for solvent action. The test is suitable for product development, specification acceptance and service evaluation. It is limited in that adhesion to itself or backing only are considered, while in use tapes are generally adhered to various surfaces. Also, the solvent action is at room temperature, while often hot solvent action occurs in application. Differences in test results of less than 90 g/mm (5 lb/in.) of width have no significance.

112. Test Specimens

112. Prepare specimens in accordance with 79.1.

113. Procedure

113.1 *Bond Strength to Adhesive*—Cure three adhesive-to-adhesive specimens in an air-circulating oven maintained at 130 ± 2 °C (266 ± 3.6 °F) for 2 h or in accordance with the manufacturer's recommendations. After curing, remove specimens from the oven and allow to cool to room temperature. Immerse the specimens for 16 h at room temperature in a specified solvent. Place the specimens on clean blotting paper or towel for 30 min, then determine the breaking force to break the bond in accordance with Section 42, using clamp-type holding fixtures.

113.2 *Bond Strength to Backing*—Conduct the bond strength to backing determination in a similar manner to 113.1, except use specimens with the adhesive-to-backing. Calculate the average bond strength in newtons per 10 mm of width, or pounds-force per inch of width.

114. Report

114.1 Report the following information:

114.1.1 Curing conditions,

114.1.2 Type of solvent used,

114.1.3 Average of measurements, the minimum and maximum shear load in N/10 mm (lbf/in.) if required, and

114.1.4 Pass or fail depending on the requirements of the reference specification regarding bond strength to adhesive or backing.

115. Precision and Bias

115.1 No statement is made about either the precision or bias of these test methods since the result merely states whether there is conformance to the required criteria specified in the procedure.

OIL RESISTANCE

116. Terminology

116.1 *Definitions of Terms Specific to This Standard:*

116.1.1 *oil resistance (pressure-sensitive adhesive tapes), n*— the property of the adhesive to withstand the attack of the oil without impairment of the adhesion strength of the tape.

116.1.1.1 *Discussion*—This property is measured by determining the adhesion strength after the tape is immersed in a specific oil for a given time at an elevated temperature.

117. Significance and Use

117.1 Pressure-sensitive adhesive tapes may be used in locations where they contact oil or oil vapors that can affect the performance of the tape. An adhesion strength test after oil immersion is a method for determining this effect.

118. Test Fluids

118.1 Select a test fluid appropriate to the intended application of the tape. The test fluid may be one or more of the following:

118.1.1 Mineral insulating oil meeting the requirements of Specification D 3487, Type I or Type II.[10]

118.1.2 Fire-resistant phosphate ester-based hydraulic liquid.[11]

118.1.3 Other fluids which are more directly applicable to the intended application for the tape, as may be specified in the tape specification.

119. Test Specimens

119.1 Remove four specimens 250 mm (10 in.) long and 6 mm (¼ in.) wide from the roll in accordance with Section 5 so that the adhesive surface contacts neither the operator's fingers nor any foreign object. For tape wider than 6 mm (¼ in.), see 5.2 for recommended procedures to slit tape to that width.

120. Procedure

120.1 *Adhesion to Steel Panel*—Clean the steel panel in accordance with 50.1 and immediately after removing the tape from the roll, apply the adhesive side down to the polished surface of the steel. Apply the specimen so that a 125-mm (5-in.) length extends beyond the end of the panel. Apply four 6 mm (¼-in.) wide tape specimens to the panel so that there is a 3 to 6-mm (⅛ to ¼-in.) space between them. Pass the adhesion roller prescribed in 48.3 over the specimens in accordance with 50.3. When thermosetting tapes are used, cure the assembly as described in 80.1, and maintain at room conditions for a minimum of 24 h before testing. Immerse the panel completely in the test fluid for 72 h at 50 ± 2 °C in a vertical position with the free ends of the specimens adhered to the back of the panel. After removal from the fluid, place the assemblies, specimen side down, on a clean blotting paper or towel for 30 min. Measure the adhesion of each specimen in accordance with 50.3.

120.2 *Adhesion to Backing*—For effect of oil on adhesion to backing, apply 6-mm (¼-in.) or wider strips to the panel in accordance with 50.3, except wrap both ends around the panel as prescribed in 50.6. Apply 6-mm (¼-in.) wide specimens to these strips as prescribed in 50.2, immerse in oil, remove, and measure adhesion to backing as prescribed in 50.6.

121. Report

121.1 Report the following information:

121.1.1 Identification of the fluid used,

[10] This oil is of a type common for immersion of transformers, switches, and circuit breakers. Exxon Univolt 60 Transformer Oil is found satisfactory for this purpose.

[11] Monsanto Skydrol 500B-4 is satisfactory for this purpose. Available from Monsanto Co., 800 N. Lindbergh Blvd., St. Louis, MO 63166.

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121.1.2 Kind of test (adhesion to steel or to backing), and

121.1.3 Average of the four specimen adhesions in newtons per 10 mm of width, or ounces-force per inch of width, plus the maximum and minimum, if specified.

122. Precision and Bias

122.1 This test method has been in use for many years, but no statement of precision has been made and no activity is planned to develop such a statement.

122.2 This test method has no bias because the value for oil resistance is defined in terms of this test method.

PUNCTURE RESISTANCE

123. Significance and Use

123.1 Puncture resistance is a test to measure the resistance of a tape to puncture by a rounded probe. Puncture resistance is important because objects with irregular surfaces or relatively sharp contours (such as wire or laminate) may be present in the application and may cause a rupture in the tape.

124. Apparatus

124.1 *Testing Equipment*, in accordance with Section 48.

124.2 *Test Fixture*, as shown in Fig. 9.

125. Test Specimens

125.1 Select test specimens and condition them in accordance with Sections 5 and 8.

125.2 Prepare five test specimens that are 25 mm (1 in.) by 75 mm (3 in.).

126. Procedure

126.1 Install the test fixture in the testing machine. Zero the testing machine to compensate for the weight and frictional drag of the test fixture.

126.2 Place each specimen adhesive side down over the hole in the lower fixture and securely clamp with the clamping device provided.

126.3 Run the testing machine with a crosshead speed of 50 mm/min (2 in./min). The maximum force recorded is defined as the puncture force.

126.4 Determine the puncture resistance for all five specimens and calculate the puncture force by averaging the five values.

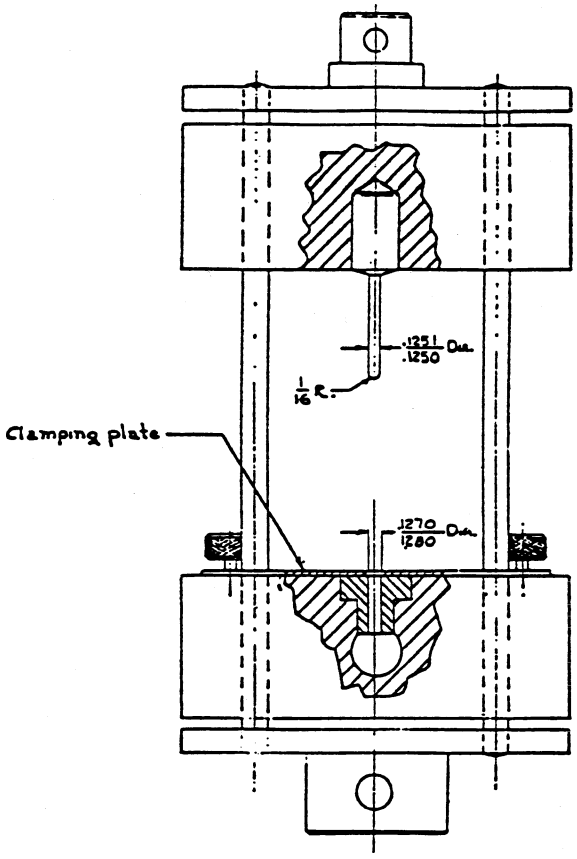
127. Report

127.1 Report the average puncture force in newtons or pounds and the minimum and maximum, if specified.

128. Precision and Bias

128.1 This test method has been in use for many years, but no statement of precision has been made and no activity is planned to develop such a statement.

128.2 This test method has no bias because the value for puncture resistance is defined in terms of this test method.



NOTE 1—The SI equivalents for the units shown are:

In radius,	1/16 in. = 1.6 mm.
In diameter,	0.1250 in. = 3.175 mm,
	0.1251 in. = 3.178 mm,
	0.1270 in. = 3.226 mm, and
	0.1280 in. = 3.251 mm.

FIG. 9 Puncture Resistance Test Unit

RESISTANCE TO ACCELERATED AGING (HEAT AND MOISTURE)

Adhesion to Steel and Backing

129. Terminology

129.1 *Definitions of Terms Specific to This Standard:*

129.1.1 *resistance to accelerated aging, n*—the characteristics of pressure-sensitive adhesive tapes to withstand the effects of combined elevated temperature and high humidity for a prescribed test period as measured by changes in the adhesion to backing.

130. Significance and Use

130.1 Pressure-sensitive adhesive tapes are subject to a wide range of environmental and physical conditions in service. This test is a measure of the stability of the tape upon exposure to one type of severe environmental condition.

131. Apparatus

131.1 *Testing Equipment*, in accordance with Section 48.

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131.2 *Humidity Chamber*, maintained at 90 ± 2 % relative humidity and 65 ± 1°C (149 ± 1.8 °F) in accordance with Practice D 5032.

Adhesion to Steel Panel

132. Test Specimens

132.1 Use test specimens in accordance with Section 49.1.

132.2 Prepare six specimens from each roll in accordance with 50.6.

133. Procedure

133.1 Test three specimens in accordance with the procedure of 50.6 to determine the original or as-received value.

133.2 Place three specimens in the humidity chamber described in 131.2 for 168 h. Remove the specimens from the chamber and condition them as described in 8.5. Determine adhesion to backing in accordance with 50.6.

134. Report

134.1 Report the following information:

134.1.1 Average of the three test values expressed in newtons per 10 mm of width (N/10 mm) or in ounces force per width of the nominal width as received,

134.1.2 Average of the three test values expressed in newtons per 10 mm of width (N/10 mm) or in ounces force per width of the nominal width determined after the accelerated aging condition, and

134.1.3 Percentage gain or loss from the original or as-received values.

135. Precision and Bias

135.1 This test method has been in use for many years, but no statement of precision has been made and no activity is planned to develop such a statement.

135.2 This test method has no bias because the value for resistance to accelerated aging is defined in terms of this test method.

Adhesion to Backing

136. Test Specimens

136.1 Use test specimens prepared in accordance with Section 41.

136.2 Prepare six specimens from each roll in accordance with 50.6.

137. Procedure

137.1 Test three specimens in accordance with the procedure of 50.6 to determine the original or as-received value.

137.2 Place three specimens in the humidity chamber described in 131.2 for 168 h (7 days). Remove the specimens from the chamber and condition them as described in 8.5. Determine adhesion to backing in accordance with 50.6.

138. Report

138.1 Report the following information for adhesion to backing:

138.1.1 Average of the three test values expressed in newtons per 10 mm of width (N/10 mm) or in ounces-force per inch of the nominal width as received,

138.1.2 Average of the three test values expressed in newtons per 10 mm (N/10 mm) of width or in ounces-force per inch or of the nominal width determined after the accelerated aging condition, and

138.1.3 Percentage gain or loss from the original or as-received values.

139. Precision and Bias

139.1 This test method has been in use for many years, but no statement of precision has been made and no activity is planned to develop such a statement.

139.2 This test method has no bias because the value for resistance to accelerated aging is defined in terms of this test method.

CURLING AND TWISTING

140. Terminology

140.1 *Definitions*—General terms in this test method are defined in Terminology D 1711.

141. Significance and Use

141.1 This test method will provide information on the relative tendency of materials to curl, twist, or form into a tube with edges touching edges. The amount of each is a predicator of the difficulty one might experience in handling strips of any length of unwound tape during their application.

142. Apparatus

142.1 *Free-Turning Spindle*, (Fig. 4) sized to fit snugly inside the sample tape core, with its axis firmly supported horizontally and adjustable in height directly above a horizontal platform. There should be no obstructions in the path between the platform and the spindle.

NOTE 18—The horizontal platform can be a bench or the floor.

143. Test Specimens

143.1 The test specimen shall be the strip of tape unwound from the originally wound sample roll during performance in accordance with procedure section.

143.1.1 No restrictions in the width of the sample (or the specimen) are made except a practical limitation due to the high unwind force that might result from wide tape rolls.

NOTE 19—This test method calls for a specific unwind rate which could be difficult to meet with high levels of unwind force.

143.2 Unwind and discard at least three, but no more than six, outer wraps of tape from the sample roll before unwinding specimens for the test.

144. Procedure

144.1 Place the sample roll on the spindle and adjust its height so that the lowest point of the roll is 900 ± 25 mm (36± 1 in.) above the horizontal platform.

144.2 Unwind 50 mm (2 in.) of tape from the roll and fold it over adhesive to adhesive to form a 25-mm (1-in.) tab.

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144.3 Firmly grasp the tab and pull the tape vertically downward at a uniform rate of 125 to 175 mm/s (5 to 7 in./s) until the end of the tab touches the horizontal platform. Immediately release the tab.

144.4 Approximately 30 s after release of the tab, make the following determinations:

144.4.1 Measure the curl of tape; this is the distance between the platform and the lowest portion of the tape. Measure to the nearest 1 mm (1⁄32 in.).

144.4.1.1 If the tape curls back onto itself, report that fact, and end the test.

144.4.2 Measure the Twist of Tape. Project an imaginary line representing the end of the tab onto the horizontal platform. This is done by sighting past the tab end from above it and lining up a pencil and a line at right angles to the edge of the roll to the nearest 5° of arc. This is angle A. Untwist the tape determining the quadrant of rotation needed to straighten it.

144.4.2.1 To find angle B, the actual twist, use the following:

When rotation is:	Then:
0 to 90°	A = B
91 to 180°	180° – A = B
181 to 270°	180° + A = B
271 to 360°	360° – A = B
361 to 450°	360° + A = B
451 to 540°	540° – A = B
541 to 630°	540° + A = B
631 to 720°	720° – A = B
721 to 810°	720° + A = B

144.4.2.2 If the angles outer edges touch to form a roll or tube, report that fact, and end the test.

145. Report

145.1 Report the following information:

145.1.1 Statement that this test method was used, and indication of any deviations from this test method as written,

145.1.2 Manufacturer's name and designation for the tape,

145.1.3 The curling found in 144.4.1, mm (in.) to the nearest 1 mm (1⁄32 in.), and

145.1.4 The twisting found in 144.4.2 to the nearest 5° arc.

146. Precision and Bias

146.1 No statement is made about either the precision or bias of this test method since the results merely state whether there is conformance to the criteria for success specified by the user of this test method.

147. Keywords

147.1 accelerated aging; adhesion; adhesive; backing; bond strength; breaking strength; conditioning; dielectric breakdown; electrical insulating tape; elongation; flagging; flammability; high temperature testing; insulation resistance; length; low temperature testing; oil resistance; pressure-sensitive adhesive tape; puncture resistance; thermosetting; thickness; unwind force; voltage; width

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