Designation: D295 – 12

Standard Test Methods for Varnished Cotton Fabrics Used for Electrical Insulation[1]

This standard is issued under the fixed designation D295; 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 U.S. Department of Defense.

1. Scope

1.1 These test methods cover procedures for the testing of varnished cotton fabrics and varnished cotton fabric tapes (Note 1) to be used as electrical insulation and are directly applicable to both "straight-cut" and "bias-cut" materials, unless otherwise stated in the test method.

NOTE 1—Methods of testing varnished glass fabrics and tapes are given in Test Methods D902.

1.2 The procedures appear in the following order:

Procedures	Sections	ASTM Test Methods
Breaking Strength	20 to 27	...
Conditioning	5	...
Dielectric Breakdown Voltage	43 to 46	D149
Dielectric Breakdown Voltage Under Elongation	47 to 53	D149
Dissipation Factor and Permittivity	54 to 60	D150
Elongation	35 to 42	...
Resistance to Oil	68 to 73	D92
Selection of Test Specimens	4	...
Tear Resistance	28 to 34	D689
Thickness	6 to 10	D374
Thread Count	15 to 19	...
Volume Resistance	61 to 67	D257
Weight	11 to 14	...

1.3 The values stated in inch-pound units are to be regarded as the standard. The metric equivalents of inch-pound units may be approximate.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* For specific precautionary statements, see 44.4, 51.1, 58.1, and 65.1.

NOTE 2—This standard resembles IEC 60394–2 in title only. The content is significantly different.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D92 Test Method for Flash and Fire Points by Cleveland Open Cup Tester

D149 Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies

D150 Test Methods for AC Loss Characteristics and Permittivity (Dielectric Constant) of Solid Electrical Insulation

D257 Test Methods for DC Resistance or Conductance of Insulating Materials

D374 Test Methods for Thickness of Solid Electrical Insulation (Metric) D0374_D0374M

D689 Test Method for Internal Tearing Resistance of Paper (Withdrawn 2009)[3]

D902 Test Methods for Flexible Resin-Coated Glass Fabrics and Glass Fabric Tapes Used for Electrical Insulation

D1711 Terminology Relating to Electrical Insulation

2.2 *IEC Standard:*

IEC 60394–2 Varnished Fabrics for Electrical Purposes — Part 2: Methods of Test[4]

3. Terminology

3.1 *Definitions*—For definitions of terms used in these test methods refer to Terminology D1711.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *weight—of varnished cloth and varnished cloth tapes*, the weight per unit area as determined in accordance with this test method. It is usually expressed in pound per square yard for a specified nominal thickness.

3.2.2 *threads per inch—of varnished cloths*, the count of the number of warp and filling yarns present in the base cloth per linear inch of width or length, respectively.

[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.

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

3.2.3 *elongation*—the amount of strain observed in a given length of varnished cloth or tape when subjected to prescribed loading conditions at prescribed atmospheric conditions. It is expressed as a percentage of the initial length.

3.2.4 *oil resistance—of varnished cloth or tape*, the ability of the varnish film to withstand the attack of oil without excessive impairment of its physical and electrical characteristics when the varnished cloth or tape is immersed in a specified oil for a prescribed period of time at a given temperature.

4. Selection of Test Specimens

4.1 Select specimens for test from portions of material free from defects.

4.2 In the case of rolls of material other than those packed in oil, remove the outer two layers of cloth or the outer six layers of tape and prepare test specimens from the remaining material. In the case of oil-packed tape, remove the outer layer from each roll to be tested. In the case of sheets and tape strips, remove the outer six layers of material and prepare test specimens from that remaining.

NOTE 3—In the case of bias-cut materials, exclude seams and jointed selvage from test areas.

NOTE 4—If it is desired to test seams and jointed selvages for breaking strength, prepare additional test specimens so that the seams or joints are in the center of the specimens.

5. Conditioning

5.1 *Significance and Use*—Because the physical and electrical properties of most fabrics change with variation of their moisture content, it is necessary to control this property at the time of testing in order to attain reasonably good reproducibility of test values. For example, when cotton fabric absorbs moisture it tends to swell and increase in dimensions. Also, the flexibility, elongation, and tensile strength of the material normally increase with increased relative humidity, whereas, conversely, the electrical properties are depreciated when the material is subjected to these conditions. The time of exposure to the conditioned atmosphere must be long enough to permit the moisture content of the test specimen to reach a relatively stable value. If the fabric is untreated, a few hours exposure is sufficient. Treated fabrics like varnished cloth require appreciably longer time.

5.2 Where it is desired to test in a controlled atmosphere, condition the test specimens for 48 h in the Standard Laboratory Atmosphere of 50 ± 2 % relative humidity at 23 ± 1 °C (73.4 ± 1.8 °F). If a conditioning cabinet or chamber is used, subject the specimens to test immediately upon withdrawal from the cabinet or chamber, unless otherwise specified.

5.3 If it is desired to test the material in the condition as received by the purchaser, allow the packages containing the rolls of material from which the specimens are to be taken to reach room temperature before opening. Open the packages, remove the roll and immediately prepare such test specimens as required, unless otherwise specified.

5.4 In the case of dispute, the procedure described in 5.2 shall be the referee method.

TEST METHOD A: THICKNESS

6. Significance and Use

6.1 The thickness test is necessary to determine whether the material meets specified tolerances for thickness. In addition, thickness values are essential because of the importance of space factor in designing electrical equipment.

7. Test Specimens

7.1 In the case of cloths or sheets, cut test specimens 1 in. (25.4 mm) wide across the entire width. In the case of bias-cut cloth, exclude seams or jointed selvages from the area of test.

7.2 In the case of tapes or strips, remove specimens 36 in. (910 mm) long from the sample of material selected in accordance with Section 4.

8. Procedure

8.1 Measure the thickness in accordance with Test Methods D374, with the following modifications:

8.1.1 Either Method B or Method C may be used but Method C is to be used unless otherwise specified. Method A shall not be used.

8.1.2 In making thickness measurements, use only one layer of material.

8.1.3 In the case of cloths, take ten measurements equally spaced across the width of the specimen. The thickness of the cloth shall be the average of the ten measurements.

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

9. Report

9.1 Report the average, maximum, and minimum thickness in inches (or centimetres).

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 thickness is determined solely in terms of this test method itself.

TEST METHOD B: WEIGHT

11. Significance and Use

11.1 Weight values are useful for estimating weight in designing electrical equipment containing a constituent part of varnished cloth or tape.

12. Procedure

12.1 Prepare either square or rectangular specimens of sufficient size to weigh not less than 0.18 oz (5 g). Accurately weigh on an analytical balance. Measure the length and width dimensions with sufficient precision to be able to compute the area within 0.3 %. Compute the weight per unit area.

13. Report

13.1 Report a description of the material and the weight in pounds per square yard or kilograms per square metre.

14. Precision and Bias

14.1 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.

14.2 This test method has no bias because the value for weight per unit area is determined solely in terms of this test method itself.

TEST METHOD C: THREAD COUNT

15. Terminology

15.1 *Definitions of Terms Specific to This Standard:*

15.1.1 *threads per inch—of varnished cloths*, the count of the number of warp and filling yarns present in the base cloth per linear inch of width or length, respectively.

16. Significance and Use

16.1 Thread count, together with the weight and width of the cloth, is accepted as the common means for designating and identifying cloth constructions.

16.2 Certain of the physical and electrical properties of woven fabrics are dependent on thread count. That is, assuming the same size of yarn, an increase in thread count increases the weight, breaking strength, and density of the cloth. Also, the dielectric breakdown voltage and the dissipation factor of the varnished fabric may be changed by altering the thread count of the cloth.

17. Procedure

17.1 Determine separately the warp and filling threads per inch of cloth by counting in a space of not less than 1 in. (25.4 mm) in at least five different places on the specimen. The average of the five determinations shall be the thread count.

18. Report

18.1 Report the warp count and the filling count separately as threads per inch (or millimetre).

NOTE 5—The warp threads in straight-cut materials are the threads that are parallel with the length or machine-direction dimension, while in bias-cut materials the warp threads are parallel with the seams or jointed selvages.

NOTE 6—Before counting black varnished materials it will be necessary to remove the varnish film with a knife blade or other suitable instrument. Liquid varnish removers are unsuitable for this purpose as they may cause a swelling of the fibers and a shrinkage of cloth with a consequent increase in threads per inch count; therefore, the films must be removed mechanically.

19. Precision and Bias

19.1 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.

19.2 This test method has no bias because the value for thread count is determined solely in terms of this test method itself.

TEST METHOD D: BREAKING STRENGTH

20. Significance and Use

20.1 The breaking strength of finished cloth and tape is of importance as a measure of its ability to withstand reasonable pulling without failure while being applied.

21. Apparatus

21.1 Testing machines of the dead-weight pendulum or of the constant-rate-of-elongation types shall be used, the latter being preferred.

21.2 The machine shall be graduated to read 0.5 kg or 1 lb, or less per scale division for testing specimens breaking at 50 lb (22.7 kg) or over, and to 0.25 kg, or 0.5 lb, or less for testing specimens breaking under 50 lb.

22. Test Specimens

22.1 Cut test specimens 1 in. (25.4 mm) in width and not less than 12 in. (305 mm) in length from full-width cloth or from tapes over 1 in. (25.4 mm) in width. In the case of tapes having a nominal width of 1 in. (25.4 mm) or less, prepare test specimens not less than 12 in. (305 mm) long using the original width.

NOTE 7—If it is desired to test the seams or jointed selvages of bias-cut materials for breaking strength, mount specimens obtained as described in Note 4, (4.2) in the testing machine so that the seams or jointed selvages are midway between the two jaws.

23. Number of Specimens

23.1 In the case of straight-cut cloths, cut five specimens in the direction of the warp threads and five in the direction of the filling threads from samples selected in accordance with 4.1 and 4.2.

23.2 In the case of bias-cut cloths, cut five specimens in the direction of the length from samples selected in accordance with 4.1 and 4.2.

23.3 In the case of tapes, cut five specimens from each roll selected in accordance with 4.1 and 4.2.

24. Conditioning

24.1 Condition specimens in accordance with Section 5.

25. Procedure

25.1 Adjust the clearance distance between jaws to be 6 in. (150 mm).

25.2 Select the rate of travel of the movable jaw to be constant and preferably 12 in. (305 mm)/min, but it may be within the limits of 11 and 13 in. (280 and 330 mm)/min, provided it is constant.

25.3 Reject all readings obtained when the specimens break at or in the jaws.

26. Report

26.1 Report the following information:

26.1.1 The average, maximum, and minimum breaking loads in kilograms or pounds, together with the width of the specimens and the nominal thickness, and

26.1.2 The relative humidity and temperature during the conditioning period, and at the time of the test.

26.2 In the case of straight-cut cloths, report the breaking strength of the warp threads and the filling threads separately.

27. Precision and Bias

27.1 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.

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

TEST METHOD E: TEAR RESISTANCE

28. Significance and Use

28.1 The results of the test are suitable for acceptance, product control, research, or referee testing and for measuring the resistance of the varnished cloth to tearing while being applied in service.

28.2 Tear resistance of varnished cloth is influenced by the construction of the base cloth and the direction of tear, and the cure of the varnish.

28.3 This test method is applicable only to straight-cut varnished cloth and to tapes not less than 2¼ in. (64 mm) wide.

29. Apparatus

29.1 Conduct tests using a machine of the pendulum-impulse type as described in Test Method D689.

30. Test Specimens

30.1 Prepare test specimens as follows from full-width cloth:

30.1.1 *Warp Threads*—Cut five specimens, 4 by 2½ in. (102 by 63.5 mm), so that the 4-in. length is parallel to the selvage edge.

30.1.2 *Filler Thread*—Cut five specimens, 4 in. by 2½ in. (102 by 63.5 mm), so that the 4-in. length is perpendicular to the selvage edge.

30.2 Cut two slits, 1⁄16 in. (1 mm) long and ¼ in. (6 mm) apart, equidistant from the center of the free side (the side not clamped in the jaws) in each specimen so that the end of the tear will fall between the two slits.

NOTE 8—Slits are cut into specimens to produce discontinuity of the outer fibers so that during the test the outer fibers unravel freely to avoid abnormal values.

31. Conditioning

31.1 Condition test specimens in accordance with Section 5.

32. Procedure

32.1 Determine the tear resistance in accordance with Test Method D689. Place test specimens cut in accordance with Section 30, in the jaws with the longer length parallel to the jaws and the two slits on the opposite long side not clamped in the jaws. Obtain warp tears by tearing across warp direction threads and filler tears by tearing across filler direction threads.

NOTE 9—Discard test values where the end of the tear does not fall between the two slits.

33. Report

33.1 Report the following:

33.1.1 The average, minimum, and maximum tear resistance in grams, separately for warp and filler threads,

33.1.2 The nominal thickness, and

33.1.3 The relative humidity and temperature during conditioning and at the time of test.

34. Precision and Bias

34.1 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.

34.2 This test method has no bias because the value for tear resistance is determined solely in terms of this test method itself.

TEST METHOD F: ELONGATION

35. Significance and Use

35.1 Elongation of a varnished cloth or tape insulation is important as a measure of the degree to which the insulation will conform to the contours of even and uneven surfaces without damaging the varnish film. Tapes that do not have sufficient elongation may be difficult to apply satisfactorily, whereas too much elongation may destroy the varnish film and thereby cause a decrease in its dielectric breakdown voltage.

36. Apparatus

36.1 The apparatus shall consist of a pair of clamps for gripping the ends of the specimen. The clamps shall be not less than 2 in. (50 mm) in width, and one shall be provided with a means for attaching to a fixed support and the other with means for affixing suspended weights. A suggested form of clamp is shown in Fig. 1.

37. Test Specimens

37.1 In the case of bias-cut cloth, cut test specimens not greater than 1.5 in. (38 mm) in width and in the direction of the length from the samples selected in accordance with 4.1 and 4.2.

37.2 In the case of straight-cut cloth, cut test specimens not greater than 1.5 in. (38 mm) in width and parallel to the warp yarns from samples selected in accordance with 4.1 and 4.2.

37.3 In the case of straight-cut and bias-cut tapes, cut test specimens not greater than 1.5 in. (38 mm) in width parallel to the slit edge from samples selected in accordance with 4.1 and 4.2. In the case of tapes of width greater than 1.5 in. (38 mm), cut test specimens therefrom to a width 1.5 in. (38 mm).

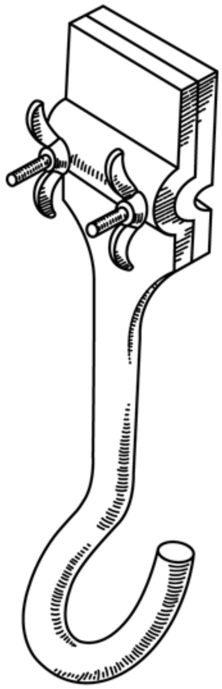

FIG. 1 Clamp for Elongation Test

38. Conditioning

38.1 Condition test specimens in accordance with Section 5.

39. Procedure

39.1 Mark a gage length of 20 in. (508 mm) on the test specimen (Note 10) and fasten the specimen between two suitable clamps so that the gage length is centrally located between the clamps. The clearance distance between each gage line and the adjacent clamp shall be not less than 4 in. (100 mm).

NOTE 10—Strips of pressure-sensitive tape can be satisfactorily employed in marking the gage length on the elongation test specimen.

39.2 Weight the specimen with a specified load (including the weight of the clamp) for a period of 35 min for loadings of 10 lb/in. (18 kg/m) of width, and for a period of 3 min for loadings of 20 lb/in. (36 kg/m), or more, of width. At the end of the loading period measure the distance corresponding to the length between the gage lines in the elongated state before the load is removed.

40. Calculation

40.1 Calculate the percentage elongation as follows:

$$\text{Elongation, \%} = \left[(L_2 - L_1)/L_1\right] \times 100 \quad (1)$$

where:

L_1 = distance between gage lines before test, and
L_2 = distance between gage lines at the end of the test.

41. Report

41.1 Report the following information:

41.1.1 Load in pounds per inch width or kilograms per centimetre width of tape,

41.1.2 Percentage elongation, and

41.1.3 Relative humidity and temperature during the conditioning period and at the time of test.

42. Precision and Bias

42.1 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.

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

TEST METHOD G: DIELECTRIC BREAKDOWN VOLTAGE

43. Significance and Use

43.1 Dielectric breakdown voltage of varnish cloth or tape insulating material is of significance for the following reasons:

43.1.1 This test indicates the presence of defects in the cloth or varnish in the part of the surface explored.

43.1.2 Four methods of testing for dielectric breakdown voltage are given: the short-time, step-by-step, slow-rate-of-rise, and the long-time voltage tests. Choice of the method should be based on whether the effect of time under stress is considered an important factor and the available time that can be allowed for each test.

NOTE 11—For a more detailed discussion of the significance of the dielectric breakdown voltage test, consult the general statements in Appendix X1 of Test Method D149.

44. Short-Time, Step-by-Step, and Slow-Rate-of-Rise Tests

44.1 *Apparatus*—Select electrodes having a diameter of ¼ in. (6.35 mm), as described in Table 1 of Test Method D149 for testing both cloths and tapes. Clamp the test specimen under pressure, using gaskets around the electrodes, in order to prevent flashover around the edges of the material. Two forms of electrode holders are described in the appendix.

44.2 *Test Specimens:*

44.2.1 In the case of cloths, cut specimens 1 in. (25.4 mm) wide across the entire width of the cloth. In the case of bias-cut cloths, exclude the seams or jointed selvages from the area of test.

44.2.2 In the case of tapes or strips, remove the specimens from a sample selected in accordance with 4.1 and 4.2.

44.3 *Conditioning*—Condition specimens in accordance with Section 5.

44.4 **Warning**—*Lethal voltages may be present during this test. 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.

44.5 *Procedure:*

44.5.1 Determine the dielectric breakdown voltage in accordance with Test Method D149, except as specified in 44.1 to 44.6.

44.5.2 Test in air unless otherwise specified.

44.5.3 Test by either the short-time test, or by the step-by-step test or its alternative, the slow-rate-of-rise test, or by both methods, at room temperature or at 85 °C (185 °F) as specified.

44.5.4 In the short-time test, increase the voltage from zero at a rate of 0.5 kV/s.

44.5.5 In the step-by-step test and slow-rate-of-rise tests, increase the voltage rapidly from zero to 850 V per mil of average thickness for room temperature tests and to 600 V per mil of average thickness for 85 °C (185 °F) tests.

NOTE 12—In the case of materials failing to meet the starting voltages prescribed, test using the short-time test only.

44.5.6 In tests made by the step-by-step procedure, increase the applied voltage by the following increments after each 20 s of duration.

Nominal Thickness of Tape, mils	Increment, V
8 or less	250
Over 8	500

Adjust the starting voltage to the nearest even 250 or 500 V depending on the increment of increase.

44.5.7 In tests made by the slow-rate-of-rise method, increase the voltage as follows:

Nominal Thickness of Tape, mils	Rate of Rise, V/s
8 or less	12.5
Over 8	25

44.5.8 Unless otherwise specified, make ten voltage breakdown measurements equally spaced along the length of each specimen.

44.6 *Report:*

44.6.1 Report the following information:

44.6.1.1 The test procedure used,

44.6.1.2 The average thickness reported in 9.1,

44.6.1.3 The average breakdown voltage in kV,

44.6.1.4 The temperature and relative humidity at the time of test, and

44.6.1.5 The conditioning of the test specimen.

45. Long-Time Tests

45.1 *Test Specimens and Apparatus:*

45.1.1 Prepare test specimens by wrapping the material in tape form with one-quarter lap, one-half lap, or butt-jointed, or in sheet form, on brass tubes. For sheets and for tapes up to 1½ in. (38 mm) in width, use tubes 36 in. (910 mm) in length and 1 in. (25 mm) in outside diameter. For tapes wider than 1½ in. use tubes 2 in. (51 mm) in outside diameter. Build up specimens to the desired thickness, to simulate practical conditions, winding all layers of tape in the same direction.

45.1.2 Smoothly apply a layer of metal foil over the insulation for a distance of 24 in. (610 mm), leaving 6 in. (150 mm) of insulation uncovered at each end of the tube. Bind the metal foil in place with a wrapping of adhesive tape which shall extend the full length of the tube in order to protect insulation at the end from corona discharge.

45.1.3 Mount a thermocouple centrally on the metal foil and secure using adhesive tape.

45.2 *Procedure:*

45.2.1 Mount the specimen in an air oven and maintain the temperature at 100 °C (212 °F) during the test. Make provision for mounting the specimen so that the tube may be connected to the high-voltage side of the circuit with the foil sheath and the thermocouple both connected to ground. Where advisable or desired, alternatively immerse the test specimen in oil at the specified temperature instead of mounting in an oven.

45.2.2 Apply a voltage equal to 10 % of the breakdown voltage (to the nearest 1 kV) obtained in the short-time test and maintain it for 30 min. Then increase the voltage by steps of 20 % of the initial value until puncture occurs, the voltage being held at each step for 30 min.

45.2.3 Observe the temperature of the specimen as indicated by the thermocouple at intervals during the test and record the readings at the end of each 30-min period. It will be found that the temperature increases rapidly. During this latter period, record the temperature readings at frequent intervals.

45.3 *Report:*

45.3.1 Report the following information:

45.3.1.1 Details of the test specimen, including its preparation, thickness of insulation, and the number of layers of insulation,

45.3.1.2 The test ambient, whether air or oil,

45.3.1.3 A plot showing the time as the abscissa and the specimen temperature as the ordinate, on which is superimposed a plot showing the initially-applied voltage and its changing value as ordinates, and

45.3.1.4 The duration of the test, the breakdown voltage in kV, the temperature of the specimen at breakdown, and the overall rate of rise of temperature during the test, all taken from the plot of 45.3.1.3.

46. Precision and Bias

46.1 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.

46.2 This test method has no bias because the value for dielectric breakdown voltage is determined solely in terms of this test method itself.

TEST METHOD H: DIELECTRIC BREAKDOWN VOLTAGE UNDER ELONGATION

NOTE 13—This test is not applicable to varnished bias tapes of less than 0.75 in. (19 mm) in nominal width.