Designation: D8355 – 21

Standard Test Methods for Flammability of Electrical Insulating Materials Used for Sleeving or Tubing[1]

This standard is issued under the fixed designation D8355; 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.

NOTE—Subsection 1.2.1 was added and the yeardate was changed on March 31, 2021.

1. Scope

1.1 This is a fire-test-response standard.

1.2 This fire test response standard contains various tests applicable to electrical insulation materials used for sleeving or for tubing (including heat-shrinkable tubing).

1.2.1 Test methods C and D are applicable to heat-shrinkable tubing only.

1.3 Use the values stated in SI units in referee decisions; see IEEE/ASTM SI-10. The values given in parentheses after SI units are provided for information only and are not considered standard.

1.4 *This standard is used to measure and describe the response of materials, products, or assemblies to heat and flame under controlled conditions, but does not by itself incorporate all factors required for fire hazard or fire risk assessment of the materials, products, or assemblies under actual fire conditions.*

1.5 *Fire testing is inherently hazardous. Adequate safeguards for personnel and property shall be employed in conducting these tests.*

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.7 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D350 Test Methods for Flexible Treated Sleeving Used for Electrical Insulation

D876 Test Methods for Nonrigid Vinyl Chloride Polymer Tubing Used for Electrical Insulation

D1711 Terminology Relating to Electrical Insulation

D2671 Test Methods for Heat-Shrinkable Tubing for Electrical Use

D2903 Specification for Crosslinked Chlorinated Polyolefin Heat-Shrinkable Tubing for Electrical Insulation

D3144 Specification for Crosslinked Poly(Vinylidene Fluoride) Heat-Shrinkable Tubing for Electrical Insulation

D3150 Specification for Crosslinked and Noncrosslinked Poly(Vinyl Chloride) Heat-Shrinkable Tubing for Electrical Insulation

D5025 Specification for Laboratory Burner Used for Small-Scale Burning Tests on Plastic Materials

D5207 Practice for Confirmation of 20-mm (50-W) and 125-mm (500-W) Test Flames for Small-Scale Burning Tests on Plastic Materials

E176 Terminology of Fire Standards

2.2 *ISO Standard:*[3]

ISO 13943 Fire Safety – Vocabulary

2.3 *Federal Standard:*[4]

PPP-T-45D Federal Specification for Tape; Paper, Gummed (Kraft)

2.4 *UL Standards:*[5]

UL 224 Extruded Insulated Tubing

UL 1441 Coated Electrical Sleeving

[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 D09.17 on Fire and Thermal Properties.

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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] Available from International Organization for Standardization (ISO), ISO Central Secretariat, BIBC II, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, http://www.iso.org.

[4] Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

[5] Available from Underwriters Laboratories (UL), UL Headquarters, 333 Pfingsten Road, Northbrook, IL, 60062, http://www.ul.com.

UL 2556 Wire and Cable Test Methods

3. Terminology

3.1 *Definitions:*

3.1.1 For definitions of terms relating to electrical and electronic insulating materials, the definitions in these test methods are in accordance with Terminology D1711. For terms relating to fire, the definitions in this test method are in accordance with Terminology E176 and ISO 13943. In case of conflict, the definitions given in Terminology E176 shall prevail.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *heat-shrinkable tubing, n*—tubing that will reduce in diameter from an expanded size to a predetermined size by the application of heat.

4. Summary of Test Methods

4.1 This standard incorporates four test methods suitable for assessing fire-test-response characteristics of electrical insulating materials exposed in the form of sleeving or tubing (including heat-shrinkable tubing). In all the tests the electrical insulating material is exposed to the flame from a gas-fueled burner.

4.1.1 Test Methods A and B are applicable to sleeving and tubing (including heat-shrinkable tubing), but Test Methods C and D are applicable to heat-shrinkable tubing only.

4.2 Test Method A assesses the resistance to spread of flame of the material, by measuring burn length and duration of burning. This test method was originally contained as Method A in Test Methods D350 (where it applied to sleeving), as Procedure A in Test Methods D876 (where it applied to tubing), and as Procedure A in Test Methods D2671 (where it applied to heat-shrinkable tubing). This test method is referenced in Specifications D2903 (for crosslinked chlorinated polyolefin heat-shrinkable tubing), D3144 (for poly(vinylidene fluoride) heat-shrinkable tubing), and D3150 (for crosslinked and non-crosslinked poly(vinyl chloride) heat-shrinkable tubing).

4.3 Test Method B assesses the rate of upward flame spread of the material. This test method was originally contained as Method B in Test Methods D350 (where it applied to sleeving).

4.4 Test Method C applies to electrical insulating material used for heat-shrinkable tubing. It assesses the propagation of flame in an upward direction, the duration of burning and the formation of flaming or glowing particles. The electrical insulating material, in contact with a metallic core, is exposed by placing it in contact with an internal metallic conductor simulating a common end use condition, while supported on a mandrel. This test method was originally contained as Procedure B in Test Methods D2671 (where it applied to heat-shrinkable tubing).

4.5 Test Method D applies to electrical insulating material used for heat-shrinkable tubing. It is similar to Test Method C, in 4.3, but differs from it in the specimen support mandrel. The electrical insulating material is in contact with a metallic core. Test Method D assesses the same fire-test-response characteristics as Test Method C, but it also determines the tendency to ignite nearby flammable materials by determining whether any falling flaming particles ignite a cotton indicator placed underneath the test specimen. Test Method D is a more severe flammability test than Test Method C. This test method was originally contained as Procedure C in Test Methods D2671 (where it applied to heat-shrinkable tubing).

5. Significance and Use

5.1 Test Method A is the required flammability test for: crosslinked chlorinated polyolefin heat-shrinkable tubing for electrical insulation (Specification D2903), crosslinked poly(vinylidene fluoride) heat-shrinkable tubing for electrical insulation (Specification D3144), and crosslinked and noncrosslinked poly(vinyl chloride) heat-shrinkable tubing for electrical insulation (Specification D3150).

5.2 Test Method A is also one of the flammability tests used for nonrigid vinyl chloride polymer tubing used for electrical insulation (in Test Methods D876), flexible treated sleeving used for electrical insulation (Test Methods D350), and heat-shrinkable tubing for electrical use (Test Methods D2671).

5.3 Test Method B is another flammability test (together with Test Method A) used for flexible treated sleeving used for electrical insulation (Test Methods D350).

5.4 Test Methods C and D are other flammability tests (together with Test Method A) used for heat-shrinkable tubing for electrical use (Test Methods D2671). In both tests the electrical insulating material is fitted with a metallic core. The electrical insulating material is tested after shrinking, but using different mandrels.

5.5 In these test methods, the test specimens are subjected to one or more specific sets of laboratory test conditions. If different test conditions are substituted or the end-use conditions are changed, it is not always possible by or from this test to predict changes in the fire-test-response characteristics measured. The results are therefore valid only for the fire-test-exposure conditions described in this procedure.

TEST METHOD A

6. Scope

6.1 This test method assesses the resistance to spread of flame of the material, by measuring burn length and duration of burning.

7. Apparatus

7.1 *Chamber*—The chamber shall be a three-walled sheet metal enclosure 300 ± 10 mm (12 ± 0.4 in.) wide by 360 ± 10 mm (14 ± 0.4 in.) deep by 740 ± 10 mm (29 ± 0.4 in.) high, open at the top. It shall be equipped with two parallel horizontal metal rods placed 410 ± 10 mm (16 ± 0.4 in.) apart, and situated such that a wire stretched perpendicularly across each rod shall be at a 70° angle with the horizontal. The lower rod shall be approximately 50 ± 10 mm (2 ± 0.4 in.) from the rear wall.

7.2 *Bare Steel Wire*—A length of bare steel wire, approximately 0.74 mm (0.029 in.) in diameter, shall be used for supporting the test specimens during the test.

7.3 *Burner*—The burner shall meet the requirements of Specification D5025.

7.3.1 Adjust the burner barrel height, as indicated in Practice D5207 to confirm that the overall height of the gas flame is 125 ± 10 mm (4⅞ ± 0.4 in.) and that the blue inner cone is 40 ± 2 mm (1⁹⁄₁₆ ± 0.08 in.) high. A gas supply gauge pressure of 69 to 138 kPa (10 to 20 lbf/in.^{2}) has been found to be adequate to maintain the required flame. A cylinder shall not be used when this range of pressure is no longer sustainable at room temperature.

7.3.2 The burner shall be designed to provide a flame that is 125 ± 10 mm (4⅞ ± 0.4 in.) long, with an intensity of 500 W (1700 BTU/h).

7.4 *Burner Mounting*—The burner shall be mounted upon a positioning mechanism as shown in Fig. 1. As shown in the figure, a pivoted positioner which forms an extension of the center line of the burner barrel shall be attached to the barrel of the burner so as to locate the exact point of impingement of the inner cone on the test specimen. The base of the burner shall be tilted 25° from the horizontal during the period that the flame is applied to the test specimen, and the flame shall impinge upon the test specimen at an angle of 45°. The system shall contain a gas regulating valve as well as a shutoff valve.

7.5 *Gas Supply*—The fuel gas to be used shall be natural gas, methane gas, or propane gas. For referee purposes, commercial grade propane gas having a nominal heating value of 94 MJ/m^3 (2521 BTU/ft^3) and a relative specific gravity of 0.508 (to that of air) at a temperature of 15.5 ºC (60 °F) shall be used at a line pressure of 2.74 kPa (11 in., or 279 mm of water).

7.5.1 The methane gas shall be technical grade, 98.0 % minimum purity. The heating value of either methane or natural gas shall be 37 ± 1 MJ/m^3 or 8.9 kcal (thermochemical)/m^3 or 1000 BTU (thermochemical)/ft^3, at 25 ± 1 ºC (77 ± 2 ºF) and 101 kPa (14.7 psi).

NOTE 1—If no regular delivery lines are available for propane gas or for methane gas, the use of small tanks is an acceptable alternate.

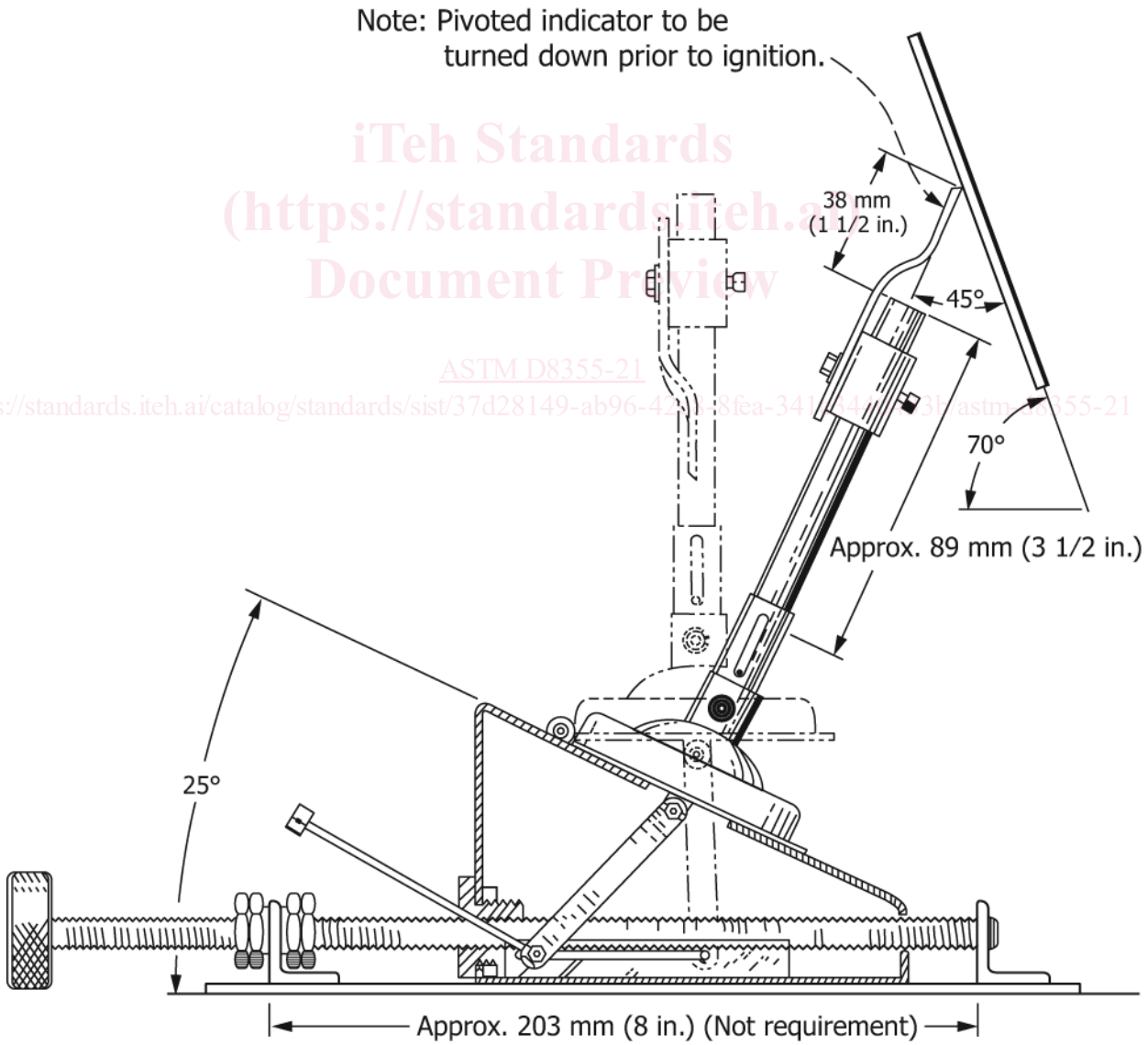

FIG. 1 Positioning Mechanism for Burner (Test Method A)

7.6 *Timing Device*—The timing device shall be a stopwatch or other suitable timing device capable of measuring the duration of flame application and of test specimen burning to within 0.5 s.

7.7 *Flame Indicator Flag*—Strips of gummed paper shall be used to determine the length of test specimen burned.

7.7.1 The flame indicator flag shall be constructed of kraft paper, made from a commercially available plain cellulose paper tape. The tape shall have an area density of 98 g/m^2 (60 lb/3000 ft^2), and a nominal thickness of 0.13 mm (0.005 in.). It shall be gummed on one side, not reinforced, and not exposed to flame retardant treatment cellulose paper tape. The flag shall have a nominal 10 mm (0.39 in.) width and a nominal 40 mm (1.57 in.) length longer than the outside circumference of the test specimen.

NOTE 2—The paper used for the indicators is that known to the trade as 60-lb stock, and is material substantially the same as that described in Federal Specification PPP-T-45D.

8. Test Specimens

8.1 Prepare five test specimens approximately 560 ± 10 mm (22 ± 0.4 in.) in length.

8.1.1 If the test is to be conducted on heat-shrinkable tubing, use tubing in the expanded state.

9. Procedure

9.1 *Test Environment*—Place the test chamber in a laboratory hood free of induced or forced draft. If a ventilated hood is used, ensure that the air currents do not affect the test flame.

9.2 Draw the test specimen onto the wire.

9.3 Attach the test specimen and the wire at one end to the middle of the upper horizontal bar by kinking the tubing or sleeving and clamping it, so as to provide a closed end to the test specimen, thus preventing any chimney effects during the test.

9.4 Pass the lower end of the wire protruding from the open end of the tubing or sleeving over the middle of the lower horizontal bar, and hold it taut against the bar by a weight of at least 500 g (1 lb), attached to the free end of the wire.

9.4.1 If the material does not have a circular cross section, position the edge with the smallest radius of curvature nearest the flame.

9.5 Attach the paper indicator to the test specimen so that the lower edge is 250 ± 10 mm (10 ± 0.4 in.) above the point of flame application.

9.6 With the burner in a vertical position adjust the height of the flame to 125 ± 10 mm (4⅞ ± 0.4 in.) and the blue inner cone to 40 ± 2 mm (1⁹⁄₁₆ ± 0.08 in.) high. The distance between the end of the burner and the edge of the test specimen shall be 40 mm (1½ in.), measured along the axis of the burner.

9.7 After preliminary positioning of the burner and before lighting the burner, in preparation to applying the flame to the test specimen, pivot the positioner away from the flame area. The burner shall be in an upright position when ignited and shall be dropped into testing position at the instant that the timer is started.

9.8 Apply the flame to the test specimen for 15 s and then extinguish it by turning off the gas supply from outside the test cabinet.

9.9 Determine the duration of burning of the test specimen as the time between turning off the gas supply and the time of extinction of the gas flame.

9.10 Determine the length of test specimen burned either by direct measurement or by subtracting the length of the unburned portion from 254 mm (10 in.).

9.11 Repeat this procedure for a total of five test specimens.

10. Report

10.1 Report the following information:

10.1.1 Identification of the tubing or sleeving tested.

10.1.2 Inside diameter and average wall thickness of the test specimens, in mm (in.).

10.1.3 The duration of burning, in seconds, for each of the five test specimens.

10.1.4 Exclude the tests with the highest and the lowest duration of burning. Then report the average duration of burning based on three tests, after the exclusion of the maximum and minimum values.

10.1.5 The length of material burnt, in mm (inches) for each of the five test specimens.

10.1.6 Exclude the tests with the highest and the lowest length of test specimen burnt. Then report the average duration of length of material burnt based on three tests, after the exclusion of the maximum and minimum values.

10.1.7 The actual reported results shall be the average duration of burning (from 10.1.3) and the average burned length (from 10.1.5) based on three tests.

11. Precision and Bias

11.1 The precision of this test method has not been determined due to inadequate voluntary participation and funding needed to conduct the round-robin testing.

11.2 This test method has no bias because the results are expressed purely in terms of this test method.

TEST METHOD B

12. Scope

12.1 This test method assesses the rate of upward flame spread of the material.

13. Apparatus

13.1 The apparatus, and the gas supply, shall be the same as that for Test Method A (Section 7).

14. Test Specimens

14.1 Prepare three test specimens 560 ± 10 mm (22 ± 0.4 in.) in length.

15. Procedure

15.1 Mark a gauge length of 25 ± 2 mm (1 ± 0.08 in.) on each test specimen approximately 13 mm (0.5 in.) from one end of the test specimen.

15.2 Using a method that will not distort the test area, close the other end to prevent passage of air through the test specimen during the test.

15.3 Insert the open end of the sleeving into the side of the burner flame with the lower side of the sleeving approximately 13 mm (0.5 in.) above the top of the burner.

15.4 Rotate the test specimen in the flame to ignite it uniformly.

15.5 Remove the sleeving from the flame and hold it vertically in the air with the burning end uppermost.

15.6 Start the timer when the leading edge of the flame reaches the upper gauge mark and observe the time in seconds for the leading edge of the flame to travel down the test specimen to the lower gauge mark.

15.7 Calculate the rate of upward flame spread, in mm/s (in./s) by dividing a distance of 25 mm (1 in.) by the time required to burn 25 mm (1 in.).

15.8 Repeat this procedure for a total of three test specimens.

16. Report

16.1 Report the following information:

16.1.1 Identification of the tubing or sleeving tested.

16.1.2 For each test specimen, the time in seconds required to burn 25 mm (1 in.) and the rate of upward flame spread, in mm/s (in./s).

16.1.3 The average time required to burn 25 mm (1 in.) and the average rate of upward flame spread.

17. Precision and Bias

17.1 The precision of this test method has not been determined due to inadequate voluntary participation and funding needed to conduct the round-robin testing.

17.2 This test method has no bias because the results are expressed purely in terms of this test method.

TEST METHOD C

18. Scope

18.1 This test method assesses the propagation of flame by the electrical insulating material used for heat-shrinkable tubing in an upward direction. It also assesses the duration of burning and the formation of flaming or glowing particles.

18.1.1 The test flame is applied to the underside of the test specimen. The test is intended to simulate, to some extent, an end-use condition, in that the tests are conducted with the pre-shrunk material in contact with a metallic core.

19. Apparatus

19.1 *Chamber*—The chamber shall be a three-walled sheet metal enclosure 300 ± 10 mm (12 ± 0.4 in.) wide by 360 ± 10 mm (14 ± 0.4 in.) deep by 610 ± 10 mm (24 ± 0.4 in.) high, open at the top and front. It shall have a provision for centering a vertical test specimen of tubing 530 ± 10 mm (21 ± 0.4 in.) long.

19.2 *Burner*—Use a gas burner with a 9.5 mm (0.38 in. bore), equipped with a pilot-flame device. The barrel of the burner shall be between 90 and 100 mm (3.5 and 4 in.) long, above the primary inlet. The burner shall be suitable for the gas supplied.

19.2.1 Adjust the burner barrel height, as indicated in Practice D5207 to confirm that the overall height of the gas flame is 125 ± 10 mm (4⅞ ± 0.4 in.) and that the blue inner cone is 40 ± 2 mm (1⁹⁄₁₆ ± 0.08 in.) high. A gas supply gauge pressure of 69 to 138 kPa (10 to 20 lbf/in.^{2}) has been found to be adequate to maintain the required flame. A cylinder shall not be used when this range of pressure is no longer sustainable at room temperature.

19.2.2 The burner shall be designed to provide a flame that is 125 ± 10 mm (4⅞ ± 0.4 in.) long, with an intensity of 500 W (1700 BTU/h).

19.2.3 The burner shall be mounted on a hinged support so that its base can be tilted 20° from the horizontal during the period that the flame is applied to the test specimen, and so that the flame will impinge on the test specimen at an angle of 70°.

19.2.4 The burner shall be fitted with a gas-regulating valve and a shut-off valve.

19.3 *Gas Supply*—The fuel gas to be used shall be natural gas or methane gas. For referee purposes, commercial grade methane gas having a nominal heating value of 37 MJ/m^3 (1000 BTU/ft^3) shall be used at a line pressure of 1.74 kPa (7 in., or 175 mm of water).

19.3.1 The methane gas shall be technical grade, 98.0 % minimum purity. The heating value of either methane or natural gas shall be 37 ± 1 MJ/m^3 or 8.9 kcal (thermochemical)/m^3 or 1000 BTU (thermochemical)/ft^3, at 25 ± 1 °C (77 ± 2 °F) and 101 kPa (14.7 psi).

NOTE 3—If no regular delivery lines are available for propane gas or for methane gas, the use of small tanks is an acceptable alternate.

19.4 *Timing Device*—The timing device shall be a stopwatch or other suitable timing device capable of measuring the duration of flame application and of test specimen burning to within 0.5 s.

19.5 *Flame Indicator Flag*—Strips of gummed paper shall be used to determine the length of test specimen burned.

19.5.1 The flame indicator flag shall be constructed of kraft paper, made from a commercially available plain cellulose paper tape. The tape shall have an area density of 98 g/m^2 (60 lb/3000 ft^2), and a nominal thickness of 0.13 mm (0.005 in.). It shall be gummed on one side, not reinforced, and not exposed to flame retardant treatment cellulose paper tape. The flag shall have a nominal 10 mm (0.39 in.) width and a nominal 40 mm (1.57 in.) length longer than the outside circumference of the test specimen.

NOTE 4—The paper used for the indicators is that known to the trade as 60-lb stock, and is material substantially the same as that described in Federal Specification PPP-T-45D.

19.6 *Test Specimen Support Mandrels*—Use lengths of metal conductors or rods, 530 ± 10 mm (21 ± 0.4 in.) long for supporting the test specimens during the test. The diameters of the mandrels shall be equal to the specified maximum recovered diameters of the test specimens under test. The types of