NFPA 701

Standard Methods of Fire Tests for *Flame Propagation of Textiles and Films*

1999 Edition

This edition of NFPA 701, *Standard Methods of Fire Tests for Flame Propagation of Textiles and Films*, was prepared by the Technical Committee on Fire Tests and acted on by the National Fire Protection Association, Inc., at its May Meeting held May 17–20, 1999, in Baltimore, MD. It was issued by the Standards Council on July 22, 1999, with an effective date of August 13, 1999, and supersedes all previous editions.

This edition of NFPA 701 was approved as an American National Standard on August 13, 1999.

Origin and Development of NFPA 701

Requirements for flameproofing of textiles were adopted by the NFPA on recommendation of the Committee on Fireproofing and Preservative Treatments in 1938. These requirements were amended in 1939, 1940, 1941, and 1951. This standard is now under the jurisdiction of the NFPA Technical Committee on Fire Tests; the 1966 edition, which was an extensive revision of the previous edition, was prepared by that committee, as were the 1968, 1969, 1975, 1976, and 1977 editions.

The 1989 edition was a complete rewrite with significant changes to the small-scale test.

The 1996 edition represented a significant departure from earlier editions, as it provided a new test for single-layer and multilayer fabric assemblies but maintained the large-scale test for multilayer assemblies involving coated fabric blackout linings. This new test was developed to address the problem presented by multilayer assemblies that could not be addressed by the current test procedures. The new Test 1 proved through experience to be an adequate predictor of the behavior of single-layer and multilayer assemblies. Chapter 10, "Field Test, Match Flame Test," of the 1989 edition was established as a separate document, NFPA 705, *Recommended Practice for a Field Flame Test for Textiles and Films.*

The 1999 edition incorporates mostly editorial revisions that reflect the appropriate terminologies used within the document. Many of the editorial changes apply to the application of test procedures for flame propagation of textiles and film in lieu of a material being designated as flame resistant. A section on conditioning of test specimens has been added to assist the user.

NFPA 701

Standard Methods of Fire Tests for

Flame Propagation of Textiles and Films

1999 Edition

NOTICE: An asterisk (*) following the number or letter designating a paragraph indicates that explanatory material on that paragraph can be found in Appendix A.

Information on referenced publications can be found in Chapter 16 and Appendix E.

Chapter 1 Scopes and Purpose

1-1 Scopes.

1-1.1 Test Method 1.

1-1.1.1 Test Method 1 shall apply to fabrics or other materials used in curtains, draperies, or other window treatments. Vinyl-coated fabric blackout linings shall be tested according to Test Method 2.

1-1.1.2 Test Method 1 shall apply to single-layer fabrics and to multilayer curtain and drapery assemblies in which the layers are fastened together by sewing or other means. Vinyl-coated fabric blackout linings shall be tested according to Test Method 2.

1-1.1.3 For the purposes of Test Method 1, the terms *curtains, draperies,* or *other window treatments,* where used, shall include, but not be limited to, the following items:

(1) Window curtains
(2) Stage or theater curtains
(3) Vertical folding shades
(4) Roll-type window shades
(5) Hospital privacy curtains
(6) Window draperies
(7) Fabric vertical shades or blinds
(8) Horizontal folding shades
(9) Swags
(10) Fabric horizontal shades or blinds

1-1.1.4 Test Method 1 also shall apply to the following textile items:

(1) Table skirts
(2) Table linens
(3) Display booth separators
(4) Textile wall hangings

1-1.1.5 Test Method 1 shall not apply to fabrics or composites having an areal density greater than 700 g/m^2 (21 oz/yd^2).

1-1.2 Test Method 2.

1-1.2.1 Test Method 2 (flat specimen configuration) shall be used for fabrics and films, with or without reinforcement or backing, with areal densities greater than 700 g/m^2 (21 oz/yd^2).

1-1.2.2 Test Method 2 shall be used for testing vinyl-coated fabric blackout linings and lined draperies using a vinyl-coated fabric blackout lining.

1-1.2.3 Test Method 2 shall be used for testing plastic films, with or without reinforcement or backing, when used for decorative or other purposes inside a building or as temporary or permanent enclosures for buildings under construction.

1-1.2.4 Test Method 2 shall apply to fabrics used in the assembly of awnings, tents, tarps, and similar architectural fabric structures and banners.

1-1.3 Test Methods 1 and 2.

1-1.3.1 When durability to cleaning or weathering is claimed, the textile or material shall be tested for flame propagation as produced and after being subjected to the applicable cleaning or exposure procedures, in accordance with Chapter 14.

1-1.3.2 For materials that are to be applied to surfaces of buildings or backing materials that are to be used in buildings as interior finishes, the test textiles and films shall be tested and classified in accordance with NFPA 255, *Standard Method of Test of Surface Burning Characteristics of Building Materials,* or NFPA 265, *Standard Methods of Fire Tests for Evaluating Room Fire Growth Contribution of Textile Wall Coverings,* whichever is required by the authority having jurisdiction.

1-2* Purpose of Test Method 1 and Test Method 2.

1-2.1 The purpose of these test methods shall be to assess the propagation of flame beyond the area exposed to the ignition source.

1-2.2 These test methods shall not be deemed to indicate whether the material tested resists the propagation of flame under more severe fire exposure conditions or when it is used in a manner that differs from the test conditions.

1-3 Units. If a value for measurement as given in this standard is followed by an equivalent value in other units, the first stated shall be regarded as the requirement. A given equivalent value shall be considered to be approximate.

Chapter 2 General Requirements for Test Method 1

2-1 General. A weighed specimen consisting of one or more layers of textile shall be suspended vertically from a pin bar near the top rear of an open-face test cabinet. A specified gas flame shall be applied to the center of the lower edge of the specimen for 45 seconds and then withdrawn. The specimen shall be allowed to burn until the flame self-extinguishes and there is no further specimen damage. The specimen then shall be removed from the pin bar and, after room conditioning, shall be weighed again. The percent weight loss shall be determined and used as a measure of total flame propagation and specimen damage.

Chapter 3 Test Apparatus and Materials for Test Method 1

3-1 Conditioning Oven. A forced-draft oven that is capable of maintaining a temperature of 105°C ± 3°C (220°F ± 5°F) shall be used to condition the test specimens prior to testing.

3-2 Hood. A standard laboratory hood (minimum 820 mm wide × 750 mm high × 630 mm deep) (32 in. × 13 in. × 25 in.) or other suitable enclosure shall be used and shall provide a draft-free environment around an open-face test chamber. The hood or other enclosure shall be equipped with an exhaust fan for exhausting the smoke as provided in 6-3.2.

3-3 Test Chamber, Specimen Mounting Pin Bar, and Gas Burner.

3-3.1 An open-face test chamber is shown in Figure 3-3.1(a). The test chamber shall be constructed in accordance with Figure 3-3.1(a) using 12-mm (0.5-in.) thick marinite mineral board. All interior surfaces of the cabinet shall be painted with a flat black paint that withstands the heating that occurs in the cabinet. Figure 3-3.1(b) shows a sketch of the cabinet with the burner and specimen in place.

Figure 3-3.1(a) Test cabinet for Test Method 1.

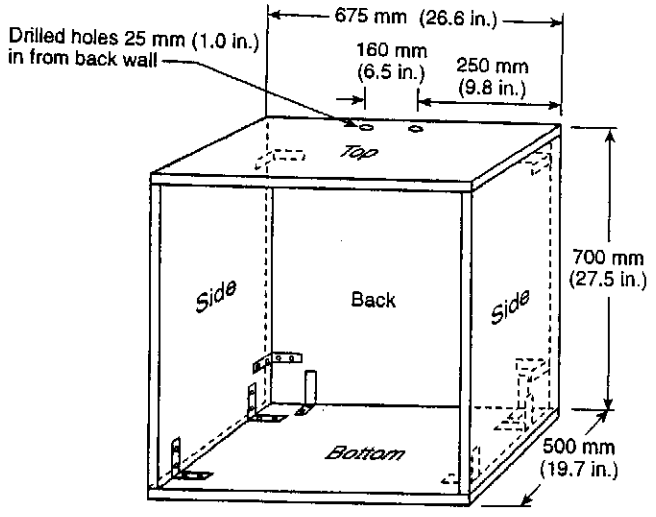
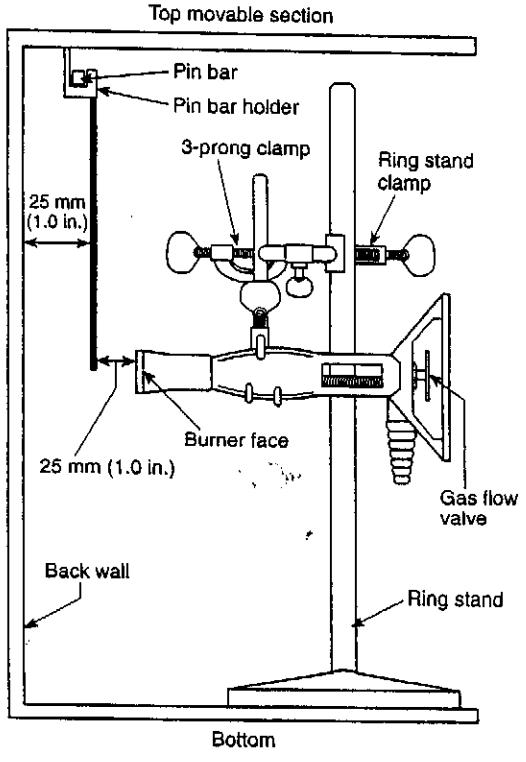


Figure 3-3.1(b) Schematic of burner and specimen placement for Test Method 1.



3-3.2 The pin bar for mounting the specimen shall be a 9-mm (0.36-in.) square stainless steel bar, 190 mm (7.5 in.) in length, with steel pins 0.7 mm (0.027 in.) in diameter and 11 mm (0.43 in.) long, mounted at distances of 37 mm, 66 mm, 95 mm, 124 mm, and 153 mm (1.45 in., 2.60 in., 3.75 in., 4.90 in., and 6.05 in.) from each end of the bar.

3-3.3* A Meeker (Fisher) tapered laboratory burner, with grid-top adjustable channels, which provides a premixed flame, shall be used as the ignition source.

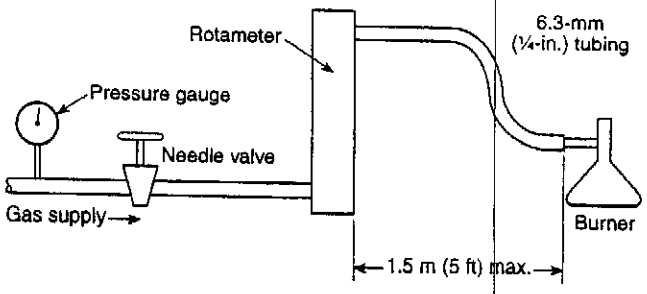
3-4 Gas and Control System.

3-4.1* Methane gas that is at least 97 percent pure shall be used for the burner fuel. The gas shall be contained in a cylinder equipped with a pressure-reducing valve and gauges to allow maintenance of a pressure of 17.5 kPa ± 2.0 kPa (2.5 psi ± 0.25 psi) (132 mm Hg ± 13 mm Hg) at the flow gauge.

3-4.2* A gas flow gauge with a flow control valve shall be used to measure and control the gas flow rate.

3-4.3 The gas tank, flow gauge, control valves, and burner shall be connected as shown in Figure 3-4.3. Hose or tubing with at least a 5-mm (0.2-in.) bore shall be used. The control valve at the tank shall not be used to control the flow through the flow gauge. The flow valve at the tank shall be fully open during the test.

Figure 3-4.3 Gas line feed arrangement to burner.



3-5* Mounting Jig. A mounting jig shall be used for mounting specimens to the pin bar in a uniform and safe manner.

3-6 Timer. A stopwatch or other timing device shall be used to measure time to the nearest 0.2 second.

3-7 Balance. A balance having a capacity of at least 100 g (3.53 oz) and a resolution of 0.1 g (3.5×10^{-3} oz) shall be used to weigh the specimen.

3-8 Ruler. A ruler, marked in 1-mm ($^1/_{32}$-in.) increments shall be used to measure the burner flame height and specimen dimensions.

3-9* Wire Brush. A brush manufactured from bronze wire shall be used for removing ash and char debris from the test specimen at the conclusion of each test and before the post-test weighing.

3-10* Binder Clips. Clips used in this test shall be 18 mm ± 1 mm (0.75 in. ± 0.04 in.) wide and shall weigh 3.0 g ± 0.2 g (0.1 oz ± 0.007 oz). In Test Method 1 they shall serve as small weights to be attached to the lower corners of the test specimens in order to stabilize them.

Chapter 4 Calibration and Standardization for Test Method 1

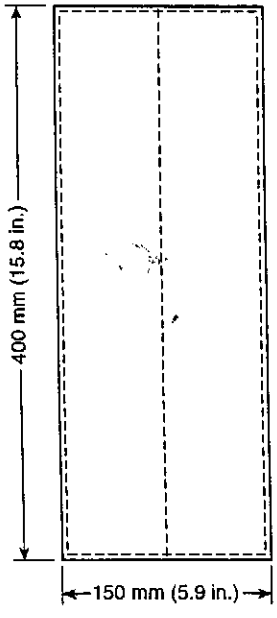
4-1 General. At the start of each series of tests, the air vents at the base of the burner shall be fully open and the gas flow set for a flow gauge scale reading of 70 ± 2 using the flow control valve on the gauge. This corresponds to an airflow of 895 ml/min ± 25 ml/min (5.26×10^{-5} ft^3/sec ± 1.47×10^{-5} ft^3/sec) and a methane flow of 1205 ml/min ± 35 ml/min (7.1×10^{-4} ft^3/sec ± 2.0×10^{-5} ft^3/sec). At the same time, the pressure gauge shall read 17.5 kPa ± 2.0 kPa (2.5 psi ± 0.25 psi) (132 mm Hg ± 13 mm Hg). These settings shall provide a flame height of 100 mm ± 10 mm (4.0 in. ± 0.4 in.) with the burner in a vertical position. The flow control valve on the burner shall be fully open.

Chapter 5 Specimens and Conditioning for Test Method 1

5-1 Test Specimens. Ten individual test specimens shall be cut from a single piece of the material to be evaluated to a size of 150 mm ± 5 mm × 400 mm ± 5 mm (5.90 in. ± 0.20 in. × 15.75 in. ± 0.20 in.), with the length parallel to the lengthwise direction of the material. These 10 specimens shall constitute a sample. Specimens shall not be taken nearer the selvage than $^1/_{10}$ of the full width of the textile.

5-1.1 For multilayer assemblies, the layers shall be sewn together as shown in Figure 5-1.1 using a plain stitch with 2.5 stitches/cm ± 0.25 stitch/cm (6.4 stitches/in. ± 0.6 stitch/in.). A No. 40 polyester/cotton sewing thread shall be used. The layers of the multilayer assembly shall be sewn along all four edges at a distance of 5 mm ± 1 mm (0.2 in. ± 0.04 in.) from the edge. A fifth seam shall be sewn along the center of the assembly in the lengthwise direction. This center seam shall extend the full length of the specimen. Seams shall not be required in single-layer textile specimens.

Figure 5-1.1 Multilayer specimen for Test Method 1.



5-1.2 Each specimen shall be numbered and weighed to the nearest 0.1 g (3.5×10^{-3} oz) before conditioning. The mass of each specimen shall be recorded.

5-2 Conditioning.

5-2.1 The specimens shall be placed in a forced-draft oven to allow free circulation of air around the specimens. The specimens shall be dried for at least 30 minutes at 105°C ± 3°C (220°F ± 5°F).

5-2.2 If the specimens melt or permanently deform at 105°C or below, condition the specimens at 20°C ± 5°C (68°F ± 9°F) for at least 24 hours prior to flame exposure.

Chapter 6 Test Procedure for Test Method 1

6-1 Mounting of Test Specimens.

6-1.1* After conditioning, the specimen shall be attached to the pin bar with the top of the specimen centered on the bar. The pins shall be 5 mm ± 1 mm (0.20 in. ± 0.04 in.) from the top edge of the specimen. The specimen shall be mounted with the assistance of a jig. The specimen shall be placed on the pin bar so that the surface or the layer intended to face the wall or window during normal use faces the pin bar.

6-1.2 The pin bar shall be mounted on the support hanger located at the back of the test chamber ceiling. The surface that in normal use is intended to face the wall or window shall face the back of the test chamber. When the pin bar and hanger are placed, the side of the specimen facing the back wall of the test chamber shall be 25 mm ± 2 mm (1.0 in. ± 0.08 in.) from the wall surface.

6-2 Burner Placement and Preparation.

6-2.1 The burner shall be placed so that it is 25 mm ± 2 mm (1.0 in. ± 0.08 in.) from the face of the specimen and with the center axis of the burner horizontal and perpendicular to the bottom of the center seam in the specimen. Position adjustments shall be permitted to be made by moving the support base and by adjusting the height and angle of the burner.

6-2.2 The exhaust fan shall be turned on.

6-3* Conducting the Test. The test shall be initiated within 2 minutes of removing the specimen from the forced-draft oven. The gas shall be turned on fully at the burner control valve and allowed to flow for 20 seconds ± 1 second before it shall be ignited. The specimen shall be exposed to the igniting flame for 45 seconds ± 1 second. After the 45-second exposure, the burner shall be turned on its mount so that its center axis is parallel to the plane of the specimen, and then the gas flow shall be turned off using the control valve on the burner. The gas flow rate shall be controlled by the valve at the flow gauge.

6-3.1 Binder clips measuring 18 mm ± 1 mm (0.75 in. ± 0.04 in.) shall be attached to the specimen at each bottom corner. The binder clip shall have a mass of 3.0 g ± 0.2 g (0.1 oz ± 7×10^{-3} oz). The clips shall be positioned such that the "bite edge" of the clip is 5 mm ± 1 mm (0.20 in. ± 0.04 in.) above the lower edge of the specimen. The clips shall be placed 5 mm ± 1 mm (0.20 in. ± 0.04 in.) in from the left and right side edges of the specimen, respectively.

6-3.2 The exhaust fan shall remain on throughout the test procedure. The front of the hood shall be closed after the burner is turned off and moved away from the specimen to remove the smoke produced by the burning specimen.

6-3.3 The afterflame time of the specimen (burning time of the specimen after the gas flow is turned off) and the burning time of material that falls to the bottom of the chamber shall be measured and recorded. Observations such as, but not limited to, the type, amount, color, density, and odor of smoke produced, the vigorousness of burning, and the dripping of molten material also shall be recorded.

6-3.4 The pin bar and specimen shall be removed from the hanger.

6-3.5 The wire brush shall be used to remove lightly attached ash and char from the specimen.

6-3.6 The specimen shall be removed from the pin bar.

6-3.7 The portion of the specimen removed from the pin bar shall be weighed to the nearest 0.1 g (3.5×10^{-3} oz), and the weight shall be recorded. Any material that has fallen away from the specimen shall not be weighed.

6-3.8 The mass shall be determined no sooner than 1 hour after the residual material has been removed from the pin bar.

Chapter 7 Calculation of Results for Test Method 1

7-1 Calculation of Percent Mass Loss.

7-1.1 The percent mass loss of each specimen shall be determined from the following equation:

$$\frac{\text{Mass before test} - \text{mass after test}}{\text{mass before test}} \times 100 = \text{percent mass loss}$$

The percent mass loss shall be recorded.

7-1.2 The mean percent mass loss and the standard deviation for the sample consisting of 10 specimens shall be calculated.

7-1.3 When the percent mass loss of any individual specimen exceeds the mean value plus 3 standard deviations, the test shall be repeated on another sample of 10 specimens. The mean percent mass loss and standard deviation for the second set of 10 specimens shall be calculated.

Chapter 8 Flame Propagation Performance Criteria for Test Method 1

8-1 Performance Criteria.

8-1.1 To pass Test Method 1, a sample shall meet the criteria in 8-1.1.1 through 8-1.1.4.

8-1.1.1 Fragments or residues of specimens that fall to the floor of the test chamber shall not continue to burn for more than an average of 2 seconds per specimen for the sample of 10 specimens.

8-1.1.2 The average weight loss of the 10 specimens in a sample shall be 40 percent or less.

8-1.1.3 No individual specimen's mass loss percent shall deviate more than 3 standard deviations from the mean for the 10 specimens.

8-1.1.4 When a retest is required, the percent mass loss of no individual specimen in the second set of specimens shall deviate from the mean value by more than 3 standard deviations calculated for the second set.

8-1.2 When a sample does not demonstrate passing performance in accordance with all of the conditions indicated in 8-1.1.1 through 8-1.1.4, the material shall be recorded as having failed Test Method 1.

Chapter 9 General Requirements for Test Method 2

9-1 General. Test Method 2 exposes a 1200-mm (47.25-in.) long specimen to a 280 mm ± 12 mm (11.0 in. ± 0.5 in.) igniting flame inside a four-sided test cabinet that is 305 mm ± 5 mm (12 in. ± 0.2 in.) wide on each side and 2.13 m ± 0.01 m (84 in. ± 0.4 in.) high.

Chapter 10 Test Apparatus and Materials for Test Method 2

10-1 Conditioning Oven.

10-1.1 A forced-draft oven shall be used to condition test specimens prior to testing.

10-1.2 The interior of the oven shall provide free airflow around each specimen it contains.

10-1.3 The oven used shall have variable temperature control that is capable of maintaining its interior at a temperature of 105°C ± 3°C (220°F ± 5°F).

10-2 Test Enclosure.

10-2.1 The test shall be conducted in a four-sided metal stack with sides of 305 mm ± 5 mm (12.0 in. ± 0.2 in.) width and 2130 mm ± 10 mm height (84.0 in. ± 0.4 in.) *[see Figure 10-2.1 (a)]*, with details as follows:

(a) The stack shall be supported 305 mm ± 5 mm (12.0 in. ± 0.2 in.) above the floor by legs and shall be open at the top and bottom.

(b) The stack shall have a means for hanging the specimen as follows:

(1) *Top Specimen Rod.* A steel rod 1.5 mm ± 0.1 mm or 3.0 mm ± 0.1 mm (0.060 in. ± 0.003 in. or 0.120 in. ± 0.003 in.) in diameter and 330 mm ± 10 mm (13 in. ± 0.4 in.) long, sharpened to a point at one end. The stack shall have holes of 4 mm on both sides aligned horizontally and located 1190 mm ± 10 mm (46.8 in. ± 0.4 in.) above the bottom edge of the cabinet for the location of the top specimen rod.

(2) *Bottom Specimen Rod.* A steel rod 1.5 mm ± 0.1 mm (0.060 in. ± 0.003 in.) in diameter, 255 mm ± 10 mm (10.0 in. ± 0.4 in.) long, sharpened to a point at one end.

(3) *Vertical Guide Wires.* Soft steel wire that makes a pair of vertical guide wires on each side of the stack spaced 100 mm ± 5 mm (4 in. ± 0.2 in.) to the right and left of the vertical center of the stack [each pair separated by 200 mm ± 5 mm (8 in. ± 0.2 in.)]. The wires of each pair shall be 25 mm ± 2 mm (1.0 in. ± 0.1 in.) apart (front to back, in the cabinet).

The vertical guide wires shall be mounted using rods 6 mm ± 0.05 mm (0.250 in. ± 0.020 in.) in diameter fixed horizontally at the top and bottom of the stack. *[See Figure 10-2.1 (b).]*

(c) A glass fiber fabric baffle shall be installed in the upper portion of the test cabinet as follows:

(1) *A piece of glass fiber fabric measuring 1000 mm ± 10 mm × 125 mm ± 5 mm (39.4 in. ± 0.4 in. × 4.9 in. ± 0.2 in.) shall be cut.

(2) A 40 mm ± 3 mm (1.6 in. ± 0.1 in.) hem shall be sewn on each end of the fabric using a glass sewing thread.

(3) A 3 mm ± 0.2 mm × 330 mm ± 5 mm (0.12 in. ± 0.01 in. × 13 in. ± 0.2 in.) rod shall be inserted through the hem at one end and through holes [4 mm ± 0.5 mm (0.158 in. ± 0.02 in.)] in the top middle of the two opposite sides of the cabinet. These holes shall be centered 10 mm ± 1 mm (0.4 in. ± 0.04 in.) below the top edge of the cabinet and midway between the front and back of the cabinet.

(4) A 3 mm ± 0.2 mm × 330 mm ± 5 mm (0.12 in. ± 0.01 in. × 13 in. ± 0.2 in.) rod shall be inserted through the bottom hem of the glass fabric and also through the slotted holes that are in the opposite sides of the test cabinet centered 930 mm ± 2 mm (36.6 in. ± 0.08 in.) below the top of the cabinet. These slotted holes shall be 4 mm ± 0.5 mm × 25 mm ± 1 mm (0.160 in. ± 0.020 in. × 1.00 in. ± 0.040 in.), rounded at each end.

10-2.2 The stack shall be located in a room, chamber, or hood where the temperature is 15°C ± 10°C (60°F ± 18°F) and the relative humidity does not exceed 70 percent. The room shall be totally enclosed and have one access door. The room shall be draft-free, such that when the room door is closed and the test cabinet door is open, the igniting flame is an undisturbed vertical diffusion flame. The room shall be provided with an exhaust system for removal of smoke and gases on the completion of each test. The exhaust system shall not be operated during the performance of a test.

10-2.3 The test chamber shall be free of drafts that affect the stability of the flame.

10-2.4 Figures 10-2.1(a), 10-2.1(b), 10-4.1, 10-4.3, 11-1.2, 11-1.3(a), and 11-1-3(b) shall be used for details regarding enclosure construction and facilities for mounting both flat and folded test specimens.

10-3 Restraining Clamps. See 12-2.3.

10-4* Gas Burner. A laboratory burner, conforming to ASTM D 5025, *Specification for a Laboratory Burner Used for Small-Scale Burning Tests in Plastic Materials,* and having an inside diameter of 9.5 mm + 1.5, –0 mm (0.37 in. + 0.06, –0 in.) and a length of 100 ± 0 mm (3.9 in. ± 0.39 in.) and that meets the calibration or confirmation practice of ASTM D 5207, *Practice for Calibration of 20 mm and 125 mm Test Flames for Small-Scale Burning Tests on Plastic Materials,* shall be used for the ignition source. If the burner is equipped with a gas flow controlling valve, the valve shall be open fully in order to prevent restriction of gas flow. The air vents shall be kept closed and sealed.

10-4.1 The burner shall be fixed in a position so that the barrel is at a 25 degree angle with the vertical, with the upper tip of the burner located 100 mm (4 in.) below the bottom edge of the test specimen as noted in Figure 10-4.1.

10-4.2 The gas supply to the burner shall be at least 97 percent pure methane or manufactured or natural gas having a heat value of 25 × 10^6 J/m^3 to 31 × 10^6 J/m^3 (800 Btu/ft^3 to 1000 Btu/ft^3).

Figure 10-2.1(a) Orthographic view of test cabinet for Test Method 2.

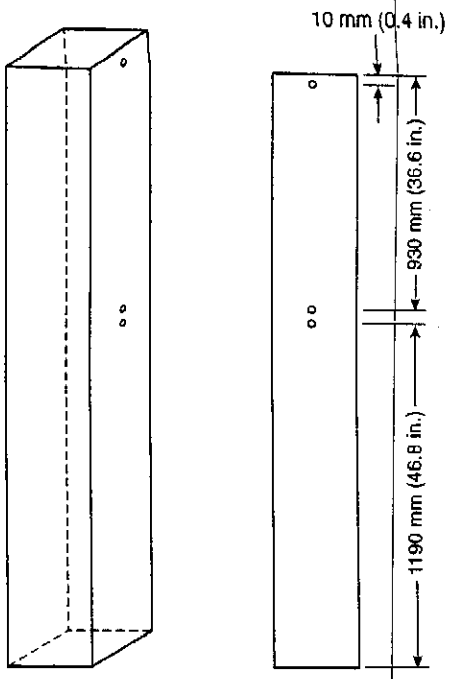


Figure 10-2.1(b) Vertical guide support.

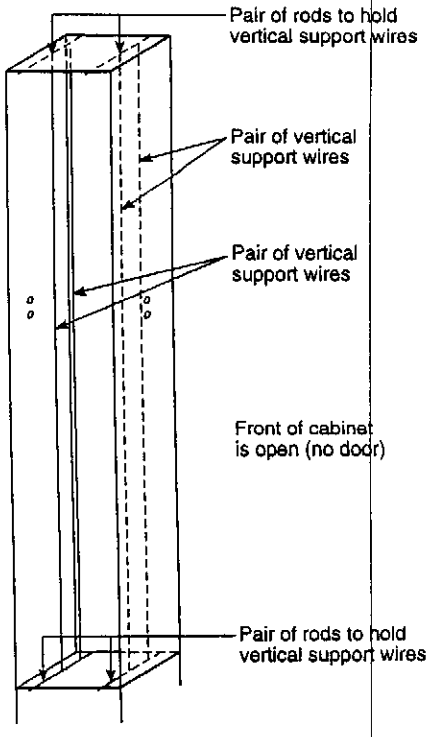
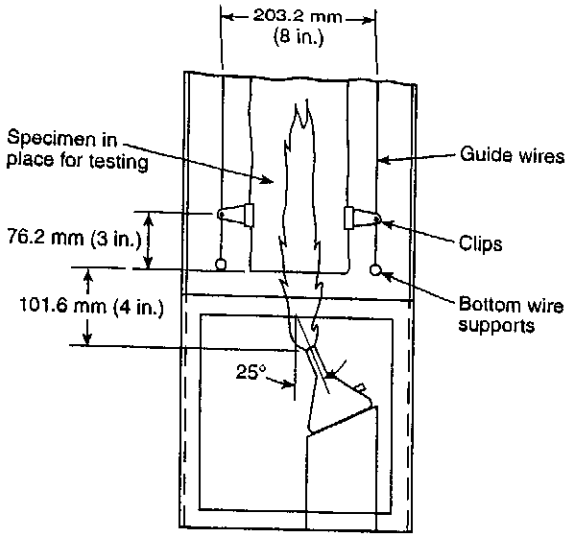
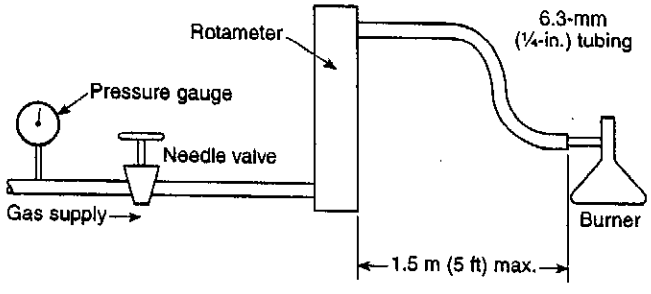


Figure 10-4.1 View of inside at bottom of cabinet.



10-4.3 A needle valve for gas flow control shall be used followed by a rotameter in the gas line leading to the burner. The upper limit of the rotameter shall be 150 L/hr to 300 L/hr (1.47×10^{-3} ft^3/sec to 2.9×10^{-3} ft^3/sec). A pressure gauge shall be located between the gas supply and the needle valve used for controlling the gas flow. The gas lines from the needle valve to the rotameter and from the rotameter to the burner shall have a bore of at least 6 mm (0.24 in.) and shall not exceed a total length of 1500 mm (59 in.). *(See Figure 10-4.3.)*

Figure 10-4.3 Gas line feed arrangement to burner.



10-5 Timer. A stopwatch or other timing device that measures to an accuracy of 0.5 second shall be used for determining afterflame of burning specimens and the flame time of portions of residues that break away or drip from the test specimen and continue to flame after reaching the floor of the test chamber.

10-6 Ruler. A ruler marked in l-mm ($^1/_{32}$-in.) increments shall be used to measure the burner flame height and specimen dimensions.

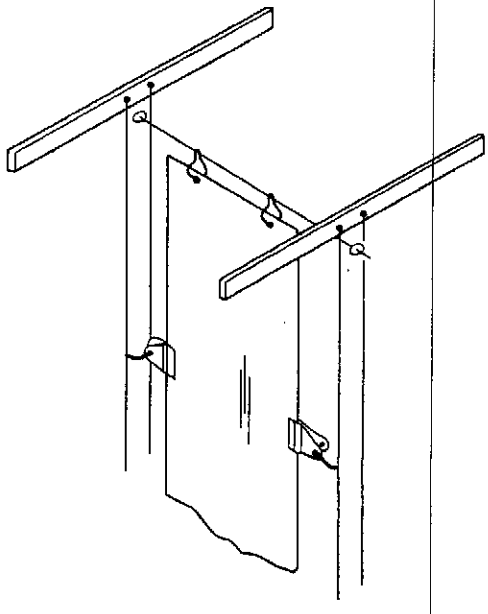
Chapter 11 Specimens and Conditioning for Test Method 2

11-1 Test Specimens.

11-1.1 Selvages shall be removed from the material to be evaluated before cutting and conditioning specimens. The test specimens shall be taken from widely separated and symmetrically located sections over the entire area of the material. The specimens shall be cut on their long dimension in the lengthwise direction of the material.

11-1.2 For conducting flame tests of flat sheet materials, at least 10 specimens measuring 125 mm × 1200 mm ± 25 mm (4.9 in. × 47.25 in. ± 1.0 in.) shall be used. Only those specimens that cannot be folded shall be tested in the flat configuration. *(See Figure 11-1.2.)*

Figure 11-1.2 Test sample flat sheet.



11-1.3 For conducting flame tests of materials hung in folds, at least four specimens, 610 mm ± 25 mm × 1200 mm ± 25 mm (24.0 in. ± 1.0 in. × 47.25 in. ± 1.0 in.), shall be used. Each specimen shall be folded longitudinally to form four folds so that the segment of material on each side of a fold uniformly measures 125 mm ± 20 mm (4.9 in. ± 0.8 in.) in width over the length of the specimen. *[See Figures 11-1.3(a) and (b).]*

11-1.4 For multilayer assemblies (either flat or folded), the layers shall be sewn together as shown in Figure 11-1.4 using a plain stitch with 2.5 stitches/cm ± 0.25 stitch/cm (6.4 stitches/in. ± 0.6 stitch/in.). A No. 40 polyester/cotton sewing thread shall be used. The layers of the multilayer assembly shall be sewn along all four edges at a distance of 5 mm ± 1 mm (0.2 in. ± 0.04 in.) from the edge. A fifth seam shall be sewn along the center of the assembly in the lengthwise direction. This center seam shall extend the full length of the specimen. The seam shall be within 10 mm (0.4 in.) of the center of the specimen.

Figure 11-1.3(a) Test sample in folds.

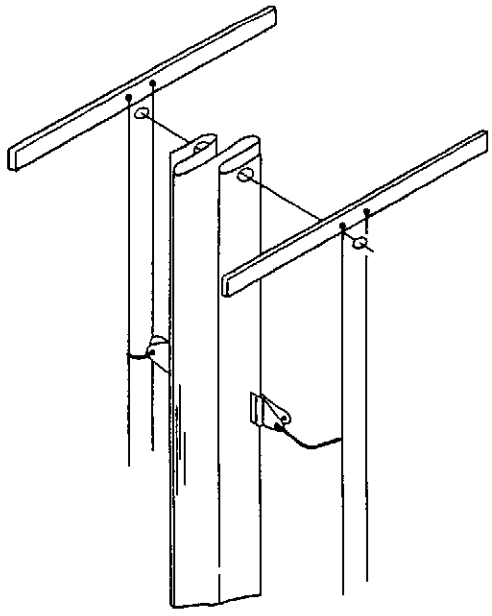
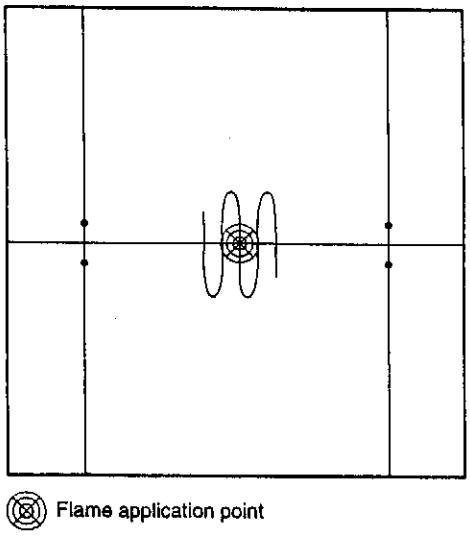


Figure 11-1.3(b) Bottom view of folded sample.



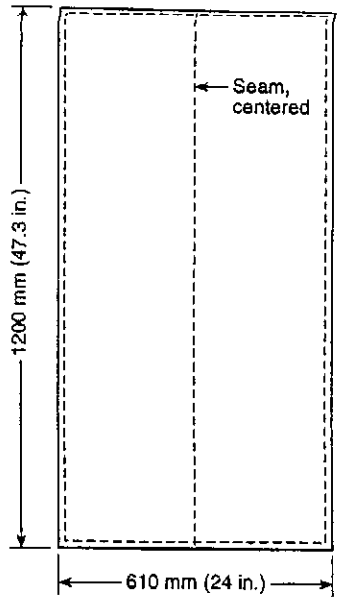
11-2 Conditioning of Test Specimens.

11-2.1 The test specimens shall be conditioned in an oven at a temperature of 105°C ± 3°C (220°F ± 5°F) for not less than 1 hour or more than 3 hours before testing.

11-2.2 Each specimen shall be removed from the oven no earlier than 2 minutes before the gas burner is ignited.

11-2.3 If the specimens melt or permanently deform at 105°C (221°F), they shall be conditioned at 20°C ± 5°C (68°F ± 9°F) for at least 24 hours prior to flame exposure.

Figure 11-1.4 Multilayer specimen for Test Method 2.



Chapter 12 Flame Test Procedures for Test Method 2

12-1 Mounting of Test Specimens.

12-1.1 The 330-mm (13-in.) steel mounting rod shall be threaded through the specimen so that the folded or flat configuration, as appropriate, shall be maintained. The rod shall be threaded through the specimen 15 mm ± 5 mm (0.6 in. ± 0.2 in.) below the top edge of the test specimen.

12-1.1.1 The folded specimens shall be suspended vertically with the edges of the two center folds facing the front of the stack. The folds shall be spread 12 mm ± 3 mm (0.5 in. ± 0.12 in.) apart by means of the top support rod and the 1.5 mm × 255 mm (0.06 in. × 10 in.) sharpened rod that shall be installed halfway down the length of the specimen to hold the folds in place. The bottom of the center portion of the section between the two middle folds shall be 100 mm ± 10 mm (4.0 in. ± 0.4 in.) above the burner.

12-1.1.2 The flat specimens shall be suspended vertically in the stack with their full width facing the front of the stack so that the center of the bottom of the specimen is located 100 mm ± 10 mm (4.0 in. ± 0.4 in.) above the burner.

12-1.2 Test specimens shall be restrained laterally at the midpoint of their length and within 75 mm (3 in.) of the bottom edge by bulldog clips and lightweight chains attached to the vertical guide wires.

12-1.3 Figures 11-1.2, 11-1.3(a), and 11-1.3(b) shall be used for details for mounting test specimens.

12-2 Conducting the Flame Test.

12-2.1 The gas burner shall be ignited. The gas pressure shall be 17.5 kPa ± 2.0 kPa (2.5 psi ± 0.25 psi) with a flow rate of 113 L/hr ± 3 L/hr (1.1×10^{-3} ft^3/sec ± 2.9×10^{-5} ft^3/sec).

12-2.2 The burner air inlets shall be sealed with vinyl electrical adhesive tape to prevent the entrance of air, and the gas shall be adjusted to produce a 280 mm ± 12 mm (11 in. ± 0.5 in.) flame.

12-2.3 The position of the specimen relative to the test flame shall be maintained by using bulldog clips attached to the edges of the specimen and the vertical guide wires with lightweight chains. These clips shall be attached to the edges of the specimen at the midpoint of the specimen's length.

12-2.4 The test flame shall be applied to the specimen for 2 minutes and then shall be withdrawn.

The flame shall be applied at an angle of 25 degrees from the vertical with the burner opening 100 mm (4 in.) below the edge of the specimen and within 20 mm (0.8 in.) of the middle of the width of the lower edge of the specimen in a single sheet, or at the middle segment of folded specimens. *[See Figure 11-1.3(b).]*

12-2.5 The duration of flaming combustion of material that drops to the floor of the test chamber shall be measured to the nearest 0.5 second and recorded.

12-2.6 The duration of burning of the specimen after the igniting flame has been removed shall be measured to the nearest 0.5 second and recorded.

12-2.7 After all flaming has ceased, the test cabinet and room shall be purged of smoke and gases prior to the next test.

12-3 Measurement of Length of Char. The length of the char after all flaming and afterglow on the specimen have ceased shall be determined. The length of char shall be defined as the original length of the specimen minus the distance from the top edge of the specimen to the horizontal line above which all material is intact.

Chapter 13 Flame Propagation Performance Criteria for Test Method 2

13-1 Performance Criteria.

13-1.1 When any specimen continues flaming for more than 2 seconds after the test flame is removed from contact with the specimen, the material shall be recorded as having failed the test. *(See 12-2.6.)*

13-1.2 When the length of char of any individual folded specimen exceeds 1050 mm (41.3 in.), the material shall be recorded as having failed the test. *(See Section 13-2.)*

13-1.3 When the char length of any single flat specimen exceeds 435 mm (17.1 in.), the material shall be recorded as having failed the test. *(See Section 13-2.)*

13-1.4 When at any time during or after the application of the test flame any portions or residues of the material being tested break or drip from the specimen and fall to the floor of the test apparatus and continue burning for more than 2 seconds after reaching the floor of the test apparatus, the material shall be recorded as having failed the test. *(See 12-2.5.)*

13-2 Retest.

13-2.1 In the event that only one of the four folded specimens does not meet the criteria of Section 13-1, two new specimens cut in the same direction as the one that failed shall be tested. If both of the new specimens meet all of the criteria, the material shall be recorded as having passed this test.

13-2.2 In the event that only one of the 10 flat specimens does not meet the criteria of Section 13-1, five new specimens cut in the same direction as the one that failed shall be tested. If all five of the new specimens meet all of the criteria, the material shall be recorded as having passed this test.

Chapter 14 Cleaning and Water Leaching Procedures

14-1 General. When a manufacturer claims that the material tested in accordance with NFPA 701 retains its flame resistance after cleaning or weathering, the material shall also be tested after it has been subjected to the exposure conditions specified in this chapter.

14-2 Application. Each fabric shall be subjected to those exposure conditions that are applicable to its intended use (dry cleaning, laundering, or other exposure to water). Each material or assembly shall pass the flame propagation requirements of either Chapter 8 or 13 after passing through the appropriate exposure cycles.

14-3 Accelerated Dry Cleaning.

14-3.1 When the material to be tested is intended to be refurbished by dry cleaning, the material shall be subjected to three full cycles of one of the following dry-cleaning procedures:

(1) A dry-cleaning procedure specified by the manufacturer or finisher for the routine care of the material. If such care instructions are provided by the manufacturer, they shall be used.
(2) Conventional commercial dry cleaning using either perchloroethylene or Stoddard solvent as the cleaning medium

14-3.2 Test specimens shall be cut from the dry-cleaned material for testing.

14-3.3 The specimens shall be conditioned before testing.

14-4 Accelerated Laundering.

14-4.1 When the material to be tested is intended to be refurbished by laundering, the material shall be subjected to five full cycles of one of the following laundering procedures:

(1) A laundering procedure specified by the manufacturer or finisher for the routine care of the material
(2) Conventional commercial laundering
(3) The home laundering procedure specified in the AATCC Technical Manual, *Standard Laboratory Practice for Home Laundering Fabrics Prior to Flammability Testing to Differentiate Between Durable and Non-Durable Finishes*

14-4.2 Test specimens cut from laundered material shall be used for testing.

14-4.3 The specimens shall be conditioned before testing.

14-5 Accelerated Water Leaching.

14-5.1 When the material is expected to be suitable for use outdoors, the material shall be immersed totally in a vessel containing tap water at room temperature (20°C ± 5°C) (68°F ± 9°F) for not less than 72 hours. A vessel with a capacity of at least 15.1 L (4 gal) shall be used.

14-5.2 The water shall be drained from the vessel at 24-hour intervals during the immersion period. After all water has drained from the vessel, it shall be refilled as done initially.

14-5.3 At the conclusion of the immersion period, the sample shall be removed from the vessel and dried at room temperature.

14-5.4 Test specimens cut from leached material shall be used for testing.

14-5.5 The specimens shall be conditioned before testing.

14-5.6 When the material is subjected to the accelerated laundering prescribed in Section 14-4, this leaching procedure shall not be required.

Chapter 15 Reporting

15-1 General. The recorded results shall be reported along with the description of the materials tested, test conditions, and the accelerated laundering, dry-cleaning, or water leaching procedures used (if any).

15-2 Material Description.

15-2.1 The composition and form of the material that was tested shall be described. The description shall include the manner in which the material was assembled. Where flame retardants have been added, they shall be described along with the method of application. The weight and construction of the material in the description shall be included.

15-2.2 The intended application of the material or assembly shall be included, if known.

15-3 Conditioning. The conditioning of the specimens shall be described.

15-4 Test Conditions. The test used and the test conditions shall be described.

15-5 Refurbishing or Weathering Conditions. When any laundering, dry-cleaning, or water leaching procedures are applied to the sample, the procedures shall be described along with the number of cycles used.

15-6 Test Results. The results from individual specimens as well as the sample average for the following measurements and observations shall be reported:

(1) The time of burning for any material that falls to the bottom of the test chamber to the nearest 0.5 second
(2) The mass of each specimen [to the nearest gram (ounce)] before and after exposure to the ignition flame (Test Method 1)
(3) The char length to the nearest 3 mm (0.12 in.) (Test Method 2)
(4) The afterflame time to the nearest 0.5 second (Test Method 2)
(5) Any unusual behavior of specimens and other observations

15-7 Final Conclusion. The report shall specify whether the material passes or fails the test based on the test results and the criteria of either Chapter 8 or 13, whichever is appropriate.

Chapter 16 Referenced Publications

16-1 The following documents or portions thereof are referenced within this standard as mandatory requirements and shall be considered part of the requirements of this standard. The edition indicated for each referenced mandatory document is the current edition as of the date of the NFPA issuance of this standard. Some of these mandatory documents might also be referenced in this standard for specific informational purposes and, therefore, are also listed in Appendix E.

16-1.1 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

NFPA 255, *Standard Method of Test of Surface Burning Characteristics of Building Materials*, 1996 edition.

NFPA 265, *Standard Methods of Fire Tests for Evaluating Room Fire Growth Contribution of Textile Wall Coverings*, 1998 edition.

16-1.2 Other Publications.

16-1.2.1 AATCC Publication. American Association of Textile Chemists and Colorists, P.O. Box 12215, Research Triangle Park, NC 27709.

AATCC Technical Manual, *Standard Laboratory Practice for Home Laundering Fabrics Prior to Flammability Testing to Differentiate Between Durable and Non-Durable Finishes*, 1994.

16-1.2.2 ASTM Publications. American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM D 5025, *Specification for a Laboratory Burner Used for Small-Scale Burning Tests in Plastic Materials*, 1994.

ASTM D 5207, *Practice in Calibration of 20 mm and 125 mm Test Flames for Small-Scale Burning Tests on Plastic Materials*, 1991.

Appendix A Explanatory Material

Appendix A is not a part of the requirements of this NFPA document but is included for informational purposes only. This appendix contains explanatory material, numbered to correspond with the applicable text paragraphs.

A-1-2 See Appendix B for further information.

A-3-3.3 The following is being provided for informational purposes only and has not been independently verified, certified, or endorsed by NFPA or any of its technical committees.

A suitable burner is available as Catalog No. 03-902 from Fisher Scientific Company, 711 Forbes Avenue, Pittsburgh, PA 15219-4785; (412) 562-8300.

A-3-4.1 The following is being provided for informational purposes only and has not been independently verified, certified, or endorsed by NFPA or any of its technical committees.

A suitable pressure gauge is available as Catalog No. 11-281B (0-300 mm Hg) from Fisher Scientific Company, 711 Forbes Avenue, Pittsburgh, PA 15219-4785; (412) 562-8300.

A-3-4.2 The following is being provided for informational purposes only and has not been independently verified, certified, or endorsed by NFPA or any of its technical committees.

A suitable gas flow gauge for maintaining and monitoring the gas flow rate is available as Catalog No. N 03229-19 from Cole-Parmer Instrument Company, 7425 North Oak Park Avenue, Chicago, IL 66048-9930; (800) 323-4340.

A-3-5 Appendix C provides information and details related to a specimen mounting jig for Test Method 1.

A-3-9 The following is being provided for informational purposes only and has not been independently verified, certified, or endorsed by NFPA or any of its technical committees.

A suitable brush can be obtained as Catalog No. 03-685 from Fisher Scientific Company, 711 Forbes Avenue, Pittsburgh, PA 15219-4785; (412) 562-8300.

A-3-10 Binder clips resemble those clips intended for holding several pages of paper together.

A-6-1.1 Appendix C provides information and details related to a specimen mounting jig for Test Method 1.

A-6-3 In those instances in which the specimen is not initially exposed directly to the flame, such as when it clings to the back wall because of static or hangs too far from the wall as when the gas and hot combustion products get behind it, the specimen should be pulled or pushed into the flame to ensure direct flame exposure. A metal wire or light rod should be used for directing the specimen into the flame.

A-10-2.1(c)(1) The following is being provided for informational purposes only and has not been independently verified, certified or endorsed by NFPA or any of its technical committees.

A suitable glass fabric is Style 2116, available from Clark Schwebel Fiber Glass Corporation, P.O. Box 2627, Anderson, SC 29622.

A-10-4 The following is being provided for informational purposes only and has not been independently verified, certified, or endorsed by NFPA or any of its technical committees.

A suitable burner is available as Catalog No. 03-917 from Fisher Scientific Company, 711 Forbes Avenue, Pittsburgh, PA 15219-4785; (412) 562-8300.

Appendix B Guidance on the Use of the Two Test Methods

This appendix is not a part of the requirements of this NFPA document but is included for informational purposes only.

B-1 Introduction. These test methods differentiate fabrics that do not spread flame extensively from those that do burn rapidly and extensively.

B-2 Test Method 1. The Test Method 1 procedure should be used for assessing the response of fabrics both individually and in multilayer composites used as curtains, draperies, or other window treatments when exposed to a 100-mm (4.0-in.) Meeker burner flame while suspended in a vertical configuration.

B-3 Test Method 2. The Test Method 2 procedure should be used for assessing the response of heavy fabrics both individually and in multilayer composites used as curtains, draperies, other window treatments, vinyl-coated blackout linings, lined draperies using a vinyl-coated blackout lining, and fabrics and films used in tents and tarpaulins using a 280-mm (11-in.) laboratory burner flame as the ignition source.

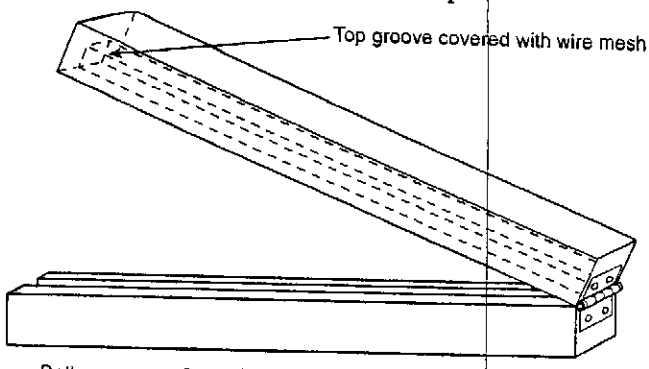
Appendix C Test Method 1 Information

This appendix is not a part of the requirements of this NFPA document but is included for informational purposes only.

C-1 Specimen Mounting Jig for Test Method 1.

C-1.1 Figure C-1.1 shows the construction details for a mounting jig, which makes it quicker, easier, and safer to mount the specimens for Test Method 1 onto the pin bar correctly.

Figure C-1.1 Mounting jig for Test Method 1 specimens.



Bottom groove: 8 mm (0.3 in.) wide x 5 mm (0.2 in.) deep
Top groove: 15 mm (0.6 in.) wide x 18 mm (0.7 in.) deep

C-1.2 With the pin bar placed in the slot of the long arm of the jig, the specimen should be held so that the top seam of composite specimens [or an imaginary line 5 mm (0.196 in.) below the top edge of single-layer specimens] is aligned with the pins on the pin bar. The short arm of the jig then should be lowered over the pins and gently pushed downward. This procedure secures the specimen to the pin bar. The short arm then should be raised, and the pin bar, with the specimen attached, should be removed from the jig and mounted on the pin bar holder that is attached to the upper back panel of the test chamber. When in place, the pins of the pin bar should face the open side of the chamber (i.e., toward the operator).

C-2 Rationale for Weighing Procedure for Test Method 1 Specimens. The specification calls for weighing the specimens in the ambient atmosphere before conditioning to obtain the pretest weight and again in the ambient atmosphere after the flame exposure. The purpose of this procedure is to ensure that the specimens are as dry as possible at the time of the test. Any delay between removal from the conditioning oven and the initiation of the test due to the weighing process can allow some fabrics to regain a significant amount of moisture, which could improve their flammability performance.

This procedure also makes for a worst case situation for those fabrics that normally do contain a significant percentage of moisture under ambient conditions. For instance, wool may contain 15 percent moisture in laboratory ambient conditions. In the case of wool, the initial weight will include the 15 percent moisture, whereas the after-test weight will have a much lower percentage of moisture because the specimen would have been conditioned to very close to bone dry. However, the wool will begin to take up moisture immediately on removal from the conditioning oven. This can result in difficulty in obtaining a stable value for the after-test weight. Otherwise the wool would be penalized for its normal moisture regain. Other fabrics that may be affected significantly by the conditioning are the cellulosics (5 to 7 percent) and nylon (2 to 5 percent). The moisture regain of almost all other fabrics is generally not significant for this test.

C-3 History and Background.

C-3.1 In the past, curtain and drapery fabrics have been evaluated for their flammability characteristics primarily using the NFPA 701 test (1977 and 1989 editions), which has demonstrated a failure that is common to all similar tests that include a small-scale test using a mounting frame for the specimen. This failure occurs when thermoplastic products are tested. Thermoplastic tends to melt and pull away from the flame. Frequently, the thermoplastic melts and spills over and onto the frame, carrying some residual flame with it. When the test material and flame reach the frame, the frame acts as a wick and allows the material to continue burning for an extended time. Sometimes the flame self-extinguishes shortly after reaching the frame. At other times, the frame acts as a candle wick and allows the flame to continue to consume test material. In any event, thermoplastics frequently fail the afterflame criterion and sometimes the char length criterion as well because burning material clings to the support frame.

C-3.2 In the past, NFPA 701 did permit the operator to test such thermoplastic materials using the large-scale test, which does not involve any sort of frame. In most cases, thermoplastic materials that failed the small-scale test using a frame would pass the large-scale test. This caused a problem for the following reasons:

(1) More testing was needed for thermoplastic materials.

(2) Much more material was needed for the large-scale test.

(3) The large-scale test is much more expensive to perform.

Furthermore, some regulatory jurisdictions required that materials pass both tests.

C-3.3 During the 1980s, considerable effort was expended to modify the NFPA 701 tests and to arrive at pass/fail criteria for the small-scale test that would agree more closely with the results obtained with the large-scale test. During this time, a series of tests involving multilayer composites were performed at Southwest Research Institute (SwRI) by Belles and Beitel.

C-3.4 The tests by Belles and Beitel primarily involved combinations of materials, each of which passed the NFPA 701 small-scale test. The tests were performed on full-scale draperies hung close to a gypsum board wall that was set up to be free-standing in a very large test room. A gypsum board ceiling extended out over the draperies for a distance of about 1 m (3.28 ft). The ignition source was a 280-mm (11-in.) flame from a laboratory burner. To ensure the validity of the test, the ignition flame was allowed to burn for 5 minutes.

C-3.5 These tests demonstrated, in general, that draperies consisting of face and lining materials made from the same type of fiber were less likely to propagate flame extensively. Also, draperies consisting of face and lining fabrics made from dissimilar materials were very likely to propagate flame extensively and to be destroyed almost totally in less than 2 minutes. The only exception to these results was draperies consisting of face and lining materials made from cotton with nondurable, flame-resistant treatments. In these cases, the fabric tended to resist the flame for 2 to 3 minutes and then to ignite and burn intensely. Since NFPA 701 is intended to evaluate fabrics for relatively short exposures to the flame, such fabrics generally pass NFPA 701 tests.

C-3.6 In any event, these tests demonstrated a serious weakness in the NFPA 701 test, since the same combinations of fabrics that propagated the flames extensively in SwRI tests performed well in both the NFPA 701 large- and small-scale tests. This led the fiber and textile industry trade associations to work closely with NFPA, ASTM, and the Center for Fire Research at the National Institute for Science and Technology (NIST) to implement a program to develop a new test that would evaluate both single-layer fabrics and multilayer composites, such as draperies, for flame resistance in a small-scale test that adequately predicts the results obtained at SwRI.

C-3.7 The first phase of work at NIST confirmed the results of the SwRI tests and also showed that existing small-scale tests did not predict the SwRI results.

C-3.8 The second phase resulted in Test Method 1. Subsequent to the work at NIST, there has been some refinement of the test method as well as much verification testing. Test Method 1, as presented here, does not reproduce the SwRI results precisely, since combinations that burned nearly completely (at least 95 percent destruction) in the SwRI tests showed an approximate weight loss of only 80 percent in this test. Nevertheless, the "good" performers at SwRI showed a weight loss of less than 40 percent in this test, and the "bad" performers at SwRI showed a weight loss of greater than 40 percent. The one exception is vinyl-coated fabric blackout linings, which behave in a very inconsistent manner. Consequently, these linings and lined draperies containing such materials should be tested using Test Method 2, the large-scale test.

C-3.9 During the development of Test Method 1, another test method was tried and eventually abandoned because of the cost of the apparatus and potential operator safety problems. This alternative test method was based on an analysis of the differences between the room-scale test and the NFPA 701 test. It was observed in the room-scale tests that flames usually propagated more rapidly on the portion of the specimen that faced the wall. This finding suggested that the radiant energy reflected back to the specimen by the wall was critical. To simulate this situation in a test cabinet such as the one used in the NFPA 701 test, it seemed appropriate to heat the back wall of the cabinet so that it would radiate heat to the back surface of the specimen.

Consequently, a cabinet was equipped with electrical strip heaters mounted on a 1-cm (0.39-in.) aluminum plate that, in turn, was attached to the back of the cabinet. The remainder of the test was identical to ASTM D 3659, *Standard Test Method for Flammability of Apparel Fabrics by Semi-Restraint Method.* Back surface temperatures in excess of 240°C (460°F) were needed to duplicate the SwRI results. The quoted cost of a test chamber modified for ASTM D 3659 is $3000. The additional modification for heating the back wall surface was estimated at an additional $3000, for a total cost for the test chamber of approximately $6000. This cost would prevent many laboratories from participating in the interlaboratory testing required to validate the test. For this reason, as well as the possibility of operators sustaining burns when placing and removing specimens, this alternative method was abandoned.

C-3.10 The present test method eliminates the need for heating the back surface by placing the specimen very close to the back surface. This placement tends to form a chimney that funnels the heat between the wall and the specimen. This arrangement permits the back wall to be heated, which, in turn, reradiates some of the heat onto the back surface of the specimen.

Appendix D Textile Considerations

This appendix is not a part of the requirements of this NFPA document but is included for informational purposes only.

D-1 General Considerations.

D-1.1 Although it is not possible to make combustible textiles and films completely resistant to charring and decomposition when exposed to flame or high temperature, a degree of flame resistance can be achieved. Most natural and synthetic fiber textiles can be treated chemically to increase their flame resistance. Such treatments might be fugitive and, hence, not durable to laundering, dry cleaning, or water leaching, whereas other treatments are very durable and can withstand many cycles of laundering, dry cleaning, or water leaching. Furthermore, some synthetic fibers are made from polymers that contain flame retardants in their basic structure. Both approaches could be necessary to impart flame resistance to materials in which different types of fibers are blended. It should be noted, however, that combinations of flame-resistant (FR) fibers with relatively small percentages of non-flame-resistant fibers can interfere with the flame-resistant effect of the FR fibers.

D-1.2 The hazards introduced by combustible textiles might, of course, be avoided entirely where the use of noncombustible fibers such as glass is practical.

D-1.3 Many flame-resistant synthetic materials soften and melt when exposed to heat and fire. They also can be subject to twisting, shrinking, dripping, and elongation when subjected to fire conditions.

D-2 Applications of Flame-Resistant Fabrics.

D-2.1 Standards for theater scenery, curtains, and furnishings in high-risk or assembly occupancies are commonly set by law.

Flame-resistant fabrics are used in hotels, hospitals, and similar occupancies in the interest of the preservation of lives and property from fire.

D-2.2 Flame-resistant fabrics also are used for work clothing in industries where exposure to heat, open flames, and flash fire is a possibility.

D-2.3 Fabrics treated for flame and weather resistance are used for tents, tarpaulins, and other outdoor protective covering.

D-2.4 Reinforced plastic films with flame-resistant qualities are used in membrane structures.

D-2.5 Transparent plastic films often are used as temporary enclosures for greenhouses and for construction work.

D-3 Flame-Retardant Treatments.

D-3.1 An increasing range of flame-retardant treatments for natural and synthetic materials is becoming available. The selection of a particular treatment is governed by the intended use of the treated fabric.

D-3.2 Topical treatments based on water-soluble chemicals are generally the least expensive and most easily applied; however, they are subject to removal by the leaching action of water in laundering, scrubbing, or exposure to weather.

D-3.3 Some treatments can be impaired by the action of the solvents used in dry cleaning, and some gradually can lose their effectiveness under conditions of storage and usage not involving leaching.

D-3.4 Relatively temporary treatments are suitable only where proper treatment renewal can be ensured or for decorations and other items that are used briefly and then discarded.

D-3.5 Situations where retreatment is uncertain or not feasible indicate the choice of one of the durable treatments that is suitable for clothing and decorative fabrics. A number of these treatments can withstand extensive laundering and dry cleaning, although they are higher in cost and should be applied professionally.

D-3.6 For outdoor use, treatments have been developed that can be expected to remain effective for the useful life of the fabric under normal conditions of weather exposure.

D-3.7 It should be noted that painting or coating a treated or flame-resistant fabric or film could impair its flame resistant qualities unless the coating itself is flame resistant.

D-4 Physical Properties of Treated Fabrics.

D-4.1 A number of factors that vary in importance depending on the end use of the fabric should be considered in selecting a flame-retardant treatment.

D-4.2 The effect on the appearance, texture, and flexibility of the fabric often is of primary concern.

Appendix E Referenced Publications

E-1 The following documents or portions thereof are referenced within Appendix C for informational purposes only and are thus not considered part of the requirements of this standard unless also listed in Chapter 16. The edition indicated here for each reference is the current edition as of the date of the NFPA issuance of this standard.

E-1.1 ASTM Publication. American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM D 3659, *Standard Test Method for Flammability of Apparel Fabrics by Semi-Restraint Method*, 1993.

Appendix F Bibliography

This appendix is not a part of the requirements of this NFPA document but is included for informational proposes only.

Arnold, G., A. Fisher, and G. Frohnsdorff, "Gillette Research Institute Final Report" (March 26, 1973). Abstracted in the *Proceedings of the 1974 International Symposium on Flammability and Fire Retardants* (Editor: V. M. Bhatnagar). Lancaster, PA: Technomic Publishing Company.

Belles, D. W., and J. J. Beitel. "Do Multi-Layer Draperies Pass the Single-Layer Fire Test?" *Fire Journal*, September–October 1988, 82, No. 5, 25–30, 90–91.

Davis, S., and K. M. Villa. "Development of a Multi-Layer Test Procedure for Inclusion in NFPA 701: Initial Experiments." NISTIR 89–4238.

Krasny, J. F., and A. L. Fisher. "Laboratory Modeling of Garment Fires." *Textile Research Journal*, 1973, 43, 272–283.

McCullough, E. A., and C. J. Noel, "Flammability Characteristics of Layered Fabric Assemblies." *Proceedings of the 12th Annual Meeting, Information Council on Fabric Flammability*, 1978, 175–184.