NFPA

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FIRE TESTS

FLAME-RESISTANT TEXTILES, FILMS 1977

NATIONAL FIRE PROTECTION ASSOCIATION

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STANDARD METHODS OF FIRE TESTS FOR FLAME-RESISTANT TEXTILES AND FILMS

NFPA 701 — 1977

1977 Edition of NFPA 701

This 1977 edition supersedes the 1976 edition of the Standard and differs from that edition due to the amendments which were adopted by the National Fire Protection Association at its Fall Meeting on November 15, 1977.

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 were amended in 1939, 1940, 1941 and 1951. This standard is now under the jurisdiction of the NFPA 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.

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Table of Contents

Standard Methods of Fire Tests for Flame-Resistant Textiles and Films

NFPA 701 — 1977

Introduction

0-1 General Considerations.

0-1.1 While it is not possible to make combustible textiles and films completely resistive to charring and decomposition when exposed to flame or high temperature, a degree of flame resistance can be achieved. Natural fiber textiles can be treated chemically to reduce their flammability and tendency toward smoldering and synthetic fibers and plastic films can be formulated to be flame resistant, the flame-retardant chemicals being incorporated into the resin formulation. Both approaches may be necessary to impart flame resistance to materials in which natural and synthetic fibers are blended. It should be noted, however, that combinations of the noncombustible fibers with a relatively small percentage of combustible fiber will cancel the noncombustible effect.

0-1.2 The hazards introduced by combustible textiles may, of course, be avoided entirely where the use of such noncombustible fibers as glass and asbestos is practical.

0-2 Applications of Flame-Resistant Fabrics.

0-2.1 Standards for theatre scenery, curtains, and furnishings in places of public assembly are commonly set by law.

0-2.2 Flame-resistant fabrics are used in hotels, hospitals, and similar occupancies in the interest of the preservation of lives and property from fire.

0-2.3 Flame-resistant fabrics are also used as work clothing in industries where exposure to heat, open flames, and flash fire is a possibility.

0-2.4 Fabrics treated for flame and weather resistance are used for tents, awnings, tarpaulins, and other outdoor protective covering.

0-2.5 Flame-resistant synthetic materials, in the form of woven fabrics and plastic films, are used decoratively and for protective coverings. Many of these materials will soften and melt when exposed to heat and fire. They may also be subject to twisting, shrinking, dripping, and elongation when subjected to fire conditions.

0-2.6 Reinforced plastic films with flame-resistant qualities are used in air-supported structures.

0-2.7 Transparent plastic films are often used as a temporary enclosure for greenhouses and for construction work.

0-3 Flame-Resistant Treatments.

0-3.1 An increasing range of flame-resistant treatments for natural fiber materials is becoming available. The selection of a particular treatment is governed by the intended use of the treated fabric.

0-3.2 Treatments based on water-soluble chemicals are generally the least expensive and most easily applied, but they are subject to removal by the leaching action of water in laundering, scrubbing, or exposure to weather.

0-3.3 Some treatments may be impaired by the action of the solvents used in dry cleaning and some may gradually lose their effectiveness under conditions of storage and use not involving leaching.

0-3.4 Relatively temporary treatments are suitable only where proper retreatment and renewal can be assured or for decorations and other items which are used briefly, then discarded.

0-3.5 Situations where retreatment is uncertain or not feasible indicate the choice of one of the most durable treatments which are suitable for clothing and decorative fabrics. A number of these will withstand extensive laundering and dry cleaning, although they are higher in cost than the water-soluble type and require professional application.

0-3.6 For outdoor use, treatments have been developed which may be expected to remain effective for the useful life of the fabric under normal conditions of weather exposure.

0-3.7 It should be noted that painting or coating a treated or noncombustible fabric may impair its flame-resistant qualities unless the coating is itself flame-resistant.

0-4 Physical Properties of Treated Fabrics.

0-4.1 A number of factors, which will vary in importance depending on the end use of the fabric, should be considered in selecting a flame-resistant treatment.

0-4.1.1 The effect on the appearance, texture, and flexibility of the fabric is often of primary concern.

0-4.1.2 Some treatments may leave a fabric objectionably stiff, or it may become tacky at high atmospheric temperatures or brittle at low temperatures.

0-4.1.3 Some flame-retardant chemicals are so hygroscopic as to dampen the fabric; others may effloresce to the extent of reduced effectiveness as well as unsightly appearance.

0-4.1.4 Treatment may result in a reduction in strength of the fabric. Also, some flame-retardant chemicals may tend to deteriorate wood or corrode metal with which the treated fabric comes in contact.

0-4.2 In all instances, the possibility of adverse physiological reactions in persons handling or otherwise exposed to the treated fabric must be considered by the manufacturer.

Standard Methods of Fire Tests for Flame-Resistant Textiles and Films

NFPA 701 — 1977

Chapter 1 General

1-1 Scope.

1-1.1 These requirements apply to flame-resistant materials which are used extensively in the interior furnishings of buildings and transport facilities, in protective clothing for certain occupations and situations, and for protective outdoor coverings such as tarpaulins and tents. The flame-resistant requirements are not dependent on the type of treatment, except that where durability to laundering or weathering is claimed, the fabric is tested for flame resistance after being subjected to the applicable cleaning or exposure procedures.

1-1.2 These requirements also apply to plastic films, with or without reinforcing or backing, when used for decorative or other purposes inside buildings or as temporary or permanent enclosure for places of public assembly and buildings under construction.

1-1.3 If these materials are to be applied to surfaces of building or backing materials as interior finishes for use in buildings, the test shall be conducted and the material classified in accordance with *Method of Test of Surface Burning Characteristics of Building Materials, NFPA 255.*

1-2 Purpose.

1-2.1 It is the intent of these requirements to provide tests to determine whether the flame-resistant textiles and films are comparatively difficult to ignite and whether it is comparatively difficult to propagate flame beyond the area exposed to the source of ignition.

1-2.2 These performance tests do not necessarily indicate whether the material tested will resist the propagation of flame under severe fire exposure or when used in a manner which differs substantially from the test requirements.

1-3 General Description.

1-3.1 Two methods of assessing flame resistance are described. Both methods will provide a comparison among textiles and films

but do not necessarily indicate the behavior of a material in a large building fire or other conflagration.

1-3.1.1 The small scale test employs a relatively small sample and small igniting flame. It is simple and convenient for general use. The small scale test is commonly used to indicate susceptibility to flame spread from small ignition sources; but may also be used as a screening test prior to large scale testing.

1-3.1.2 The large scale test requires a much larger sample and applies a more severe fire exposure which will more nearly approach severe fire conditions. Initial screening may be done with the small scale test. This method is also useful for investigating the flammability of fabrics when hung in folds.

1-4 Test Selection.

1-4.1 All flame-resistant textiles and films shall be capable of complying with the performance requirements of either the small or the large scale tests or both. The authority having jurisdiction shall determine whether both the small and the large scale tests are required and this will generally depend on the purpose to be served or the nature of the materials tested.

1-4.2 For those materials which show excessive melting or shrinkage by the small scale test, then the large scale test shall be considered applicable.

1-4.3 Textiles which are expected to retain their flame resistance through dry cleaning, laundering, water leaching, or weathering exposures shall be subjected to the applicable procedures of Chapter 4 before being tested by either the small scale or the large scale flame test.

Chapter 2 Test Apparatus and Materials

2-1 Pre-Conditioning Oven.

2-1.1 A forced draft oven shall be used to properly condition test specimens prior to testing in either the small scale test or the large scale test.

2-1.1.1 The interior of the oven shall be large enough to provide free air flow around each specimen contained.

2-1.1.2 The oven shall have variable temperature control.

2-2 Small Scale Test Apparatus.

2-2.1 Specimen Holder.

2-2.1.1 A metal holder, having clamps arranged to grip the specimen along its edges only, shall be used to support the specimen. The ends of the specimen shall remain free.

2-2.2 Test Shield.

2-2.2.1 The specimen and its holder shall be supported in the vertical position within a metal shield having a depth of 12 inches, a width of 12 inches and a height of 30 inches.

(a) The shield shall be open at the top and shall be provided with baffled vent openings along the bottom of at least two sides, totaling 6 square inches of free vent area.

(b) The shield shall also have a glass door or panel.

2-2.3 Gas Burner.

2-2.3.1 A Bunsen or Tirrell gas burner, approximately 6 inches high and ⅜-inch tube diameter, shall be used as an ignition source.

(a) The burner shall be supported so that its barrel will be at a 25 degree angle with vertical.

(b) The burner shall have means for being moved into test position after the shield has been closed.[1]

(c) The gas supply to the burner shall be natural gas or a mixture of natural and manufactured gases having a heat value of approximately 800–1000 BTU per cubic foot.

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[1]A rod attached to the base of the burner and extending through a slot at the bottom of the shield will serve the purpose.

2-2.4 Hook and Weight.

2-2.4.1 A hook and weight assembly shall be used to determine the length of char or destruction of the specimen.

(a) The combined weight of the assembly shall follow Table 2-2.4.

Table 2-2.4
Tearing Weights — Small Scale Test

Weight of Treated Fabric Being Tested	Total Tearing Weight for Determination of Length of Char
Ounces per Square Yard	**Pounds**
2 to 6 inclusive	0.25
Over 6 and not exceeding 15	0.5
Over 15 and not exceeding 23	0.75
Over 23	1.00

2-3 Large Scale Test Apparatus.

2-3.1 Test Enclosure.

2-3.1.1 The test shall be carried out in a sheet-iron stack 12 inches square and 7 feet high.

(a) The stack shall be supported 1 foot above the floor by legs and shall be open at the top and bottom.

(b) The stack shall also be fitted with a wired-glass observation window extending the full length of the front.

(c) The stack shall have means for hanging the specimen.

2-3.2 Restraining Clamps.

2-3.2.1 Test specimens shall be lightly restrained laterally in the stack by suitable clamps and guide wires attached to the outer edges of the specimen.

Exception: Folded specimens may not require clamps.

2-3.3 Gas Burner.

2-3.3.1 A Bunsen burner having ⅜-inch tube diameter and means for measuring the gas pressure shall be used for the ignition source.

(a) The burner shall be fixed in a position so that the barrel is at a 25 degree angle with the vertical.

(b) The gas supply to the burner shall be natural gas or a mixture of natural and manufactured gases having a heat value of 800 to 1000 BTU per cubic foot.

(c) The burner tube shall be fully adjustable so as to vary flame height and pattern.

2-4 Test Specimens.

2-4.1 Small Scale Test.

2-4.1.1 Five specimens of the material, 2¾ by 10 inches, shall be cut with their long dimension in the direction of the warp and five in the direction of the filling.

2-4.1.2 Each lot of five shall be cut from at least four places in the sample separated sufficiently to give indication as to the uniformity of the flame-resistant treatment.

2-4.2 Large Scale Test.

2-4.2.1 The test specimens shall be taken from as widely separated and symmetrically located sections as possible over the entire area of the sample of each fabric. One-half of the specimens of each kind shall be cut with the long dimension in the direction of the warp, and the balance of the specimens shall be cut with the long dimension in the direction of the fill.

2-4.2.2 For conducting flame tests of fabrics in single sheets, at least 10 specimens, 5 inches by 7 feet, shall be used.

2-4.2.3 For conducting flame tests of fabrics hung in folds, at least 4 specimens, 25 inches by 7 feet, shall be cut. Each specimen shall be folded longitudinally to form four folds, each approximately 5 inches wide, uniformly over the length (spacing about ½ inch).

Chapter 3 Flame Test Procedures

3-1 Small Scale Test.

3-1.1 Preconditioning of Test Specimens.

3-1.1.1 The test specimens shall be conditioned in an oven at temperatures of 140–145 degrees Fahrenheit, for durations of one to one and one-half hours prior to testing.

3-1.1.2 Materials which distort or melt at the above indicated oven exposure are to be conditioned at 60–80 degrees Fahrenheit and 25–50 percent relative humidity for not less than 24 hours.

3-1.1.3 Specimens shall be removed from the oven one at a time and immediately subjected to the procedures described in Sections 3-1.2 and 3-1.3.

3-1.2 Mounting of Test Specimens.

3-1.2.1 The specimen shall be placed on the specimen holder and clamped so that a strip 2 inches wide and 10 inches long is left exposed.

3-1.2.2 The specimen and its holder shall be supported within the test shield so that its lower end will be ¾ inch above the top of the gas burner.

3-1.3 Conducting the Flame Test.

3-1.3.1 The gas burner shall be ignited and, with the air supply completely shut off, shall be adjusted to give a luminous flame about 1½ inches long.

3-1.3.2 The burner shall be moved under the specimen so that the flame is applied vertically to the lower end of the specimen, near the middle of its width. The flame shall be applied for 12 seconds, then withdrawn.

3-1.3.3 The duration of flaming of the specimen shall be noted after withdrawal of the burner.

3-1.4 Measurement of Length of Char or Material Destruction.

3-1.4.1 After all flaming and afterglow on the specimen has ceased, the length of char or material destruction shall be determined immediately. The length of char in this test is defined as the distance from the end of the specimen which was exposed to

the flame to the end of a tear made lengthwise of the specimen through the center of the charred area in the following manner:

(a) The specimen shall be folded lengthwise and creased by hand along a line through the highest point in the charred area.

(b) The hook of the hook/weight assembly is inserted in the specimen, on one side of the charred area, ¼ inch in from the adjacent outside edge and ¼ inch up from the bottom.

(c) The specimen is then grasped on the opposite side of the charred area with the fingers, and raised gently until it supports the weight. The specimen will tear through the charred area until fabric strong enough to carry the load is reached.

3-1.4.2 When it is not feasible to measure char, the material destruction can normally be judged as the measurement from the bottom of the sample to a horizontal line above which all material is sound and in original condition.

3-2 Large Scale Test.

3-2.1 Preconditioning of Test Specimens.

3-2.1.1 The test specimens shall be conditioned in an oven, at temperatures of 140–145 degrees Fahrenheit for durations of not less than one hour nor more than one and one-half hours before testing.

3-2.1.2 Materials which distort or melt at the above indicated oven exposure shall be conditioned at 60–80 degrees Fahrenheit and 25-50 percent relative humidity for not less than 24 hours.

3-2.1.3 Specimens shall be removed from the oven one at a time and immediately subjected to the procedures described in Sections 3-2.2 and 3-2.3.

3.2.2 Mounting of Test Specimens.

3-2.2.1 The single-sheet specimen shall be suspended vertically in the stack with its full width facing the observer so that the bottom of the specimen will be 4 inches above the top of the Bunsen burner.

3-2.2.2 For the folded specimen the conditions of test shall be the same as above except that it shall be suspended vertically with the edges of the folds facing the observer. The folds shall be spread apart about ½ inch by means of guide rods inserted at the top and bottom ends.

3-2.3 Conducting the Flame Test.

3-2.3.1 The gas burner shall be ignited and the gas pressure regulated at 4¼ inches (108mm) of water.

3-2.3.2 The burner shall be adjusted to produce an 11-inch oxidizing flame having an indistinct inner cone.

3-2.3.3 The flame shall be applied vertically near the middle of the width of the lower end of the specimen in a single sheet, or to the middle of the width of the lower end of the middle fold of the specimen in folds. The position of the specimen relative to the test flame shall be maintained by guide wires attached to the outer edges of the specimen. The test flame shall be applied to the specimen for two minutes, then withdrawn.

3-2.3.4 The duration of flaming combustion on the specimen shall be recorded after withdrawal of the burner.

3-2.4 Measurement of Length of Char.

3-2.4.1 After all flaming and afterglow on the specimen has ceased, the length of char shall be determined. For purposes of this test, the length of char is defined as the vertical distance on the specimen from the top of the test flame to the top of the charred area resulting from spread of flame and afterglow. For synthetic textiles and films the length of char is defined as the vertical distance from the tip of the test flame to a horizontal line, above which all material is sound and in essentially original condition.

Chapter 4 Cleaning and Weathering Procedures

4-1 General Considerations.

4-1.1 The probable durability of a treatment relative to the life of the fabric is difficult to assess but, in general, flame-retardant treatments tend to be either very tenacious or quite easily removed.

4-2 Application.

4-2.1 These procedures shall be applied to fabrics which are expected to retain their flame-resistant qualities through dry cleaning, laundering, weathering, or other exposures to water.

4-2.2 Each fabric shall be subjected to only those exposure procedures which are applicable to its intended use. It shall meet the flame resistance requirements of Chapter 5 after passing through the appropriate exposure cycles.

4-2.2.1 It is believed that such accelerated exposure tests as those described in this section provide sufficient testing to permit a reasonable appraisal of the durability of the treatment (under the conditions for which it was designed) for the useful life of the fabric.

4-3 Accelerated Dry Cleaning.

4-3.1 The treated fabric shall be dry cleaned in a Coin-op dry cleaning apparatus[1] as part of a 4-lb. (1.82-kg) load made up with dummy pieces of dry cleanable fabrics.

4-3.2 The Coin-op apparatus with perchlorethylene solvent (about 1 percent charge system) shall be run for the full cycle which includes tumble drying. At the end of each dry cleaning cycle, remove the load from the unit and separate the pieces.

4-3.3 The above dry cleaning is repeated until ten complete cycles of cleaning and drying have been realized.

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[1]Norge Coin-Op Dry Cleaning Model DML-5832 or equivalent meeting the following criteria:
Capacity: 10 lbs. (4.5 kg)
Drum diam: 26 in. (66 cm)
Drum depth: 16 in. (41 cm)
Number of fins: 4
Cleaning cycle rpm: 46
Spin cycle rpm: 162/325

4-3.4 Test specimens shall then be cut from the dry cleaned fabric for testing.

4-4 Accelerated Laundering.

4-4.1 A sample of the treated fabric shall be washed in an automatic commercial washing machine using a solution containing 0.15 percent solution of tallow soap and 0.20 to 0.25 percent alkali.

4-4.2 The operating cycle outlined in Table 4–4 shall be followed.

Table 4-4

Operating Cycle for Accelerated Laundering[1]

Operation	*Time, Min.*	*Temp. — Deg. F.*
1. Sudsing	6	130
2. Sudsing	6	160
3. Sudsing	6	160
4. Bleaching	8	150
5. Rinsing	2	160
6. Rinsing	2	160
7. Rinsing	2	160
8. Rinsing	2	130
9. Bluing	3	100
10. Scouring	3	100

[1]This cycle is intended for white fabrics. For colored fabrics, the bleaching and bluing operations are omitted and the temperature of the "Sudsing" and "Rinsing" operations is reduced 30 degrees F.

4-4.3 The sample shall then be dried in a drying tumbler at 250 degrees F.

4-4.4 The above procedure shall be repeated until ten complete cycles of washing and drying have been accomplished.

4-4.4.1 If the material is to be subjected to a special use, more laundering may be required.

4-4.5 Where instructions for laundering a fabric are supplied by the manufacturer or finisher, those instructions should be followed in preference to the above procedure which simulates a typical commercial laundering practice.

4-5 Accelerated Water Leaching.

4-5.1 A sample of the treated fabric shall be totally submerged in a vessel containing tap water at room temperature for a period of 72 hours. The vessel shall have a capacity of at least four gallons of water.

4-5.2 The water shall be drained from the tank and replenished at 24-hour intervals during the immersion period.

4-5.3 At the conclusion of the immersion period, the sample shall be removed from the test vessel and dried at room temperature.

4-6 Accelerated Weathering.

4-6.1 Either of the following alternative Accelerated Weathering Conditioning procedures shall be used.

4-6.2 Alternative Procedure No. 1.

4-6.2.1 Apparatus.

(a) The apparatus shall consist of a vertical metal cylinder fitted with a vertical carbon arc at its center and having a specimen holder mounted within.

(b) The diameter of the cylinder shall be such that the distance to the face of the specimen holder from the center of the carbon arc is $14\frac{3}{4}$ inches.

(c) The cylinder shall be arranged to rotate about the arc at a rate of approximately three revolutions per minute.

(d) A water spray shall be provided within the cylinder and fitted with means to regulate the amount of water discharged.

(e) The vertical carbon arc shall be either 0.5 inches diameter solid electrode type, if operating on direct current, or a single-cored electrode, if operating on alternating current. The electrodes shall be of uniform composition.

(f) The arc shall be surrounded by a clear globe of No. 9200 PX Pyrex glass, 0.0625 inches thick, or other enclosure having equivalent absorbing and transmitting properties.

4-6.2.2 Operation of the Test Equipment.

(a) The specimens for test shall be mounted on the inside of the cylinder facing the arc.

(b) The cylinder shall rotate at approximately three revolutions per minute for the duration of the test.

(c) The water spray shall discharge about 0.7 gallons per minute onto the specimens for about one minute during each revolution.

(d) The arc shall operate on 13 amperes direct current or 17 amperes, 60 hertz alternating current, with voltage at the arc of 140 volts.

(e) The electrodes shall be renewed at intervals sufficiently frequent to insure full operative conditions of the lamp.

(f) The globe shall be cleaned when the electrodes are removed or at least once in each 36 hours of operation.

4-6.2.3 Test Cycle.

(a) Specimens shall be subjected to this exposure for 360 hours.

(b) Specimens shall then be allowed to dry thoroughly at a temperature between 70 and 100 degrees Fahrenheit.

(c) After drying, the specimens shall proceed through the Flame Test.

4-6.3 Alternative Procedure No. 2.

4-6.3.1 Apparatus.

(a) The apparatus shall consist of a vertical carbon arc mounted at the center of a vertical cylinder.

(b) A rotating rack shall be mounted on the inside of the cylinder such that the distance from the face of the specimen to the center of the arc is 18¾ inches.

(c) The arc shall be designed to accommodate two pairs of carbon: No. 22 upper electrodes and No. 13 lower electrodes. However, the arc shall burn between only one pair of electrodes at a time.

(d) No filters or enclosures shall be used between the arcs and the specimens.

(e) Spray nozzles shall be mounted in the cylinder so that the specimens shall be exposed to wetting once during each revolution of the track.

4-6.3.2 Operation of Test Equipment.

(a) The specimens for test shall be mounted on the rotating rack, facing the arc.

(b) The rack shall rotate about the arc at a uniform speed of about one revolution in two hours.

(c) The arc shall operate on 60 amperes and 50 volts across the arc for alternating current or 50 amperes and 60 volts across the arc for direct current.

4-6.3.3 Test Cycle.

(a) Specimens shall be subjected to this exposure for 100 hours.

(b) They shall then be allowed to dry thoroughly at a temperature between 70 and 100 degrees Fahrenheit.

(c) After drying, the specimens shall proceed through the Flame Test.

Chapter 5 Flame Resistance Requirements

5-1 Small Scale Test.

5-1.1 When subjected to the small scale test described in Section 3-1 no specimen shall continue flaming for more than two seconds after the test flame is removed from contact with the specimen.

5-1.2 The vertical spread of flame and afterglow (smoldering combustion) on the material, as indicated by the length of char or the measurement from the bottom of the sample above which all material is sound and in original condition, shall not exceed the values shown in Table 5-1.

5-1.3 At no time during or after the application of the test flame shall portions or residues of textiles or films which break or drip from any test specimen continue to flame after they reach the floor of the tester.

5-1.4 There are some synthetic fabrics that are made of inherently flame retardant fibers or having flame retardant treatment that will not meet the requirements of the small scale test due to the restrictive nature of the specimen holder. When this occurs, the fabric should be evaluated by means of the large scale test.

Table 5-1

Permissible Length of Char or Destroyed Material — Small Scale Test

Weight of Treated Fabric Being Tested	Maximum Average Length of Char or Destroyed Material for Ten Specimens	Maximum Length of Char or Destroyed Material for Any Specimen
Ounces per Square Yard	Inches	Inches
Over 10	3½	4½
Over 6 and not exceeding 10	4½	5½
Not exceeding 6	5½	6½

5-2 Large Scale Test.

5-2.1 When subjected to the large scale test described in Section 3-2, no specimen, in single sheets or in folds, shall continue flaming for more than two seconds after the test flame is removed from contact with the specimen.

5-2.2 The vertical spread of burning on the material in single sheets shall not exceed 10 inches above the tip of the test flame. This vertical spread shall be measured as the distance from the tip of the test flame to a horizontal line above which all material is sound and in original condition, except for possible smoke deposits.

5-2.3 The vertical spread of burning on the folded specimens shall not exceed 35 inches above the tip of the test flame, but the afterglow may spread in the folds.

5-2.4 At no time during or after the application of the test flame shall any portions or residues of textiles or films which break or drip from the test specimen continue to flame after they reach the floor of the tester.

Chapter 6 Field Test: Match Flame Test[1]

6-1 Test Materials.

6-1.1 Test specimens shall be dry and shall be a minimum 1½ inches wide by 4 inches long.

6-1.2 The fire exposure shall be the flame from a common wood kitchen match (approximate length – 2 7/16 inches; approximate weight – 29 grams per hundred), which is reasonably equivalent to that of a standard small-scale test described in Section 3-3, applied for 12 seconds.

6-2 Test Method.

6-2.1 The test shall be performed in a draft-free and safe location.

6-2.2 The sample shall be suspended (preferably held with a spring clip, tongs or some similar device) with the long axis vertical, with the flame applied to the center of the bottom edge, and the bottom edge ½ inch above the bottom of the flame.

6-2.3 After 12 seconds of exposure, the match is to be removed gently away from the sample.

6-3 Test Requirements.

6-3.1 During the exposure, flaming shall not spread over the complete length of the sample or in excess of 4 inches from the bottom of the sample (for larger size samples).

6-3.2 There shall be not more than two seconds of afterflame.

6-3.3 Materials which break and drip flaming particles shall be rejected if the materials continue to burn after they reach the floor.

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[1]For discussion of limitations and interpretations of results of this field test, see Appendix A.

Appendix A Field Test

This Appendix is not a part of this NFPA Standard but is included for information purposes only.

A-1 General.

A-1-1 Field tests for flame resistance — what are they or what should they be, what do they mean, how dependable are they? These are complex and controversial questions, and the answers can vary considerably depending upon many factors and circumstances. If field tests are to be used as part of a regulatory program, it is vitally important that their function and validity be understood.

A-1-2 With rare exceptions, small-scale field tests leave something to be desired, and cannot be as good or as reliable as formal laboratory tests. Therefore, it is strongly recommended that, whenever possible, tests should be performed strictly in accordance with the requirements of Section 3-1 for the laboratory test. The greatest deficiency in field tests is that in most instances the size and number of samples which can be taken for test are very limited. In the context of this field test, the test flame can be subject to much variation, and a completely draft-free location for testing is seldom available.

A-2 Applications/Specific Limitations.

A-2-1 Field testing is most useful and meaningful for confirmatory purposes, as just one part of a regulatory program which gives the authority having jurisdiction control over the installation of fabrics and other decorative materials. In other words, a field test should be primarily to verify that a material is probably what it has been represented to be. The field test has much less value when the authority having jurisdiction has no supplementary information about what is being tested and therefore is forced to rely solely on the field test findings.

A-2-2 There are only two types of decorative materials for which field tests can be deemed to provide foolproof and totally adequate results: those made entirely of noncombustible inorganic material, and those which ignite and burn readily on exposure to a small flame. For example, with only a little experience an inspector will have no difficulty in identifying an all-glass fabric by means of a very small-scale field test, and nothing more is necessary. The only effect of a small fire exposure on a glass fabric is to burn off the surface coloring, if any, leaving the threads themselves virtually undamaged. This result is not obtained with any other type of decorative fabric and it is readily recognized. At the other extreme, if a material ignites and burns readily with a very small scale test,

showing no semblance of flame resistance, again, nothing more is necessary since the material obviously is not acceptable.

A-2-3 Between these two extremes, field tests have a limited and a varying degree of reliability. In this large group, comprising the great majority of materials the inspector is likely to encounter in the field, the most reliable results will be obtained in the testing of cellulose-based materials (cotton, rayon, and paper) flame-retardant treated with the common inorganic salt formulations such as those listed in Appendix B-4. These materials retain their shape reasonably during testing, and the results are not greatly affected by differences in sample size or severity of fire exposure. On the other hand, the least reliable results are obtained with chemically treated fabrics of synthetic fibers, or flexible plastic films and laminates. These materials are subject to a variety of physical changes when exposed to fire, such as shrinking, curling, melting, elongating and similar distortions, making the testing of small samples quite difficult and the results ambiguous. Furthermore, some of these thermo-plastic materials are apt to appear flame resistant with small flame exposures, but ignite and burn fiercely with larger and longer exposures.

A-3 Number of Samples.

A-3-1 Probably the most difficult and controversial question relates to the minimum number of samples which should be tested. The answer must be dictated by a number of factors, and certainly a good general rule would be the more samples, the better; but, in all cases, the inspector must be governed by exercising good judgment. The variety of circumstances which can be encountered is perhaps best illustrated by some specific examples:

(a) A dance in a school gymnasium, student-decorated with a profusion of paper banners, crepe paper streamers, figures made of pieces of tissue paper stuffed in chicken wire molds, hay and straw, painted fabrics, dry palm fronds and you-name-it, all supposed to be flame resistant: In this situation, the inspector has neither reason nor excuse to be inhibited in his taking of samples for tests. The materials are inexpensive, more than likely are not intended to be reused, and the taking of samples for tests will cause little if any damage to the decorative effect.

(b) A large assembly tent made of supposedly treated canvas but with no identifying marks and no confirming evidence of such treatment: The life hazard is acute, tent canvas can readily be patched, and therefore, the situation calls for nothing less than the taking of sufficient samples from all sections of canvas for the inspector to be satisfied that the quality and uniformity of the treatment are acceptable.

(c) A nightclub with very expensive draperies known to be adequately flame-retardant treated when installed two years ago: Is the quality of flame resistance still acceptable? The only way to be sure is to take a sample, but this is where, in the interest of maintaining good public relations, the inspector must be very diplomatic and very persuasive. Almost always, a place can be found where a small sample, hopefully large enough, can be extracted without causing any readily visible damage, and often this is all the inspector can hope to get.

A-4 Other Technical Complications.

A-4-1 There can be other complications of a technical nature. Decorative fabrics sometimes are installed overhead, in or near a horizontal position. Some plastic films or fabrics woven of thermoplastic synthetic fibers will successfully resist continued burning in the normal vertical position of test, but will exhibit continued burning if exposed in a horizontal position. It seems reasonable to assume that fabrics installed horizontally overhead are a more serious potential threat to fire safety than in the case of vertical hangings, and, therefore, the inspector is justified in taking stricter measures, including testing of such fabrics in a horizontal position.

A-4-2 A somewhat similar problem can exist with some of the new and increasingly popular decorative fabrics with one or more types of fibers in the threads along the length (warp) and different fibers in the threads along the widths (fill). This can result in a different burning behavior in the two directions of the fabric, to the extent that where a flame-retardant treatment has been applied, tests for flame resistance in one direction may be acceptable, but the fabric could show continued burning in the other direction. Where visual examination of the fabric indicates this condition might exist, the inspector should test samples cut with the long dimension paralleling both the length and width of the fabric.

A-5 Experience of Inspector/Accuracy of Method.

A-5-1 By far the greatest benefit can be derived from field tests when the inspector has had the opportunity to practice and experiment on a variety of decorative materials, and particularly make comparisons between the results of more formal laboratory tests and the less precise field tests. Here, too, experience is the best teacher, and it is strongly recommended that inspectors who may be involved in this activity familiarize themselves with a wide variety of treated and inherently flame-resistant fabrics of many types, and their typical behavior under a variety of test conditions. With this background, the inspector is much more capable of properly interpreting field tests results.

A-5-2 The deficiencies and limitations of field tests can lead to misleading or erroneous results, and the error can be in both directions. It is quite possible to have a too-small sample show several seconds of afterflaming and the material be rejected, when full-scale tests would show it to conform. This, of course, is unfair to the owner, but at least the error is in the direction of safety. Unfortunately, it is equally possible for improper or inadequate field testing to indicate satisfactory flame resistance, whereas formal testing would show an unacceptable degree of flame resistance. Obviously, this can be a dangerous error.

A-6 Summary.

A-6-1 Field testing certainly is better than nothing, but it must be used with good judgment and its limitations recognized.

A-6-2 Field testing must not be relied upon as the sole means for insuring adequate flame resistance of decorative materials but is useful to augment a comprehensive regulatory program.

Appendix B Flame-Resistance Treatments

This Appendix is not a part of this NFPA Standard but is included for information purposes only.

B-1 General.

B-1-1 Hundreds of different chemicals have been used or tested for flame-retarding fabrics. Many proved reasonably effective flame retardants, but only a few are in general use. Many chemicals are not suitable because of objectionable characteristics such as moisture absorption, change in color or deterioration of the fabric, deterioration under high-temperature drying or pressing, corrosion of metal in contact with the fabric, toxicity, requiring an excessively heavy weighting of the fabric to be effective, requiring difficult techniques in application, or being unduly expensive.

B-1-2 Mixtures of two or more chemicals are usually more effective than the same chemicals used alone. Figure B-1 shows that borax and boric acid together are far more effective than the same weight of either chemical alone.

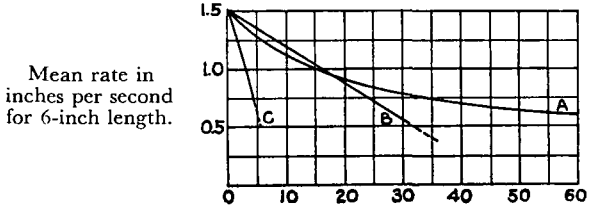

Fig. B-1 Rate of Flame Propagation

(Source: Second Report of Fabrics Coordinating Research Committee. London: H.M. Stationery Office. Department of Scientific and Industrial Research publication. 1930.)

B-1-3 There are many proprietary flame-retardant preparations which vary greatly in effectiveness, cost, and other factors, such as tendency to absorb moisture. The purchaser should consult responsible testing authorities prior to purchase and use.

B-1-4 Many concerns specialize in the effective flame-resistance treatment of theater scenery, draperies, and other fabrics, using standard flame-retardant chemicals. It is advisable to deal only with concerns of known reliability, or, if dealing with an unknown concern, to have treated fabrics tested for adequacy of treatment.

B-1-5 Most of the treatments used are not resistive to water since the chemicals are water-soluble. A few have been developed that resist leaching action from exposure to weather, laundering, or dry cleaning.

B-1-6 Most of the treatments in use cause very little reduction in the strength of the fabric, but, when subjected to higher than normal temperature and sunlight, some of the treatments cause decided loss in strength.

B-1-7 It is often important that change in color and texture shall not be caused by the flame-resistant treatment of fabrics. There are a number of treatments that will meet this requirement.

B-1-8 Few of the treatments used contain chemicals that would cause poisoning or injury from handling of the treated fabric.

B-1-9 Fabrics made of natural fibers (cotton, flax, hemp, silk, wool) and rayon, which is cellulose based, are generally easy to treat. Simple formulations of chemicals dissolved in water, such as those listed in B-3-2 are usually effective. However, these chemicals are not applicable to fabrics made from synthetic (man-made) fibers. The latter generally require commercial treatments specific to the fibers in question.

B-2 Methods of Application.

B-2-1 Water soluble flame-retardant chemicals may be applied by immersion of the fabric in a solution, by spraying, or by brushing. The objective is to deposit in the fabric the desired amount of the flame-retardant chemicals, measured in terms of percentage increase in weight obtained. The particular method of application and the proportion of water used in the solution are unimportant. Good results may be obtained by dipping, spraying or brushing; the method selected is dictated by convenience and the character of the fabric to be treated.

B-2-2 Effective flame-resistant treatments may be obtained by the use of nonproprietary solutions of flame-retardant chemicals in water, without professional assistance, after some experience and testing of the results. The chemicals should be dissolved in clean water. Warm water and stirring will dissolve chemicals more quickly.

B-2-3 It is desirable to wash new fabrics containing sizing prior to treatment so as to secure proper absorption of flame-retardant chemicals. Commercial wetting agents may be added to the treating solution to increase penetration of flame-retardant ingredients.

B-2-4 When a piece of fabric is immersed, usually at room temperature, in a flame-retardant solution, the container must be large enough so that all the fabric is thoroughly wet and there are no folds which the solution does not penetrate, e.g., if too small tubs or tanks were used.

B-2-5 Care must be used in the wringing of the immersed material. If a mechanical wringer is used, more of the solution is likely to be extracted and a more concentrated solution may be necessary to obtain the desired weighting.

B-2-6 Best results will be obtained if the articles can be dried in a horizontal position. Drying in a vertical position permits a certain amount of drainage of the solution, depending upon the wetness of the wrung articles. It is advisable to increase the weighting if horizontal drying is not feasible.

B-2-7 Where solutions are applied by brushing or spraying, some skill is required for uniform application; repeated application may be necessary to secure the desired weighting.

B-3 Formulas for Flame-Resistant Treatments.

B-3-1 General.

B-3-1.1 The nonproprietary flame-resistant formulations described in the following subsections are applied mainly to fabrics used for decorative or other purposes inside buildings. They are intended to provide protection against small sources of ignition, such as matches, cigarette lighters, sparks, small coals, and smoldering cigars and cigarettes, and do not necessarily protect a fabric against flaming combustion under severe fire exposure, or when hung in folds or parallel strips. Renewal of the treatment is required after a certain time, and after every laundering, dry cleaning, or exposure to weather where the flame-retardant chemicals are subject to leaching by water.

B-3-1.2 Where flame resistance is required by law, it is common practice to require renewal of treatments at least annually.

B-3-1.3 Formulas are stated in terms of parts by weight. Also, where water is the solvent, avoirdupois weight of chemicals and volume of water, in U. S. gallons, are also stated.

B-3-2 Specific Formulas. (*Not suitable for many synthetic fibers, see B-1-9.*)

B-3-2.1

Formula No. 1:

Borax, $Na_2B_4O_7 \cdot 10H_2O$	6 parts	6 pounds
Boric acid, H_3BO_3	5 parts	5 pounds
Water	100 parts	12 gallons

The fabric is steeped in a cool solution until thoroughly impregnated, then dried. Heavy applications by spray or brush are usually reasonably effective. Such applications may have to be repeated two or three times with drying between applications to obtain the desired degree of flame-resistance. The treatment has been used for many kinds of fabrics, including theater scenery. It is recommended for rayon. As in the case of most of the other formulas listed, care must be taken in ironing the fabric to avoid discoloration by heat.

The treatment is effective in weighting from 8 to 12 per cent, depending upon the type of fabric. Hand-wringing the above solution from a fabric leaves a weighting of 10 to 12 per cent after drying.

B-3-2.2

Formula No. 2:

Borax, $Na_2B_4O_7 \cdot 10H_2O$	7 parts	7 pounds
Boric acid, H_3BO_3	3 parts	3 pounds
Water	100 parts	12 gallons

The amount of water may be varied, and should depend upon the absorptive capacity of the fabric to be treated. For rayon and sheer fabrics, the same quantities of borax and boric acid may be used in 17 gallons of water. Loadings from 8 to 10 per cent of the weight of the dry cloth usually will be found effective. Hand-wringing the above solution from a fabric will give approximately these weightings. Fabrics so treated retain their flexibility and softness. They do not become dusty, feel damp, or lose their strength under ordinary conditions of use. The chemicals are nonpoisonous and do not promote the growth of destructive micro-organisms.

B-3-2.3

Formula No. 3:

Borax, $Na_2B_4O_7 \cdot 10H_2O$	7 parts	7 pounds
Boric acid, H_3BO_3	3 parts	3 pounds
Diammonium phosphate, $(NH_4)_2HPO_4$	5 parts	5 pounds
Water	110 parts	$13\frac{1}{5}$ gallons

This formula gives very satisfactory results both in flame-resistance and glow-resistance. It will be found effective in weightings of 7 to 15 per cent, depending upon the fabric treated. Hand-wringing the above solution from a fabric leaves weighting of about 10 to 12 per cent.

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[1]Formulas 1 through 5 are from Circular C455 of the National Bureau of Standards. (See References.) Formulas 6 and 7 are from York Research Corp. of Conn., Stamford, Conn. (New York: American Hotel Association, 221 West 57th Street) Research Report No. 8, March 3, 1947 and Research Report No. 14, August 18, 1947.