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Recommended Requirements for

Flameproofing of Textiles

1941

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The National Fire Protection Association was organized in 1896 to promote the science and improve the methods of fire protection and prevention, to obtain and circulate information on these subjects and to secure the cooperation of its members in establishing proper safeguards against loss of life and property by fire. Its membership includes over a hundred national and regional societies and associations and five thousand individuals, corporations, and organizations.

Membership in the National Fire Protection Association is open to any Society, Corporation, Firm or Individual interested in the protection of life or property against loss by fire. All the valuable engineering and popular literature issued by the Association is sent, as issued, to every member. The Association is the clearing house for all the authoritative information on fire protection and prevention and members are privileged to submit to it their individual problems for solution. The Association is always glad to send samples of its publications to prospective members.

This pamphlet is one of a large number of publications on fire safety issued by the Association. The standards, prepared by the technical committees of the National Fire Protection Association and adopted in the conventions of the Association, are intended to prescribe reasonable measures for minimizing fire losses. All interests concerned have opportunity through the National Fire Protection Association to participate in the development of the standards and to secure impartial consideration of matters affecting them.

This pamphlet presents a series of related standards, prepared by the N.F.P.A. Committee on Fireproofing and Preservative Treatments and adopted by the Association in 1940 and 1941. Record of the discussion and action on the original reports will be found in the Proceedings for the years indicated.

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INTRODUCTION.

There is at present considerable public interest in the flameproofing of textiles and other materials, particularly as used for decorative and other more utilitarian purposes within buildings, ships, airplanes, and other structures, and also as used for awnings, boat covers, and salvage covers, where it may be subjected to weathering or to leaching with water. While it is not possible to make textiles fully resistive to charring and decomposition when exposed to flame and high temperature, treatments can be applied that will considerably reduce their flammability. Such treatments may be the means of preventing loss of life where otherwise highly flammable decorations are subject to fire, such as in places of public assembly.

The protection given by such treatments is supposed to be due to nonflammable gases formed as decomposition products when the chemicals are exposed to heat, to the forming of a glaze over the fiber surface preventing free access of air for ready combustion, or due to a more intimate combination with the basic substances of the textiles, such as is produced by loading of the fibers. Most of the treatments are not resistive to water, since the chemicals used are soluble. A few have been developed that apparently resist leaching action from exposure to weather or laundering for a considerable portion if not for the whole useful life of the fabric.

Where the fabric is not exposed to direct sunlight or to temperatures higher than those within the normal atmospheric range, most of the treatments in use cause at most no more than a minor reduction in the tensile strength of the fabric. For some of the treatments there is an increase in strength. The ripping strength, however, appears to be decreased considerably for almost all treatments. As subjected to higher than normal temperatures, and also as subjected to sunlight, a number of the treatments cause decided loss in strength that would need consideration where treated fabrics are to be exposed to such conditions.

Besides reduction in flammability, it is often important that change in color and texture shall not be caused by the flameproofing treatment and a number of treatments can be applied that will meet this requirement. Few of the treatments used contain chemicals that would cause poisoning or injury from handling of the treated fabric, although some of them have minor antiseptic properties.

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RECOMMENDED REQUIREMENTS FOR FLAMEPROOFING OF TEXTILES.

Presented, 1938. Amended, 1939. Adopted, 1940.

1. Scope.

These requirements apply mainly to fabrics used for decorative or other purposes on the inside of buildings or other structures. Most of the treatments applied are not resistant to leaching with water or to dry cleaning and these will require renewal after laundering, dry cleaning, or exposure to the weather.

Flameproofing processes producing results which comply with these requirements may not protect a fabric against flaming combustion under severe fire exposure or when hung in folds or parallel strips.

2. General Requirements.

The fabric shall be treated with chemicals that do not cause injury to the skin from handling of the treated material.

The chemicals used shall not be hygroscopic to an extent that will induce dampness in the treated fabric.

The treatment shall not cause dusting nor shall it lose its effectiveness under conditions not involving dry cleaning, laundering or other leaching of the fabric.

Where the appearance and texture of the treated material are important the treatment shall not cause changes objectionable from this standpoint. Requirements relative thereto should be included if deemed necessary.

3. Flameproofing Requirements.

When tested by the method given below, a fabric shall not continue flaming for more than two seconds after the test flame is removed from contact with the specimen. The average length of char for the ten specimens shall be not more than 3½ in., and the maximum length for any specimen shall be not more than 4½ in. By length of char is meant the distance from the end of the specimen which was exposed to the fire to the end of the tear made lengthwise of the specimen through the center of the charred area in the following way. Hooks are inserted in the specimen, one on each side of the charred area ¼ inch in from the adjacent outside edge. A weight, determined in the manner described below, is attached to one hook and applied to the specimen gently without impact by raising the other hook. The specimen will tear through the charred area until fabric strong enough to carry the load is reached. The tearing weight, inclusive of the hook shall be equal approximately to 10 per cent of that required to tear the unburned cloth.

4. Method of Testing.

FLAME TEST. A specimen 2 in. wide and 12½ in. long is suspended vertically with ½ in. of the upper end in a clamp, so that a 12-in. length is exposed. To protect the specimen from drafts, the apparatus is enclosed in a sheet metal shield 12 in. wide, 12 in. deep, and 30 in. high, open at the top, and provided with a vertical sliding glass front. Sufficient room is left at the bottom of the front to allow manipulation of the gas burner used in igniting the specimen.

The specimen is suspended ¾ in. above the top of a Bunsen or Tirrill gas burner, which has a tube of ⅜ in. inside diameter, and with the air supply completely shut off is adjusted to give a luminous flame 1½ in. long. The flame is applied for 12 seconds, then withdrawn, and the behavior of the specimen noted.

Ten specimens of each kind and weight of fabric shall be submitted to test, five to be cut with the long dimension in the direction of the warp and five in the direction of the filling.

5. Sampling.

Samples of not less than two square yards of each kind of cloth in each type of treatment, as well as of the untreated cloth, shall be selected for testing. Test specimens shall be cut from at least three different places in the sample.

RECOMMENDED REQUIREMENTS FOR FLAMEPROOFED TEXTILES SUBJECT TO LAUNDERING OR WEATHER EXPOSURE.

Presented, 1940. Adopted, 1941.

1. Scope.

These requirements apply to fabrics subject to leaching with water from such causes as laundering, exposure to the weather, or hose streams.

2. General Requirements.

(a) The fabric shall be treated with chemicals that do not cause injury to the skin from handling of the treated material.

(b) The chemicals used shall not be hygroscopic to an extent that will induce dampness in the treated fabric.

(c) Where the appearance and texture of the treated material are important the treatment shall not cause changes objectionable from this standpoint. Requirements relative thereto should be included if deemed necessary, as also requirements relative to water permeability and mildew resistance where these are important. For waterproofing requirements reference is made to Federal Specification CCC-D-746 for "Duck, Cotton; Fire, Water, and Weather Resistant."

(d) The treated material shall have no deteriorating effect on wood or metal with which it may be in contact.

(e) It shall be approximately as flexible as the untreated material from which it is made and shall not show a marked increase in stiffness after exposure in the accelerated weathering test. The treatment shall cause no decided decrease in strength either with or without weather exposure.

(f) The treated material shall show no tackiness even when subjected to high atmospheric temperatures and shall not crease or crack when subjected to low temperatures.

3. Flameproofing Requirements.

When tested by the method given below no specimen of the treated material shall continue flaming for more than 2 seconds after the burner flame is withdrawn. The average length of char of the 10 specimens shall not be more than 3½ in., and the maximum length of char for any one of the 10 specimens shall not be more than 4½ in. The treated material after subjection to the accelerated weathering described below shall meet the same requirements as the unweathered material, the specimens being tested with the same end down that was in this position during the accelerated weathering.

4. Method of Testing.

(a) FLAME TEST.—For the flame tests, 10 specimens 2 by 12½ in. shall be cut with their long dimension in the direction of the warp and 10 in the direction of the filling. Each lot of 10 shall be cut from at least four

places in the sample. One half of each lot is to be subjected to the flame test after conditioning as received and the other after exposure to the accelerated weathering described below.

The specimens shall be suspended vertically from a clamp covering the upper ½ in. of the length. To protect the specimen from drafts, the apparatus shall be inclosed in a sheet-metal shield 12 in. wide, 12 in. deep, and 30 in. high, open at the top, and provided with a vertical sliding glass front. Sufficient room shall be left at the bottom of the front to allow manipulation of the gas burner used in igniting the specimen.

The specimen shall be suspended with its lower end ¾ in. above the top of a Bunsen or Tirrill gas burner, having a tube of ⅜ in. inside diameter, and with the air supply completely shut off, adjusted to give a luminous flame 1½ in. long. The flame is applied vertically near the middle of the width of the lower end of the specimen for 12 seconds, then withdrawn, and the duration of flaming in the specimen noted.

The length of char shall then be determined. The length of char is the distance from the end of the specimen which was exposed to the flame to the end of the tear made lengthwise of the specimen through the center of the charred area in the following way. Hooks are inserted in the specimen, one on each side of the charred area ¼ in. in from the adjacent outside edge. A weight, which inclusive of the hook is equal to approximately 10 per cent of that required to tear the unburned cloth, is attached to one hook and applied to the specimen gently without impact by raising the other hook. The specimen will tear through the charred area until fabric strong enough to carry the load is reached.

(b) Accelerated Weathering Test.—The apparatus shall consist of a vertical carbon arc with solid electrodes 0.5 in. in diameter (1 cored electrode is used if the arc operates on a.c.) and uniform in composition throughout, mounted at the center of a vertical metal cylinder. The arc shall be surrounded by a clear globe of No. 9200 PX Pyrex glass 0.0625 in. thick or other enclosure having equivalent absorbing and transmitting properties. The electrodes shall be renewed at intervals sufficiently frequent to insure full operative conditions of the lamp. The globe shall be cleaned when carbons are removed or at least once in each 36 hours of operation. The arc shall be operated on 13 amperes direct or 17 amperes 60 cycle alternating current with the voltage at the arc 140 volts. The specimens for test shall be mounted on the inside of the cylinder facing the arc. The diameter of the cylinder shall be such that the distance of the face of the specimen holder from the center of the arc is 14¾ in. The cylinder shall rotate about the arc at a uniform speed of approximately three revolutions per hour.

Ten specimens 2 by 12½ in., five with the long dimension in the direction of the warp and five with the long dimension in the direction of the filling, are required for the flame test after aging. The specimens shall be clamped at the upper end of the inside of the cylinder and a length of at least ten inches exposed. The center line crosswise of the exposed areas of all specimens shall be in the horizontal plane passing through the center of the arc.

A water spray discharging about 0.7 gallons per minute shall strike each specimen in turn for about 1 minute during each revolution of the cylinder.

The specimens shall be aged by the above exposure for 360 hours. They shall then be allowed to dry thoroughly at a temperature bteween 70 and 100° F. before testing.

5. Sampling.

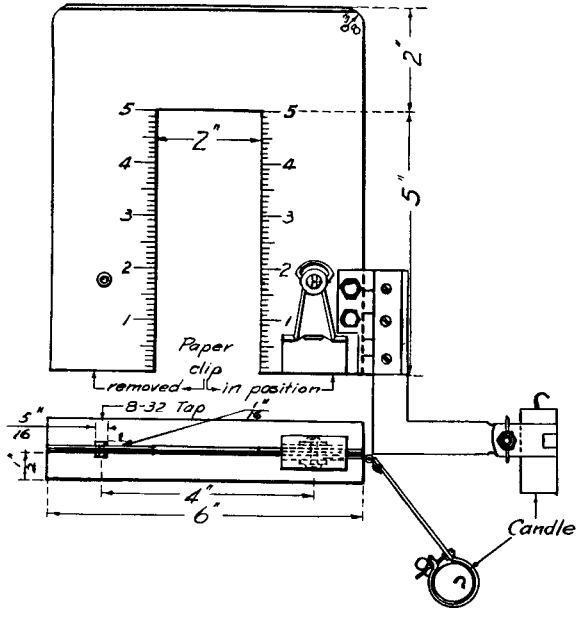
Samples of not less than two square yards of each kind of cloth in each type of treatment shall be selected for testing.

FIELD TEST FOR FLAMEPROOFED TEXTILES.

Presented as progress report, 1939. Amended, 1940. Tentatively Adopted, 1941.

The following method for conducting fire tests of textiles such as curtains in place uses a vertical clamp with attachment for supporting the candle that enables the test to be conducted with convenience and a minimum of incidental variation in the test results due to the method of testing. The clamp is inserted at a horizontal edge or slit in the fabric or at a vertical edge or slit that can be placed in horizontal position for testing. The clamping of the material in the device will prevent spread of fire to portions of the material beyond the area exposed in the clamp. Due care must however be taken in any use of open flame in the presence of combustible materials.

Comparative results with this clamp method and the regular 12 in. strip method are given in the tabulation.



Pinkney test clamp for making fire tests of textiles in place. The clamp is made of No. 14 gauge rolled brass (.065-in.) and is made of two pieces in duplicate as shown, with graduations to 1/10-in. on one side of one piece. The clamp is chromium plated with outside surfaces polished.

1. Scope.

These requirements supplement those given in the "Recommended Requirements for Flameproofing of Textiles." This field test is intended to accomplish the same result as that achieved by laboratory tests and the same general requirements apply.

2. Flameproofing Requirements.

When tested by the method given below, a fabric shall not continue flaming for more than two seconds after the test flame is removed from

contact with the specimen. The average length of char in three tests shall not be more than 2.5 in. By length of char is meant the length from the zero point on the scale to the point on the scale opposite the end of a tear through the charred area. This is to be made by hand with enough force to tear through the charred or scorched portion but not sufficient to break undamaged threads.

3. Method of Testing.

The test clamp, as illustrated, holds the portion of the curtain to be tested at any convenient edge or slit. The candle is of paraffin and of ¾ in. nominal diameter. It is swung away from the fabric and the tapered portion allowed to burn away until a normal constant flame is reached. The wick should bend to near the outer boundary of the flame and burn to a length that remains constant at about ⅝ in. The candle is then adjusted in its holder until the top of the wick is 1/10 in. below the bottom edge of the fabric or zero point on the graduated scale. The candle flame is applied to the exposed edge of the fabric for 12 seconds. The tear is to be made by applying pressure by hand against the side of the specimen as mounted in the clamp.

The clamp is made of duplicate pieces of sheet metal about 1/16 in. thick held with spring type paper clamps 1¼ in. wide. The candle holder can be made of a ¾ in. hose clamp bolted to a window screen corner angle and hinged to the front clamp member with a 2 by ½ in. brass hinge, the lower portion of one leaf of which is cut away to clear the paper clamp. The hinge and clamp support are mounted in such a manner that the candle will swing against a stop when its center is directly under the middle of the 2-in. wide exposed lower edge of the specimen.

APPENDIX A.

TESTS OF FLAMEPROOFED TEXTILES BY SEVERAL METHODS.

There are reported herewith results of a series of tests of various flameproofed fabrics made mainly for the purpose of comparing the results obtained by several testing methods.*

I. Test Samples.

Table 1 gives a description of the various fabrics used, the weight and thread count given being for the untreated material. The thread count of the treated material did not differ appreciably from that of the untreated, and comparison of treated and untreated samples indicated that there was in general no loss of strength due to treatment. The weight per square yard of the treated fabric was generally greater than that of the untreated fabric but, due to partial or complete removal of the sizing, it was not possible to determine the gain in weight due to the treatment as such.

Table 1. Description of Fabrics.

Fabric	Thread Count: Warp (Threads per in.)	Thread Count: Filling (Threads per in.)	Weight (Oz. per sq. yd.)
Cheesecloth, bleached	28	25	1.0
Muslin, bleached	64	48	2.8
Velveteen, black	70	53	7.2
Flannelette, black	48	44	5.5
Felt, black	—	—	12.0

NOTE: All fabrics were of cotton except the felt which was partly of wool.

II. Testing Methods.

(a) The National Bureau of Standards Vertical Burning Test.

A specimen 2 in. wide by 12½ in. long is suspended in a vertical position with the lower end free so that a 12 in. length is exposed for 12 seconds to a luminous flame 1½ in. long from a ⅜-in. Tirrill burner, the air ports of which are completely shut. The specimen is suspended ¾ in. above the top of the burner. To protect the specimen from drafts, the apparatus is enclosed in a sheet metal shield 14 in. wide, 12 in. deep, and 30 in. high, open at the top and provided with a vertical sliding glass front. Sufficient room is left at the bottom of the front to allow manipulation of the gas burner.

A record is made of the time from the application of the burner flame until flaming, if any, ceases. Determination is made of the length of the specimen that is burnt or charred in the test to an extent that it will separate readily from the remaining portion.

Among the advantages of this test are the moderate size of the specimen, the short flame which is easily controlled, and the fact that the specimen moves little during the test, since there is only a mild draft. The results are not appreciably affected by other incidental conditions and the test can be conducted by relatively inexperienced operators. Since the flame spread is greatest on a vertical specimen, this test represents the most hazardous position. It is not as severe as a multiple-strip test but it gives a greater difference in results between well-treated and poorly-treated fabrics.

*These tests were conducted in the Fire Resistance Laboratories of the National Bureau of Standards by F. M. Hoffheins, assisted by J. T. Duck and R. L. Messimer. Some previous tests with several of the equipments were made by S. B. Detwiler, Jr., and used as a partial basis for Bureau of Standards Letter Circular No. 467 on Flameproofing of Textiles.

(b) Underwriters' Laboratories Flammability Test.

The apparatus consists of a sheet iron stack, 12 in. square, 7 ft. high, and supported 1 ft. above the floor on legs. The specimen, 7 ft. long by 5 in. wide, is hung from a bar at the top of the stack so that the bottom of the specimen is 5¾ in. above the top of a ⅜-in. Fletcher burner. With a gas pressure of 108 mm. of water the burner flame is made 11 in. high by adjusting the air supply. The specimen is exposed to the flame for 2 minutes. A record is made of the time when the specimen ignites and the time flaming and glowing cease. Measurements are also made of the distance from the tip of the burner flame to the top of the charred area.

This test uses a large specimen and a long flame. The draft is strong and the opportunities for spread of flame are most favorable. However, it is difficult to maintain the long flame at constant height and to measure its height accurately. The bottom of the sample moves about considerably making it difficult to keep the burner beneath it. In the tests by this method herein reported the specimen was finally held in place by placing it between two guide wires. The test requires experience before dependable results are obtained and close regulation of the gas pressure is necessary throughout the test. It is necessary to move the gas burner during the test to keep it under the center of the specimen.

(c) Freeman Stove Pipe Test.

A 5-in. brass tube 24 in. long lined with asbestos paper has eight ¾ by 1½-in. vertical slots at the bottom for admission of air. Six 24 by 3-in. specimens spaced ¾ in. on centers are hung from a rack placed on top of the tube. The samples are ignited by burning 1 oz. of excelsior at the base of the apparatus. The per cent of the initial weight lost is calculated and used as the criterion of performance.

The exposure in this test was so severe that all treated materials burned completely with a resulting high per cent loss in weight so that little difference could be noted between treated and untreated materials. This test was discarded and a modified Freeman test with a less severe exposure substituted. (Trans. Am. Soc. Mech. Engr., *27*, 71 (1906).)

Modified Freeman Stove Pipe Test.

The same stove pipe apparatus was used with a Fletcher radial gas burner (5-in. outside ring diameter) having a flame 4 in. high. Three specimens of the same size and hanging as in the original Freeman test are exposed for 15 seconds. The per cent loss in weight was again used as a criterion of performance and was found to be much lower than when using more strips and the more severe exposure. The per cent loss in weight depends on the type of fabric as well as the treatment so that a general requirement for a well-treated fabric can not easily be specified in terms of results of this test.

(d) Whipple-Fay Burning Test.

The apparatus consists of a small alcohol lamp having a glass chimney 8 in. long and 2 in. in diameter. The specimen, 1 in. wide and 8 in. long, is folded over for ½ in. at the top and hung from a wire across the top of the chimney, the bottom of the specimen projecting ½ in. into a 2 in. long flame from a ¼ in. diameter wick. The specimens are left in the test flame for 1 minute, then withdrawn and a record is made of any independent flaming and the length of char. This test was designed to be used by the inspector on the job as an improvement over a simple match test. The draft is greater than that in the National Bureau of Standards test and the height of flame is more difficult to control. No requirements for well-treated fabrics have been given other than that there shall be no sustained flaming after removal of the specimen from the flame. (Trans. Am. Soc. Mech. Engr., *27*, 71 (1906).)

(e) British Standards Institution Test.

The specimen, 6 by 6 in., is spread over a wire grid stretched on a 6½-in. square metal frame so that its major plane is at an angle of 45 deg. with the horizontal. The frame rests on vertical supports such that (1) the center portion of the specimen is not shielded from the flame, (2) air necessary for combustion is freely accessible, and (3) the progress of the test can be observed. A flat-bottomed cup, 11/16 in. external diameter (⅝ in. internal diameter) 9/32 in. high, is placed on a cork and supported so that the center of its base is 1 in. vertically below the center of the lower face of the specimen. The specimen is exposed to the flame from 0.3 ml. of absolute alcohol in the metal cup. (Under most conditions the flame lasts about 45 seconds.) A record is made of the time of flaming and glow after the alcohol flame burns out, and measurements are taken of the extent of char. In Table 2 the length of char on the original upper edge of the specimen is recorded.

The exposure in this test is fairly reproducible and the results could probably be duplicated in different laboratories if the test specimens are uniform. The test combines both horizontal and vertical flame travel but exposes only a portion of the specimen to the flame. This test requires special equipment and careful manipulation. According to the British Standard, the edge of a well-treated specimen should not char for a length greater than 2 in. when exposed to this test. This test appears to be better adapted to materials in the form of sheets or boards of appreciable thickness than to fabrics. (British Standards Specification 476—1932.)

(f) Fold Test.

A 12 by 15-in. specimen is folded so that there are five folds of cloth each about 3 in. wide. It is suspended from a clamp so that the bottom of the specimen is ¾ in. above the burner and exposed to a 1½-in. yellow flame as in (a) above for 2 minutes. The time of glow and the weight of specimen before and after test are recorded. This test was suggested by a similar test used by the Underwriters' Laboratories and gives an idea of the hazard of the material when hanging in folds. The loss in weight depends on the treatment, fabric, and room draft conditions at the time of the test, as most of the combustion takes place as glow.

III. The Flameproofing Treatments.

The various fabrics were first placed for several hours in hot water to remove a portion of the sizing. They were then dried and placed in the flameproofing solution for an hour at room temperature. They were wrung until the damp weight was about twice that of the dry weight before treatment and after removal of the sizing. The position while drying was changed to minimize the concentration of the solution in one portion. After drying and smoothing, the various test specimens were cut.

Two kinds of solutions were used in treating specimens, one expressed in the tables as proportions by weight of borax, boric acid and water, the other as per cent diammonium phosphate solution. For example, 6 parts borax, 5 parts boric acid, and 100 parts water contained 60 grams borax ($Na_2B_4O_7.10\ H_2O$), 50 grams boric acid (H_3BO_3), and 1,000 grams (1 liter) water.

A 10 per cent diammonium phosphate solution contained 100 grams diammonium phosphate [$(NH_4)_2HPO_4$], and 900 grams water.

IV. Results and Comparisons.

The results of the tests are given in Table 2. The length charred is measured from the tip of the burner flame and as previously indicated is

Table 2. Results of Tests

Material	Treatment	National Bureau of Standards				Underwriters' Laboratories				Freeman Modified				Whipple-Fay				British Standards Institution				Fold Test			
		Tests	Length Charred* (Inches) Max.	Min.	Av.	Tests	Length Charred* (Inches) Max.	Min.	Av.	Tests	Loss in Wt. (Per cent) Max.	Min.	Av.	Tests	Length Charred* (Inches) Max.	Min.	Av.	Tests	Length of Charred Edge (Inches) Max.	Min.	Av.	Tests	Loss in Wt. (Per cent) Max.	Min.	Av.
Cheese-Cloth	10% Diammonium Phosphate	5	2.2	1.2	1.8	5	8.0	2.0	5.4	3	56	31	43	6	7.0	3.0	5.0	6	6.0	1.5	3.8	5	6	5	5
Cheese-Cloth	5% Diammonium Phosphate	5	11.2	3.2	7.0	5	78.0	5.0	20.5	5	72	67	70	5	7.0	7.0	7.0	6	6.0	3.0	4.7	5	38	23	32
Cheese-Cloth	6 parts Borax, 5 parts Boric Acid, 100 parts Water	5	2.2	.2	1.2	5	3.0	1.0	1.4	3	69	16	37	6	7.0	2.5	5.0	5	5.0	0.0	1.0	5	13	7	10
Muslin	15% Diammonium Phosphate	5	2.8	1.8	2.0	5	7.0	2.0	3.7	5	21	8	14	5	5.8	2.5	4.1	5	3.5	2.5	3.0	5	21	13	16
Muslin	10% Diammonium Phosphate	6	2.0	1.2	1.5	5	5.5	1.5	3.9	3	59	39	52	6	7.0	.8	4.4	6	6.0	0.0	4.8	5	18	6	13
Muslin	5% Diammonium Phosphate	6	11.2	1.2	4.0	5	78.0	3.0	25.6	5	64	59	60	5	7.0	7.0	7.0	5	5.8	3.5	4.4	5	65	52	58
Muslin	7 parts Borax, 3 parts Boric Acid, 100 parts Water	5	8.2	2.2	4.0	6	10.0	3.0	5.0	5	69	60	65	5	1.8	.5	1.2	5	2.5	1.5	2.1	5	73	65	70
Muslin	6 parts Borax, 5 parts Boric Acid, 100 parts Water	5	1.2	1.2	1.2	4	3.0	0.0	2.2	3	70	10	39	6	4.0	.8	2.0	6	4.0	0.0	2.2	5	9	6	8
Muslin	6 parts Borax, 5 parts Boric Acid, 150 parts Water	5	11.2	1.2	7.2	5	5.0	2.0	3.2	4	66	39	56	5	7.0	2.5	6.1	5	3.5	1.8	2.3	5	61	12	39
Muslin	6 parts Borax, 5 parts Boric Acid, 200 parts Water	5	3.8	1.2	2.1	5	19.0	1.0	5.6	5	68	63	65	5	7.0	7.0	7.0	5	4.0	2.5	3.2	5	67	18	48
Muslin	6 parts Borax, 5 parts Boric Acid, 250 parts Water	5	11.2	1.5	6.2	5	78.0	3.5	23.7	5	74	66	71	5	7.0	1.8	6.0	5	6.0	3.5	5.1	5	74	59	64
Muslin	6 parts Borax, 5 parts Boric Acid, 300 parts Water	5	11.2	3.8	8.8	5	75.0	1.0	17.6	5	73	69	71	5	7.0	7.0	7.0	5	6.0	4.8	5.4	5	76	67	72
Flannel-ette	10% Diammonium Phosphate	6	1.5	.8	1.2	6	4.0	.5	2.7	3	47	12	25	5	7.0	7.0	7.0	6	2.1	1.8	1.9	3	70	4	42
Flannel-ette	5% Diammonium Phosphate	5	3.8	1.2	2.2	5	78.0	3.0	23.2	5	90	85	87	5	7.0	7.0	7.0	5	6.0	3.5	5.5	5	89	86	87
Flannel-ette	6 parts Borax, 5 parts Boric Acid, 100 parts Water	5	.8	.2	3	5	0.0	0.0	0.0	3	63	12	31	6	2.5	.5	1.3	7	2.5	1.0	1.8	3	82	77	79
Velvet-een	10% Diammonium Phosphate	5	1.5	1.2	1.3	5	3.0	1.8	2.2	3	10	8	9	6	7.0	2.2	5.5	6	2.5	1.0	1.7	5	81	18	52
Velvet-een	5% Diammonium Phosphate	5	11.2	.8	3.5	5	22.0	15.5	19.7																
Velvet-een	6 parts Borax, 5 parts Boric Acid, 100 parts Water	5	.8	.8	.8	5	0.0	0.0	0.0	3	28	16	21	6	7.0	2.0	4.7	6	1.0	0.0	.3	4	84	67	77
Felt	10% Diammonium Phosphate	5	1.2	.8	1.0	5	3.0	1.0	1.9																
Felt	5% Diammonium Phosphate	5	1.5	.8	1.3	6	10.2	0.0	3.9																
Felt	6 parts Borax, 5 parts Boric Acid, 100 parts Water	5	.2	.2	.2	5	1.0	0.0	.2																

* The length of the specimen in contact with the flame at the beginning of the test is not included in the charred length.

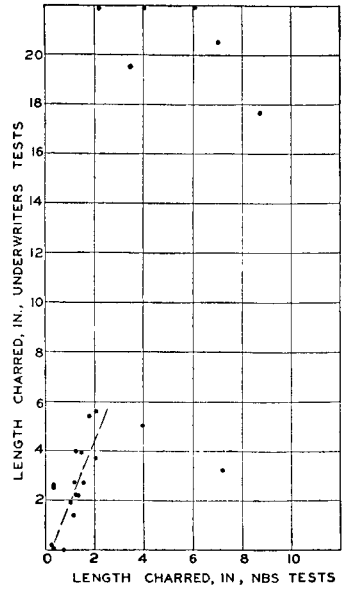


Figure 1. Comparison of National Bureau of Standards and Underwriters' Laboratories, Inc. Test Data.

taken as the length of the specimen which is completely burned or damaged sufficiently so that a slight pull will separate it from the upper portion. Comparisons were placed on this basis in preference to the total charred length on account of the different flame lengths employed in the compared tests.

The results of the National Bureau of Standards tests and the Underwriters' Laboratories test have been compared and are shown in Figure 1. The comparison shows that the relationship between the length charred in the Underwriters' Laboratories test and that charred in the National Bureau of Standards test may for well-treated fabrics be represented by a straight line, within experimental variations. The results from the Underwriters' Laboratories test show that a long specimen is not necessary to give an indication of the effectiveness of the treatment since with only a few of the less effective treatments was more than 12 in. of the specimen burned.

There is little relationship between the loss in weight either in the Fold test or the Modified Freeman test and the National Bureau of Standards single-strip test. This would be expected from the dependence of the weight loss on the type of fabric. The results of the Freeman and Fold tests bear no consistent relationship to each other. The Whipple-Fay test is apparently too severe and does not show up differences in treatment as do the National Bureau of Standards and Underwriters' Laboratories single-strip tests. The British Standards Institution test results show only a general correlation with those obtained by the National Bureau of Standards test and no consistent curve could be drawn.

All untreated material burned completely in all tests. Even the poorest treatment was partially effective in checking flaming in some tests.

The properties of the fabric other than those given it by the treatment, have a decided effect on the results obtained in the various tests so that comparisons should be made only on the same material.

APPENDIX B.

TESTS OF FLAMEPROOFED FABRICS SUBJECTED TO LAUNDERING OR EXPOSURE TO WEATHER.

Natural and accelerated weathering tests of samples of flame and waterproofed cotton duck described in Table 3 have been in progress at the National Bureau of Standards during the past two years. The results of the first year of natural weathering on a roof in Washington, D. C., and of accelerated weathering tests are given in Table 5. The effect of weathering on the strength is indicated in Table 4. The awnings were attached to a penthouse and were faced to the south and west. They were kept in lowered position during the whole period. The exposure incidental to conditions of use would in general be less severe since the awnings would be in raised position for a considerable portion of the time and with the pliability and permeability required for awning material the raising and lowering should have little effect on the treatment. This conclusion is based in part on exposure of fabricated awnings made of flameproofed duck over windows on the south side of a building in Washington, D. C., for periods up to 480 days.

Fire tests of well-treated awning material subject to artificial rainfall intermittently over a 40-hour period equivalent in amount to about 12 years of natural rainfall for Washington, D. C., indicated little loss in flameproofing properties. Natural weathering for six months and one year and artificial weathering for 15 and 30 days had a much greater effect, indicating that the sunlight and carbon arc light have decided deteriorating effects. In the artificial weathering apparatus employed, the total radiation at the plane of the sample in 360 hours is equivalent to that received as an average from outdoor radiation in Washington, D. C., during a period of 68 days. There is, however, a greater proportionate amount of ultra-violet radiation from the carbon arc, the ratio being approximately 2:1. The quantity of water sprayed on the specimen in the accelerated weathering equipment at 0.7 gallons per minute is equivalent to a depth of water at the plane of the specimens of 3,100 in. from 360 hours discharge which is the same in quantity as 74 years rainfall for Washington, D. C., assumed at 42 in. per year.

The results in Table 5, while indicating that treated fabrics may not be affected the same relatively from exposure to accelerated and natural weathering, do give approximate relations between the two types of exposure. Based thereon it appears that 15 days (360) hours of accelerated weathering by the method given in the present proposed requirements approximates in effect the six months of natural weathering. This is apparently equivalent to a considerable longer period assuming the ordinary conditions of use for awnings, which is one of the principal applications of flameproofed cotton duck. Only a few of the lots tested would pass the present proposed requirements and more rigid requirements would further restrict the field of available materials. Hence, these requirements may be regarded as giving fairly acceptable material for awnings or similar purposes where the weathering conditions are not too severe and for which the normal useful life is limited to three to six years or seasons. For purposes involving more severe and continuous weather exposure, such as roof and sidewall coverings of buildings and boat covers, this degree of weathering resistance will probably not be sufficient unless the fabric is further protected with coatings of paint. For fabrics subject to laundering rather than to weather exposure, the requirements should give reasonable assurance of satisfactory material from the standpoint of fire-resistance.

With respect to dry cleaning, most of the salts employed in flameproofing are much less soluble in dry-cleaning agents than in water. Carbon-tetrachloride in the presence of moisture and exposure to air and sunlight may liberate hydrochloric acid which would have some effect on salts otherwise insoluble. Flameproofing treatments depending on rubber compounds for weathering resistance are subject to decided deterioration from hydrocarbon and chlorinated carbon dry-cleaning agents such as Stoddard solvent and carbon-tetrachloride. However, so far as is known, such treatments are confined to fabrics intended for exposure to the weather and which accordingly would not be subjected to dry cleaning.

TABLE 3. DESCRIPTION OF MATERIALS.

Lot No.[1]	Material	Width	Weight Untreated per Lin. Yd. Nominal	Weight Untreated per Sq. Yd. Actual	Threads per In. Warp	Threads per In. Filling	Weight Treated per Sq. Yd.	Increase in Weight from Treatment
		in.	oz.	oz.			oz.	percent
1 & 9	Medium Weight No. 12 Green.	36	12	11.8	46* 45	35* 34	21.1	79
2 & 10	Heavy Weight No. 4 Gray...	36	24	24.7	36½* 36	21* 22	35.3	43
3 & 11	Medium Weight Green	31	8.7	10.4	54	40	16.1	55
4 & 12	Light Weight Khaki	28	8	10.2	53	42	17.4	71
5 & 12	Light Weight Green	28	8	10.2	53	42	14.7	44
6 & 12	Light Weight Terra Cotta ..	28	8	10.2	53	42	15.7	54
7 & 13	Medium Weight Terra Cotta ..	28	10	12.9	47	37	19.3	50
8 & 13	Medium Weight Green	28	10	12.9	47	37	18.9	47

[1] First lot number refers to treated material.
Second lot number refers to same material untreated.

* Manufacturer's Standard Count.

TABLE 4. STRENGTH (GRAB) TESTS OF FLAMEPROOFED AND WATERPROOFED DUCK.

	Lot Number												
	Treated Material								Untreated Material				
	1	2	3	4	5	6	7	8	9	10	11	12	13
	Warp Strength, Lb.												
New Material ...	236	450	221	218	207	191	268	291	176	393	179	181	217
1 Yr. in Storage.	252	492	225	215	219	194	248	270	213	418	173	176	238
6 Mo. Natural Weathering ...	209	430	200	168	180	155	194	227	151	327	139	135	174
1 Yr. Natural Weathering ...	240	309	194	133	136	123	207	184	102	211	86	86	115
	Filling Strength, Lb.												
New Material ...	134	391	140	143	142	149	155	163	116	324	117	126	141
1 Yr. in Storage.	152	507	152	157	157	154	170	158	119	323	110	121	132
6 Mo. Natural Weathering ...	126	383	136	115	135	136	151	150	91	274	87	94	97
1 Yr. Natural Weathering ...	155	379	142	100	101	89	135	135	65	239	62	62	77

TABLE 5. RESULTS OF FLAME TESTS OF FLAMEPROOFED AND WATERPROOFED DUCK.

	Lot Numbers							
	1	2	3	4	5	6	7	8
	Average Charred Length, Inches							
New Material	1.9	0.7	3.2	2.6	2.6	2.6	2.2	2.2
After Accelerated Weathering for								
7½ Days	—	—	—	3.2	5.4	3.3	2.8	3.6
8 Days	—	—	3.0	3.7	—	3.5	2.9	2.5
15 Days (I)	1.8	1.0	3.0	4.7	7.3	3.2	6.5	3.2
15 Days (II)	1.7	1.2	2.6	3.1	7.5	3.4	2.8	2.6
30 Days (I)	2.1	0.8	3.7	5.5	4.1	3.9	3.4	3.2
30 Days (II)	2.1	1.1	3.4	4.4	11.0	3.6	8.0	4.7
After Natural Weathering for								
6 Months	1.8	0.8	3.3	3.5	5.8	3.8	5.2	2.5
1 Year	2.5	1.2	3.8	10.8	12.0	12.0	12.0	9.8
	Maximum Charred Length, Inches							
New Material	2.2	1.0	3.5	3.0	3.2	2.9	2.4	2.4
After Accelerated Weathering for								
7½ Days	—	—	—	4.5	8.0	3.7	3.5	7.0
8 Days	—	—	3.7	4.7	—	3.8	5.5	2.6
15 Days (I)	2.3	1.2	3.7	12.0	12.0	3.5	10.0	3.8
15 Days (II)	1.9	1.5	2.8	3.7	12.0	3.8	3.1	2.7
30 Days (I)	2.6	1.0	3.9	11.0	4.8	4.2	3.9	3.8
30 Days (II)	2.3	1.3	3.9	6.5	12.0	3.7	12.0	6.5
After Natural Weathering for								
6 Months	2.0	1.0	4.2	3.9	7.8	4.4	7.4	3.2
1 Year	2.9	1.6	4.1	12.0	12.0	12.0	12.0	12.0
	Maximum Time of Flaming, Seconds							
New Material	0	0	0	0	0	0	0	0
After Accelerated Weathering for								
7½ Days	–	–	–	0	0	0	0	0
8 Days	0	0	0	0	0	0	0	0
15 Days (I)	0	0	0	0	0	0	0	0
15 Days (II)	0	0	0	0	1	1	1	1
30 Days (I)	0	0	1	1	2	2	2	3
30 Days (II)	0	0	0	0	0	0	0	
After Natural Weathering for								
6 Months	0	0	0	2	25	4	19	2
1 Year	0	0	1	38	33	32	33	60