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Standard Performance Specification for Flame Resistant Textile Materials for Wearing Apparel for Use by Electrical Workers Exposed to Momentary Electric Arc and Related Thermal Hazards[1]

This standard is issued under the fixed designation F 1506; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

ε[1] NOTE—Editorial changes were made in February 2004.

1. Scope

1.1 This performance specification covers the flame resistance of textile materials to be used for wearing apparel for use by electrical workers exposed to momentary electric arc and related thermal hazards.

NOTE 1—This performance specification does not cover coated fabrics commonly used in rainwear.

NOTE 2—At present, a bench scale arc test for laboratory use is not available. It is the intent of the committee to continue the search for an acceptable laboratory test based on either an electric arc exposure or an acceptable alternative, which will form the basis of a modification of this performance specification.

1.2 Materials used for basic protection levels are covered.

1.3 Protective properties relate to thermal exposure from momentary arc and associated exposure to open flame and radiant heat. (See Appendix X1.)

1.4 This performance specification covers wearing apparel design characteristics that relate specifically to protection from exposure to momentary electric arc and that relate to the utility of the wearing apparel.

NOTE 3—A number of other thermal test methods are under consideration and development and, when evaluated and proved effective by Committee F18, will be incorporated in either this performance specification or an appropriate alternative test method or specification.

1.5 *This standard should be used to evaluate and describe the properties of materials, products, or assemblies in response to heat and flame under controlled laboratory conditions. It should not be used to describe or appraise the fire hazard or fire risk of materials, products, or assemblies under actual fire conditions*.

1.5.1 The results of this evaluation may be used as elements of a fire-risk assessment that takes into account all of the factors that are pertinent to an assessment of the fire hazard of a particular end use.

1.6 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.7 The following precautionary caveat pertains only to the test methods portion, Section 7, of this performance specification: *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:* [2]

D 123 Terminology Relating to Textiles

D 434 Test Method for Resistance to Slippage of Yarns in Woven Fabrics Using a Standard Seam

D 1424 Test Method for Tearing Strength of Fabrics by Falling-Pendulum Type (Elmendorf) Apparatus

D 2262 Test Method for Tearing Strength of Woven Fabrics by the Tongue (Single Rip) Method (Constant-Rate-of-Traverse Tensile Testing Machine)

D 2724 Test Methods for Bonded, Fused, and Laminated Apparel Fabrics

D 3786 Test Method for Hydraulic Bursting Strength of Knitted Goods and Nonwoven Fabrics—Diaphragm Bursting Strength Tester Method

D 5034 Test Method for Breaking Strength and Elongation of Textile Fabrics (Grab Test)

D 6413 Test Method for Flame Resistance of Textiles (Vertical Test)

F 1449 Guide for Care and Maintenance for Flame Resistant and Thermally Protective Clothing

F 1959 Test Method for Determining the Arc Thermal Performance Value of Materials for Clothing

[1] This performance specification is under the jurisdiction of ASTM Committee F18 on Electrical Protective Equipment for Workers and is the direct responsibility of Subcommittee F18.65 on Wearing Apparel.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

2.2 *AATCC Test Methods:*[3]

Method 61 Colorfastness to Washing, Domestic and Laundering, Commercial: Accelerated

Method 132 Colorfastness to Dry-Cleaning

Method 135 Dimensional Changes Automatic Home Laundering of Woven and Knitted Fabrics

Method 158 Dimensional Changes on Drycleaning in Perchloroethylene: Machine Method

2.3 *Federal Standard:*[4]

Test Method 191A, 1534

3. Terminology

3.1 *Definitions*—For definitions of textile terms used in this performance specification, refer to Terminology D 123.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *afterflame, n*—persistent flaming of a material after the ignition source has been removed.

3.2.1.1 *Discussion*—In arc testing, a visible flaming on or near a test specimen which persists after the arc exposure has ended. The afterflame ceases when flaming is no longer visible.

3.2.2 *afterflame time, n*—the length of time for which a material continues to flame after the ignition source has been removed.

3.2.2.1 *Discussion*—In arc testing, the length of time for which a specimen continues to exhibit a visible flaming as determined by a time display video recording of the specimen during arc testing.

3.2.3 *arc rating, n*—the maximum incident energy (E_1) resistance demonstrated by a material prior to breakopen or at the onset of a second–degree burn.

3.2.3.1 *Discussion*—When the Arc Thermal Performance Value (ATPV) of the material cannot be determined due to breakopen, the arc rating is determined by measuring the Breakopen Threshold Energy (E_{BT}) according to Test Method F 1959. When the arc rating represents the Arc Thermal Performance Value, it is indicated as arc rating (ATPV); when representing the Breakopen Threshold Energy, it is indicated as arc rating (E_{BT}).

3.2.4 *arc thermal performance value (ATPV), n—in arc testing*, the incident energy on a fabric or material that results in sufficient heat transfer through the fabric or material to cause the onset of a second-degree burn based on the Stoll curve.

3.2.5 *basic protection level*—the level of protection provided by flame-resistant materials that do not continue to burn after exposure to and removal of a source of ignition (see 7.6).

3.2.6 *basic protection level wearing apparel*—clothing intended for continuous wear for work activities in designated locations in which exposure to momentary electric arc and related radiant heat and open-flame sources is possible.

3.2.7 *breakopen threshold energy (E_{BT}), n—in electric arc testing*, the average of the five highest E_1 values that did not cause specimen breakopen and did not cause sensor temperature rise to exceed the Stoll curve.

3.2.8 *design test, n*—for arc and flame resistant textile materials, one made on a sample treated as representative of an industrial product; these tests will not generally be repeated in quantity production.

3.2.8.1 *Discussion*—Perform the design test only when a new or modified textile material, that is, fabric, is used to manufacture apparel. A modification in the fabric could be, but is not limited to, any of the following: the supplier, composition, weave type, weight, or dyeing and finishing process.

3.2.9 *findings*—miscellaneous fabrics in garments such as zipper tapes, linings, pockets, waistbands, and facings.

3.2.10 *momentary electric arc*—a discharge of electricity through a gaseous media, normally characterized by a voltage drop in the immediate vicinity of the electrodes, approximately equal to the ionization potential of the gaseous media.

3.2.11 *radiant heat*—heat communicated by energy propagated through space and transmitted by electromagnetic waves.

3.2.12 *thermal hazard*—the heat energy sufficient to cause burn injury to human tissue subjected to a momentary electric arc.

3.2.13 *user*—the employer or entity purchasing the equipment to be utilized by workers for their protection; in the absence of such an employer or entity, the individual purchasing and utilizing the protective equipment.

4. Significance and Use

4.1 This performance specification provides performance properties for textile materials used in wearing apparel that represent initial minimum requirements for basic protection levels.

4.1.1 The performance properties have been selected based on materials in use and take into consideration durability requirements for specific apparel.

4.2 Work practices vary from user to user depending upon many factors. These may include, but are not limited to, operating system voltages, construction design, work procedure or techniques, and weather conditions. Therefore, except for the restrictions set forth in this performance specification because of design limitations, the use and maintenance of this equipment is beyond the scope of this performance specification.

4.2.1 It is common practice and the responsibility of the user of this type of protective equipment to prepare complete instructions and regulations to govern in detail the correct and safe use of such equipment.

5. Materials and Manufacture

5.1 Material tests shall be performed on textile materials as they are delivered to the clothing manufacturer.

5.1.1 Material tests may be performed on samples taken from finished garments.

5.2 Lot size for the initial (without laundering) flammability test shall be 4572 m (5000 yd) of manufactured fabric or the manufactured yardage, whichever is less. One sample of 1.0 m shall be taken from each lot.

5.3 Lot size for all other tests except design tests shall be 45 720 m (50 000 yd) or at least every three months, whichever is more frequent. One sample of 4.0 m shall be taken from each lot.

[3] *AATCC Technical Manual*, available from American Association of Textile Chemists and Colorists, PO Box 12215, Research Triangle Park, NC 27709-2215.

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

5.4 Design tests shall be run on the original and when changes are made to flame resistant textile materials, for example, fiber type, yarn type, weaving style, fabric weight, dyeing, or finishing procedure.

6. Requirements

6.1 Thread, findings, and closures used in garment construction shall not contribute to the severity of injuries to the wearer in the event of a momentary electric arc and related thermal exposure.

6.1.1 Sewing thread utilized in the construction of garments shall be made of an inherently flame-resistant fiber and shall not melt when tested at a temperature of 260°C (500°F) in accordance with Federal Test Method Standard 191A, 1534.

NOTE 4—If fasteners or closures, for example, zippers, snaps, or buttons, or a combination thereof, are used in a manner in which they are in contact with the skin, they can increase heat transfer and burn injury due to heat conduction or melting onto the skin. Fasteners or closures that are used in this manner should be covered with a layer of fabric between the fastener or closure and the skin. The fabric used for this purpose shall meet the requirements of this performance specification.

6.2 The properties of materials for basic protection level wearing apparel shall conform to the specifications in Table 1 and Table 2, when evaluated in accordance with Section 7.

NOTE 5—Physical characteristic tests and values in Section 7 and Table 1 and Table 2 are based on experience from woven and knit fabrics currently in use and may not be applicable to other fabric types.

NOTE 6—Characteristics (for example, clothing ensembles, design, and laundry maintenance) of protective garments for basic protection level wearing apparel should be guided by the information contained in Appendix X1.

6.3 Garments shall be labeled with the following information:

6.3.1 Tracking identification code system,

TABLE 2 Requirements, Knit Fabrics

	Fabric Weight Ranges, oz/yd^2		Section Reference
	3.0–8.0	8.1–16.0	
Characteristic:			
Bursting strength, min, N (lbf)	179 (40)	268 (60)	7.7
Colorfastness:			
Laundering shade change, min	Class 3	Class 3	7.4.1
Dry-cleaning shade change, min	Class 3	Class 3	7.4.2
Dimensional change, max	...	...	7.5
Initial Flammability: [A,B]			
Char length, max, mm (in.)	152 (6.0)	152 (6.0)	7.6
Afterflame, max, s	2	2	7.6
Flammability After 25 Washes/Dry Cleaning:			
Char length, max, mm (in.)	152 (6.0)	152 (6.0)	7.6
Afterflame, max, s	2	2	7.6
Arc Test Results:			
Afterflame time, max, s (for single layer arc test specimens)	5	5	7.8.1
Reported Values Arc Rating,[C] cal/cm^2	Report measured values[C]		7.8

[A] Certain treated fabrics exhibit afterglow during the flammability test. This has been judged not a serious hazard. When afterglow occurs, extinguish it after 10 s. Then measure char length and record either the actual time, or greater than 10 s for afterglow in the report.

[B] No melting and dripping of the test material is permitted.

[C] When the arc rating represents the ATPV, it shall be designated as arc rating (ATPV). When arc rating represents the E_{BT}, it shall be designated as arc rating (E_{BT}). Arc rating is determined and reported for a fabric that meets all the requirements of this performance specification to provide guidance on the performance of the fabric in arc exposure testing. There is no minimum required value for arc rating. For additional information on ATPV and E_{BT}, see Test Method F 1959.

6.3.2 Meets requirements of Performance Specification F 1506,

6.3.3 Manufacturer's name,

6.3.4 Size and other associated standard labeling,

6.3.5 Care instructions and fiber content, and

6.3.6 Arc rating (ATPV) or arc rating (E_{BT}).

TABLE 1 Requirements, Woven Fabrics

	Fabric Weight Ranges, oz/yd^2			Section Reference
	3.0–5.9	6.0–8.4	8.5 and higher	
Characteristic:				
Breaking load, min, N (lbf)	134 (30)	179 (40)	223 (50)	7.1
Tear resistance, min, N (lbf)	11 (2.5)	18 (4.0)	22 (5.0)	7.2
Seam slippage, max	6 mm at 134 N (0.25 in. at 30 lbf)	6 mm at 179 N (0.25 in. at 40 lbf)	6 mm at 223 N (0.25 in. at 50 lbf)	7.3
Colorfastness:				
Laundering shade change, min	Class 3	Class 3	Class 3	7.4.1
Dry-cleaning shade change, min	Class 3	Class 3	Class 3	7.4.2
Dimensional change, max	3.0 %	3.0 %	3.0 %	7.5
Initial Flammability: [A,B]				
Char length, max, mm (in.)	152 (6.0)	152 (6.0)	152 (6.0)	7.6
Afterflame, max, s	2	2	2	7.6
Flammability After 25 Washes/Dry Cleaning:				
Char length, max, mm (in.)	152 (6.0)	152 (6.0)	152 (6.0)	7.6
Afterflame, max, s	2	2	2	7.6
Arc Test Results:				
Afterflame time, max, s (for single layer arc test specimens)	5	5	5	7.8.1
Reported Values Arc Rating,[C] cal/cm^2		Report measured values[C]		7.8

[A] Certain treated fabrics exhibit afterglow during the flammability test. This has been judged not a serious hazard. When afterglow occurs, extinguish it after 10 s. Then measure char length and record either the actual time, or greater than 10 s for afterglow in the report.

[B] No melting and dripping of the test material is permitted.

[C] When the arc rating represents the ATPV, it shall be designated as arc rating (ATPV). When arc rating represents the E_{BT}, it shall be designated as arc rating (E_{BT}). Arc rating is determined and reported for a fabric that meets all the requirements of this performance specification to provide guidance on the performance of the fabric in arc exposure testing. There is no minimum required value for arc rating. For additional information on ATPV and E_{BT}, see Test Method F 1959.

6.3.6.1 When garments are made with a different number of fabric layers in different areas of the garment, the arc rating for each area shall be designated. Pockets, trim, closures, seams, labels, and heraldry shall not be considered as extra layers.

7. Test Methods

7.1 *Breaking Load*—Determine the breaking load in accordance with Test Methods D 5034 (Grab test G: CRT or CRE).

7.2 *Tear Resistance*—Determine the tear resistance in accordance with Test Method D 1424.

7.2.1 As an option for selected materials, Test Method D 2262 may be employed. This option may be exercised upon agreement between the buyer and the seller. However, correlation between this test method and Test Method D 1424 is not expected.

7.3 *Seam Slippage*—Determine the seam slippage in accordance with Test Method D 434.

7.4 *Colorfastness*:

7.4.1 *Laundering*—Determine the colorfastness to laundering in accordance with AATCC Method 61, IIA.

7.4.2 *Dry Cleaning*—Determine the colorfastness to dry cleaning in accordance with AATCC Method 132.

NOTE 7—Launderable fabrics are expected to be dry-cleanable except where all or part of the fabric is not dry-cleanable and is so labeled. Goods labeled "Dry Clean Only" are to be only dry-cleaned.

7.5 *Dimensional Change*—For laundry shrinkage, determine dimensional change as directed in AATCC Method 135, using Conditions for Machine Cycle 3, Wash Cycle IV, Drying Procedure A iii, five washes. For dry-cleanable shrinkage, use AATCC Test Method 158.

NOTE 8—AATCC Method 135 should not be employed for fabrics marked "Do Not Wash."

7.6 *Flammability*—The flammability of the material shall be tested in accordance with Test Method D 6413 for samples both initially and after washing as specified in 7.6.1 or dry cleaning as specified in 7.6.2. No melting and dripping of the test material is permitted.

7.6.1 Fabrics suitable for washing shall be washed 25 times using the AATCC Method 135 (3, IV, A iii).

7.6.2 Fabrics labeled "Dry Clean Only" shall be dry-cleaned 25 times using the procedure in Test Methods D 2724, Section 6.1.

7.7 *Bursting Strength*—Determine the bursting strength of knitted fabrics in accordance with Test Method D 3786.

7.8 *Arc Rating*—If the material meets the flammability requirements in 7.6 and Tables 1 and 2, determine the arc rating of the material in accordance with Test Method F 1959. Test Method F 1959 is a design test.

NOTE 9—Arc rating values below 10 cal/cm^2 shall be reported to the nearest 0.1 cal/cm^2, and arc rating values above 10 cal/cm^2 shall be reported to the nearest 1 cal/cm^2.

7.8.1 When arc testing in accordance with Test Method F 1959, for single layer systems only, afterflame time shall be determined by calculating the average afterflame time of at least three arc test specimens for which the incident energy is equal to or greater than the ATPV or E_{BT} (which ever is applicable). All arc test specimen exposures for which the incident energy is equal to or greater than the ATPV or E_{BT} shall be reported and used in the determination of afterflame time. Afterflame time shall not be more than 5 s.

8. Report

8.1 Report the following information:

8.1.1 Results of testing as required in Sections 5, 6, and 7,

8.1.2 Lot number,

8.1.3 Size of lot,

8.1.4 Sample identification, and

8.1.5 Number of samples tested in accordance with 6.2.

8.2 For each sample fabric that meets the requirements of this performance specification, a report similar to the format shown in Table 1 for woven fabrics or Table 2 for knit fabrics shall be used to report the results of testing that is required in Sections 5, 6, and 7. In addition, a description of the fabric composition, weight, color, and weave or knit construction shall be included. This report shall be made available to the purchaser of garments meeting this performance specification by the garment manufacturer.

APPENDIX

(Nonmandatory Information)

X1. GUIDELINES FOR PROTECTIVE WEARING APPAREL

X1.1 Although this performance specification for basic protection level wearing apparel for electrical workers is written for single-layer work clothing, it is recognized that optimum protective performance to severe exposure (for example, high currents, closeness to the arc, long time periods) involves the use of an appropriate system.

X1.1.1 Garments worn as underlayers (underwear) that neither ignite nor melt and drip in the course of an exposure to the electric arc and related thermal hazard may provide additional thermal insulation.

X1.1.2 Garments that meet this performance specification may be used for a layered system for added protection. A typical layering system may include an undershirt, a shirt, trousers, and a flash jacket or may include a shirt and trouser and coverall. Specific tasks that may involve high-energy levels, for example switching, grounding, and jumpering, may require specialized clothing.

X1.1.3 Additional factors that may contribute to injury are under consideration and may result in the need to consider other specifications for protective systems.

X1.2 *Design Considerations*—The following are some of the principles that should be considered in the design and use of wearing apparel for protection from momentary electric arc and related thermal hazards:

X1.2.1 Clothing should cover potentially exposed areas as completely as practicable. This should include proper interfacing of related items.

X1.2.2 Garment design should permit easy and rapid removal. Closure design should be appropriate for easy removal of the garment.

X1.2.3 Garment design should be such that the garment interferes the least with work function but still provides the necessary protection.

X1.2.4 The fit of all garments is important to acceptance and function. A sizing document for protective wearing apparel is under consideration by Subcommittee F18.40.

X1.2.5 Logos, name tags, and other heraldry, such as flag patches and company award insignias, are used to identify the organization and individual. If these items are constructed of non-flame resistant materials (such as polyester or rayon), their overall area should be minimized on the garment. For example, large company logos across the back of the garment should not be applied. In addition, the use of several logos over the entire garment should be avoided.

X1.3 *Laundering:*

X1.3.1 The garment manufacturer in conjunction with the fiber and fabric supplier should provide instructions for the care and maintenance of protective wearing apparel. See Guide F 1449 concerning care and maintenance of protective garments.

X1.3.2 Because of the variety of different types of knitted fabrics that might be used in different configurations of protective wearing apparel, it is not possible to provide a meaningful value for shrinkage in Table 2. Values of 10 to 12 % shrinkage are not uncommon. It is suggested that knitted garments expected to shrink significantly be purchased appropriately oversized and that they be washed one time by the wearer in accordance with the instructions of the manufacturer prior to use to thus reach a more stable configuration.