



Designation: F1891 – 06

## Standard Specification for Arc and Flame Resistant Rainwear<sup>1</sup>

This standard is issued under the fixed designation F1891; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

### 1. Scope

1.1 This specification establishes applicable test methods, minimum physical and thermal performance criteria, a suggested sizing guide, and suggested purchasing information for rainwear for use by workers who may be exposed to thermal hazards of momentary electric arcs and open flames.

1.1.1 This specification does not apply to the electrical contact hazards or electric shock hazards involved with electric arcs.

1.1.2 This specification does not apply to flash fire hazards such as industrial hydrocarbon flash fires or other petrochemical flash fire hazards.

1.2 The objective of this specification is to prescribe fit, function and performance criteria for rainwear that meets a minimum level of thermal and physical performance when exposed to a laboratory-simulated electric arc or flame exposure.

1.3 This specification is not intended to serve as a detailed manufacturing or purchasing specification, but can be referenced in purchase contracts to ensure that minimum performance requirements are met.

1.4 Controlled laboratory tests used to determine compliance with the performance requirements of this specification shall not be deemed as establishing performance levels for all situations to which wearers of this protective clothing may be exposed.

1.5 The in-service care and use of this rainwear is beyond the scope of this specification.

1.6 The values stated in inch-pound units are to be regarded as the standard. The SI units shown in parentheses are for information only.

1.7 The following safety hazards caveat pertains only to Sections 7 and 9, of this 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*

<sup>1</sup> This 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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*to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

### 2. Referenced Documents

#### 2.1 ASTM Standards:<sup>2</sup>

D123 Terminology Relating to Textiles

D751 Test Methods for Coated Fabrics

D1117 Guide for Evaluating Nonwoven Fabrics (Withdrawn 2009)<sup>3</sup>

D1388 Test Method for Stiffness of Fabrics

D3393 Specification for Coated Fabrics—Waterproofness

D3776 Test Methods for Mass Per Unit Area (Weight) of Fabric

D4391 Terminology Relating to The Burning Behavior of Textiles

D6413 Test Method for Flame Resistance of Textiles (Vertical Test)

F1494 Terminology Relating to Protective Clothing

F1958/F1958M Test Method for Determining the Ignitability of Non-flame-Resistant Materials for Clothing by Electric Arc Exposure Method Using Mannequins

F1959/F1959M Test Method for Determining the Arc Rating of Materials for Clothing

#### 2.2 Federal Specifications:<sup>4</sup>

Federal Test Method Standard (FTMS) No. 191A Method 5516

Federal Test Method Standard (FTMS) No. CCC-T-191b Method 5204

#### 2.3 AATCC Standards:

AATCC Test Method 135 Dimensional Changes Automatic Home Laundering of Woven and Knitted Fabrics<sup>5</sup>

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

<sup>3</sup> The last approved version of this historical standard is referenced on [www.astm.org](http://www.astm.org).

<sup>4</sup> Available from Standardization Documents Order Desk, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

<sup>5</sup> AATCC Technical Manual, available from American Association of Textile Chemists and Colorists, One Davis Dr., PO Box 12215, Research Triangle Park, NC 27709-2215.

### 3. Terminology

#### 3.1 Definitions:

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

3.1.1.1 *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.

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

3.1.2.1 *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.

3.1.3 *arc rating*, *n*—value attributed to materials that describes their performances to an exposure to an electric arc discharge.

3.1.3.1 *Discussion*—The arc rating is expressed in cal/cm<sup>2</sup> and is derived from the determined value of ATPV or  $E_{BT}$  (should a material system exhibit a breakopen response below the ATPV value).

3.1.4 *arc resistant*, *adj*—the property of a material or clothing system that provides thermal protection from an arc exposure.

3.1.5 *arc thermal performance value (ATPV)*, *n*—in arc testing, the incident energy on a material or multilayer system of materials that results in a 50 % probability that sufficient heat transfer through the tested specimen is predicted to cause the onset of a second-degree skin burn injury based on the Stoll curve, cal/cm<sup>2</sup> (j/cm<sup>2</sup>).

3.1.6 *breakopen*, *n*—in testing thermal protective materials, a material response evidenced by the formation of one or more holes in the material which may allow thermal energy to pass through the material.

3.1.6.1 *Discussion*—The specimen shall be considered to exhibit breakopen when any hole is at least 3.2 cm<sup>2</sup> (0.5 in.<sup>2</sup>) in area or at least 2.5 cm (1.0 in.) in any dimension. Single threads across the opening or hole do not reduce the size of the hole for the purposes of this practice. In multiple layer specimens of flame resistant materials all the layers must breakopen to meet the definition. In multiple layer specimens, if any of the specimen layers are ignitable, these hole dimension criteria for breakopen are applied to the FR layer covering ignitable layer that is closest to the heat exposure surface.

3.1.7 *breakopen threshold energy ( $E_{BT}$ )*, *n*—the incident energy on a material or system of materials that results in a 50 % probability of breakopen.

3.1.7.1 *Discussion*—Both  $E_{BT}$  and ATPV are determined and reported for the purposes of this specification.

3.1.8 *char length*, *n*—in measuring flame resistance of textiles, the distance from the fabric edge which was directly exposed to the flame to the furthest point of visible fabric damage after a specified tearing force has been applied.

3.1.9 *charring*, *n*—the formation of carbonaceous residue as the result of pyrolysis or incomplete combustion.

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

3.1.10.1 *Discussion*—Perform the design test only when a new or modified rainwear material, substrate, coating or adhesive is used to manufacture rainwear. A change in rainwear material could be, but is not limited to, any of the following: The composition, weight or supplier of the substrate, or both, coating, laminate, or adhesive.

3.1.11 *dripping*, *n*—in testing thermal protective fabrics, coated fabrics or laminates, a material response evidenced by flowing of the fiber polymer, the fabric, or the fabric coating, and the evidence of droplets from the material.

3.1.12 *electric arc ignition*, *n*—as related to electric arc exposure, a response that causes the ignition of textile material which is accompanied by heat and light, and then subsequent burning for at least 5 s, or consumption of at least 25 % of the test specimen area.

3.1.13 *embrittlement*, *n*—the formation of a brittle residue as the result of pyrolysis or incomplete combustion.

3.1.14 *flame resistance*, *n*—the property of a material whereby flaming combustion is prevented, terminated, or inhibited following application of a flaming or nonflaming source of ignition, with or without subsequent removal of the ignition source.

3.1.15 *heat attenuation factor (HAF)*, *n*—in electric arc testing, the percent of the incident energy which is blocked by a material at an incident energy level equal to ATPV.

3.1.16 *human tissue heat tolerance*, *n*—in testing of thermal protective materials, the amount of thermal energy transferred to human tissue, which is predicted to cause a second degree burn; the Stoll curve.

3.1.17 *incident energy ( $E_i$ )*, *n*—in electric arc testing, the total heat energy received at a surface as a direct result of an electric arc.

3.1.17.1 *Discussion*—In an arc test, incident energy for a specimen is determined from the average temperature rise response of the two monitor sensors adjacent to the test specimen.

3.1.18 *melting*, *n*—the liquefaction of material under the influence of heat.

3.1.19 *shrinkage*, *n*—a decrease in one or more dimensions of an object or material.

3.1.19.1 *Discussion*—Shrinkage shall be determined as follows: before mounting the material specimen for arc exposure, measure the specimen width in inches (cm) at the mid point along the long dimension of the specimen. After arc exposure, measure the specimen width in inches (cm) at the point of greatest specimen shrinkage. The “shrinkage” in inches (cm) of the specimen is determined by subtracting the specimen width after arc exposure from the specimen width before arc exposure. The percent shrinkage is determined by dividing the “shrinkage” by the “specimen width” (before arc exposure) and multiplying by 100.

3.1.20 *stoll curve, n*—curve used to predict the onset of second degree burn injury.

3.1.20.1 *Discussion*—The values which make up the Stoll curve are listed in Table X5.1.

3.1.21 *thermal exposure, n*—the intensity of heat energy to which a fabric is exposed.

3.1.21.1 *Discussion*—As related to electric arc testing, the level of incident energy, in calories per centimetre squared ( $\text{cal/cm}^2$ ), that is transferred to the material surface as determined by measuring the rise in temperature on monitor copper calorimeters, positioned adjacent to the material.

3.1.22 *thermal protection, n*—of a material, the property that characterizes overall performance relative to reducing the transfer of heat that is sufficient to cause a second-degree burn.

3.1.22.1 *Discussion*—Thermal protection of a material and the predicted second-degree burn injury can be quantified by the measured sensor response and the observed breakopen material response which indicate how well the material blocks heat from the sensor surface and how well the material resists breakopen.

3.1.23 *thermal resistance, n*—the reciprocal of thermal transmittance.

3.1.24 *thermal material response, n*—in the testing of thermal protective materials, the effects that are observed concurrent and subsequent to thermal exposure, which can include phenomena such as breakopen, charring, embrittlement, melting, shrinkage, etc.

3.1.24.1 *Discussion*—In electric arc testing, the thermal material response can be a result of intense radiant energy, convective energy, molten metal splatter from electrodes or shock wave from rapidly expanding heated, ionized air, or any combination of these.

3.1.25 *thermal transmittance, n*—time rate of unidirectional heat transfer per unit area, in the steady-state, between parallel planes separated by unit difference of temperature of the planes.

3.2 *Definitions*—For definitions of other textile terms used in this specification refer to Terminology **D123**, **D4391** and **F1494**.

## 4. Significance and Use

4.1 This specification covers the minimum performance criteria for arc resistance, flame resistance and other requirements for rainwear used by workers who may be exposed to thermal hazards of momentary electric arcs or flame.

4.1.1 Material response characteristics, resulting from the arc exposure shall be reported as a part of the thermal performance characteristics (see 9.3.4).

4.2 This specification establishes minimum performance criteria for rainwear material and rainwear seams that will provide workers with protection from rain under conditions of possible exposure to the thermal hazards of momentary electric arcs and open flames.

4.3 Rainwear material that meets the thermal and physical performance criteria of this specification has been subjected to an electric arc exposure test, Test Method **F1959/F1959M**.

NOTE 1—When rainwear is worn over conventional clothing or flame resistant garments, the rainwear material in combination with fabric(s) worn under the rainwear may also be subjected to the electric arc exposure test, Provisional Test Methods **PS 57F1958/F1958M** or **F1959/F1959M** and the results reported.

4.4 The purchaser has the option to perform or have performed any of these tests in order to verify the performance of the rainwear. Claims for failure to meet the specification are subject to verification by the manufacturer.

4.5 This specification for rainwear shall not be construed as a requirement for the use of any particular rainwear material.

## 5. Ordering Information

5.1 The following items should be considered by the purchaser when buying rainwear under this specification and included, as necessary, in purchasing documents:

- 5.1.1 Type of material,
- 5.1.2 Fabric weight ( $\text{oz/yd}^2$ ),
- 5.1.3 Type and material of fasteners (buttons, snaps, zippers or hook and loop fasteners),
- 5.1.4 Reflective material sections (optional),
- 5.1.5 Style and design or catalog number,
- 5.1.6 Hood design (attached or detachable),
- 5.1.7 Sizes,
- 5.1.8 Color,
- 5.1.9 Special identification markings (optional),
- 5.1.10 Jacket length, and
- 5.1.11 Notation of conformance to this specification.

## 6. Materials and Manufacture

6.1 The rainwear shall be manufactured of materials and constructed using seams that meet the requirements for leak resistance.

6.2 Positive closures, such as buttons or snaps, should be constructed so that they are covered by the rainwear outer layer material. This will result in the garment having a multiple layer construction in the area of the closure. This will also prevent the positive closure from being directly exposed to the hazard.

NOTE 2—In limited testing, some uncovered closures may melt and fuse. Constructing the closures so that they are covered as described above eliminates the melting and fusing observed with uncovered closures.

## 7. Physical Requirements

7.1 Rainwear material shall meet the physical requirements of this specification initially as manufactured and shall meet this specification after five cleanings, when cleaned as directed by the care instructions from the manufacturer.

7.1.1 If no cleaning instructions are provided by the manufacturer, the garments shall be laundered five times in accordance with AATCC Method 135 (3, IV A iii).

7.1.2 The average weight of the rainwear material shall be determined in accordance with Test Method **D3776**, Option C, using the following instructions: Five weight determination specimens, each consisting of a circle of material 3.5 in. (8.9 cm) in diameter, shall be taken from the sample of rainwear material which will be submitted for the material testing required in 7.2.1, 7.4.1, 9.2, and 9.3. If a single, continuous sample of rainwear material is used for all of the designated

tests, one weight determination shall be done. If a different sample of rainwear material is used for one or more of the designated tests, a separate weight determination shall be done for each rainwear material sample. The five weight determination specimens shall be selected at approximately equally spaced intervals diagonally along the length of the rainwear material sample. For each weight determination that is done, the average weight for the five specimens and the weights of the individual specimens with the highest and lowest weights shall be reported on **Table 1** and to the testing laboratory. The supplier's nominal weight for the rainwear material shall also be reported on **Table 1** and to the testing laboratory.

**7.2 Leak Resistance—Fabric and Seams:**

7.2.1 The fabric of the sample rainwear shall withstand water pressure without leaking at 30 psig (207 kPa), when tested by Specification **D3393**.

7.2.2 The seams of the sample rainwear material shall withstand water pressure with no evidence of water leakage at 3 psig (20.7 kPa) for 2 min, when tested by Federal Test

Method Standard (FTMS) No. 191A Method 5516 as modified. (Note that this requirement is modified versus the parameters listed in the referenced test method.)

7.2.2.1 A pump device may be used to achieve 3 psig (20.7 kPa) if extension of the water column is not practical.

7.3 Markings and reflective materials attached to the rainwear shall be of the permanent type and electrically non-conductive, and shall not degrade the performance of the rainwear.

**7.4 Trapezoidal Tearing Resistance—Fabric :**

7.4.1 The rainwear material shall be tested for trapezoidal tearing resistance according to Test Methods **D1117** except that the measured value shall be the average of the five highest peak loads. Rainwear material shall have a trapezoidal tearing resistance of not less than 6 lb (2.7 kg) in the warp direction and 6 lb (2.7 kg) in the fill direction. **Appendix X3** provides detailed information for the trapezoidal tearing resistance of rainwear material according to Test Methods **D1117**.

**TABLE 1 Rainwear Material Performance Requirements Test Report**

Company Issuing Report _____				
Date of Report _____				
Sample description for rainwear material				
Composition of substrate _____				
Coating or laminate _____				
Nominal Weight, oz/yd <sup>2</sup> (g/m <sup>2</sup> ) _____				
Average Weight per Test Method <b>D3776</b> , oz/yd <sup>2</sup> (g/m <sup>2</sup> ) _____				
Lowest and Highest Weights per Test Method <b>D3776</b> , oz/yd <sup>2</sup> (g/m <sup>2</sup> ) _____				
Color _____				
		Specification F1891 Requirement	Material Performance	
		Initial & After 5 Cleanings (except where noted)	Initial	After 5 Cleanings
Flame Resistance – Test Method <b>D6413</b>	After flame	ASTM F1891-06 ≤ 2 s	____ s	____ s
	Char length	< 6 in.	____ in.	____ in.
	Melt and drip	no	yes/no	yes/no
Tear Strength Resistance – Guide <b>D1117</b> (modified)		≥ 6 lb (w), ≥ 6 lb (f)	____ lb (w), ____ lb (f)	____ lb. (w), ____ lb. (f)
Waterproofness of Rainwear Fabric Specification <b>D3393</b> at 30 psi		no leakage	- - - -	- - - -
Waterproofness of Seams at 3 psi for 2 min. – FED-STD-191A Method 5516		no leakage	- - - -	- - - -
Electric Arc Resistance — Test Method <b>F1959/F1959M</b> @ 8kA, 12 in. gap, 12 in. distance from arc, stainless steel electrodes		ASTM F1891 Requirement	Material Performance	
Material Average Weight as tested		n/a	____ oz/yd <sup>2</sup> (g/m <sup>2</sup> )	
Material Weight Range as tested (after cleaning)			____ oz/yd <sup>2</sup> (g/m <sup>2</sup> )	
Arc Rating (ATPV) or Arc Rating ( $E_{BT}$ ) (Report lower value of ATPV or $E_{BT}$ )		≥ 5 cal/cm <sup>2</sup> (20.9 J/cm <sup>2</sup> ) Determined after 3 washings and 1 drying	____ cal/cm <sup>2</sup> (J/cm <sup>2</sup> ) Indicate whether Arc Rating (ATPV) or Arc Rating ( $E_{BT}$ )	
ATPV or $E_{BT}$ (Report higher value of ATPV or $E_{BT}$ )		Report Only	____ cal/cm <sup>2</sup> (J/cm <sup>2</sup> ) Indicate whether ATPV or $E_{BT}$	
Heat Attenuation Factor – HAF		Report Only no minimum value	— % HAF	
Melting and Dripping at 2X Arc Rating		No melting and dripping	yes/no	



**8. Performance Requirements**

8.1 Rainwear material shall conform to the requirements of 7.2.1 for leak resistance.

8.2 Rainwear shall be manufactured with seams that meet the criteria of 7.2.2 for leak resistance.

8.3 Markings and reflective materials shall conform to the requirements of 7.3.

8.4 Rainwear material shall conform to the requirements of 7.4 for trapezoidal tearing resistance.

8.5 The fabrics, stitchings, tapes, coatings, fasteners, and closures used to manufacture the rainwear should be made from electrically non-conductive materials. If conductive fasteners or closures, for example, zippers, snaps, or buttons, or combination thereof, are used, they shall be covered with a layer of rainwear material on the inside of the garment between the closure and the undergarment or skin.

8.5.1 *Discussion*—If fasteners or closures, for example, zippers, snaps, or buttons, or 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 to the skin. Using a layer of material between the conductive fastener or closure and the undergarment or skin can reduce heat transfer to the skin. There is no intent that this added layer of material can provide a reliable electrical insulation barrier.

8.6 The stitchings, thread, findings, zipper tapes, or fasteners, or combination thereof, used to manufacture the rainwear shall not degrade the flame resistance or thermal performance of the rainwear.

8.7 Rainwear material shall conform to the requirements of 9.2 for flame resistance.

8.8 Rainwear material shall conform to the requirements of 9.3 for thermal resistance to an electric arc exposure.

8.9 The format shown in Tables 1 and 2 shall be used to report the results for all performance requirements and test observations. This report shall be made available to the purchaser of rainwear meeting this specification by the rainwear manufacturer.

**9. Thermal Performance Requirements**

9.1 If the rainwear is constructed of a single-layer material or a multi-layer system of materials, then a single-or multi-layer sample of the rainwear as constructed shall be subjected to all thermal tests.

9.2 The rainwear material shall be tested for flame resistance by use of Test Method D6413. Specimens shall not melt and drip when subjected to the flame or continue to burn for more than 2 s after removal of the ignition source. The char length shall be equal to or less than 15 cm (6 in.) for each specimen.

NOTE 3—Both melting and dripping must occur for a specimen to fail. An indication of melting by itself shall not be interpreted as melting and dripping.

9.2.1 Rainwear material shall meet the requirements of 9.2 initially as manufactured and after five cleanings when cleaned as directed by care instructions from the manufacturer.

9.2.1.1 If no cleaning instructions are provided by the manufacturer, the garments shall be laundered three times in accordance with AATCC Method 135 (3, IV A iii).

9.3 Rainwear material shall be tested for thermal resistance to an electric arc exposure by the use of Test Method F1959/F1959M. Test parameters for Test Method F1959/F1959M shall be 8 ± 1 kA arc current, 30 cm (12 in.) electrode gap, stainless steel electrodes, 30 cm (12 in.) distance between the arc center line and the rainwear material specimen surface. Additional test parameters may also be used and the results reported on an optional basis.

NOTE 4— Test Method F1959/F1959M is a design test.

9.3.1 Rainwear material shall be tested in accordance with 9.3 after three washings followed by one drying. The washing shall be done as directed by care instructions from the manufacturer.

9.3.1.1 If no cleaning instructions are provided by the manufacturer, the garments shall be washed three times in accordance with the AATCC Method 135 (3, IV A iii) followed by one drying.

9.3.1.2 For the rainwear material sample submitted for arc testing the material weight after cleaning shall be determined according to Test Method D3776, Option C per the following instructions. One weight determination specimen consisting of a circle of material 3.5 in. (8.9 cm) in diameter shall be taken from each of five rainwear material arc test specimens selected at random. The average material weight and the total range of material weight for the five specimens shall be reported with the arc test results.

NOTE 5—In arc testing of FR rainwear material, large material weight variations have on occasion been observed. The intent of this provision is to indicate situations in which the material weight variation exceeds a total

**TABLE 2 Subjective Material Response Characteristics**

	Within 1.0cal/cm <sup>2</sup> of Arc Rating		At Two Times Arc Rating	
	Observation # 1	Observation # 2	Observation # 1	Observation # 2
Incident Energy, cal/cm <sup>2</sup>				
After flame time, s				
Breakopen (yes/no), in. (cm)				
Charring (yes/no)				
Melting (yes/no)				
Dripping (yes/no)				
Electric Arc Ignition (yes/no)				
Embrittlement (yes/no)				
Shrinkage, %				

of 5 % which would normally be expected from laundering, drying, humidity differences and normal test method error.

9.3.2 When rainwear is subjected to higher arc current exposures, the arc rating (ATPV) increases due to surface cooling effects or rainwear material changes, or both, during arc exposure. Consequently, Test Method **F1959/F1959M** arc test parameters are mandated in order to provide a consistent comparative database for rainwear fabrics. The specific parameter of 8 kA was selected due to ATPV changes leveling off close to a minimum value at this arc current level and due to relatively high availability of rainwear results at this arc current level.

9.3.3 The arc rating, the arc thermal performance value (ATPV), heat attenuation factor (HAF), and the breakopen threshold energy ( $E_{BT}$ ) shall be determined according to Test Method **F1959/F1959M** and reported.

NOTE 6—In most cases,  $E_{BT}$  is greater than ATPV, and in this case ATPV is designated by Test Method **F1959/F1959M** to be the arc rating. However, in the few cases in which the breakopen threshold is less than ATPV,  $E_{BT}$  is designated by Test Method **F1959/F1959M** to be the arc rating. In either case  $E_{BT}$  is provided to aid end users in matching rainwear to the appropriate protective ensemble. That is to say, after the electrical arc hazard level has been quantified in terms of cal/cm<sup>2</sup>, the next step is to select a protective ensemble with an arc rating, quantified in terms of cal/cm<sup>2</sup>, that is equal to or greater than the electrical arc hazard level. Rainwear to be worn as an outer layer can be matched to the subject's ensemble by ensuring that the  $E_{BT}$  of the rainwear is equal to or greater than the arc rating for the ensemble it is to be worn over. If rainwear is to be relied on as one of the protective layers in a protective ensemble, then it needs to be tested as a multi-layer ensemble in accordance with Test Method **F1959/F1959M** and assigned an arc rating, which in turn has to be equal to or greater than the hazard level in question. In other words, the  $E_{BT}$  is not to be used as a protective term in matching rainwear to a hazard level, but rather is a breakopen term to be used to match rainwear to the protective ensemble that has already been appropriately matched with the hazard in question. It should be noted that rainwear may pose a hazard to the wearer if it is exposed to energy beyond  $E_{BT}$  regardless of the presence of protective under layers.

NOTE 7— $E_{BT}$  is determined and reported because it is important to report a breakopen threshold for rainwear material, since melting and ignition hazards may occur when a rainwear material breaks open during arc exposure.

9.3.4 Arc rating shall be equal to or greater than 5.0 cal/cm<sup>2</sup> (20.9 J/cm<sup>2</sup>).

9.3.5 The material response characteristics for rainwear material, including *afterflame time, breakopen, charring, dripping, electric arc ignition, embrittlement, melting, and shrinkage*, shall be reported for two typical exposures at least equal to the arc rating and also for two typical exposures at least two times the arc rating.

9.3.6 When arc testing according to Test Method **F1959/F1959M**, dripping shall be determined by observing all valid arc test specimen exposures in an incident energy range from the arc rating to 2 cal/cm<sup>2</sup> (8.4 J/cm<sup>2</sup>) above the arc rating. At least three arc test specimen exposures for which the incident energy is at least equal to the arc rating but not greater than 2.0 cal/cm<sup>2</sup> (8.4 J/cm<sup>2</sup>) above the arc rating shall be used in the determination of dripping. There shall be no dripping for valid arc test specimen exposures within this range of incident energy.

9.3.6.1 An arc test specimen exposure involves a single test specimen on one instrumented panel in Test Method **F1959/F1959M**. A valid arc test specimen exposure is one which can be used in the determination of arc rating according to Test Method **F1959/F1959M**. Both melting and dripping must occur for a specimen to fail.

9.3.6.2 Specimen exposures for the determination of dripping shall all be from the same lot of test material.

9.3.6.3 Specimen exposures for the determination of dripping shall be from the same arc testing series and shall be conducted on a single day or consecutive testing days.

9.3.7 There shall be no dripping for the specimen exposures at least two times the arc rating.

## 10. Stiffness of Rainwear Fabrics (Optional Test Method)

10.1 Optional test methods for determining stiffness of the rainwear are provided in **Appendix X2**.

## 11. Sequence of Testing and Inspection

11.1 The following order of testing is suggested for the evaluation of rainwear material:

11.1.1 Inspection of the fabric and seam specimen.

11.1.2 Water leakage testing; fabric and prepared seam specimen.

11.1.3 Fabric trapezoidal tearing resistance testing.

11.1.4 Fabric flame resistance testing.

11.1.5 Electric arc exposure testing. (This is a design test.)

11.1.6 Inspection of rainwear, seams, style, labeling, markings and color.

## 12. Compliance Certification

12.1 Rainwear material shall be tested and certified by the manufacturer or supplier to be in compliance with the requirements of this specification.

12.1.1 The user, at his expense, shall have the option to verify compliance with the requirements of this specification.

12.2 Except where noted as a design test, the rainwear material shall be tested at least every 12 months to confirm compliance with the requirements of this specification.

12.3 The rainwear supplier or manufacturer shall provide compliance testing and certification to the purchaser when a new or modified rainwear material, substrate, coating, or adhesive is used to manufacture rainwear. A change in rainwear material could be, but is not limited to, any of the following: the composition, weight, or supplier of the substrate, coating, laminate, or adhesive, or combination thereof. The test noted as "design test" as well as all other tests shall be repeated to verify compliance with the performance requirements of this specification.

12.4 The entire shipment or lot of rainwear material shall be rejected for use under this specification if the selected samples do not meet the requirements of this specification.

## 13. Labeling, Identification, and Packaging

13.1 Each item of rainwear shall be permanently identified or labeled with its size, style designation or catalog number, the manufacturer's name and notation of conformance to this