



Designation: F2178/F2178M – 22

## Standard Specification for Arc Rated Eye or Face Protective Products<sup>1</sup>

This standard is issued under the fixed designation F2178/F2178M; 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 product specification is used to determine the arc rating and specify the requirements for products intended for use as eye or face protection for workers exposed to electric arcs. The arc rating is determined in the test with an arc which has a heat flux value of 2100 kW/m<sup>2</sup> [50 cal/cm<sup>2</sup>/s]. Products are tested as sold.

1.2 The products covered by this standard are in the form of faceshields attached to the head by protective helmets (hard hats), headgear, hood assemblies, safety spectacles or goggles. Faceshields, safety spectacles or goggles are tested with or without other face and head protective products, for example, sock hoods, balaclavas, sweat shirt hoods or jacket hoods.

1.2.1 Fabric layers used in the design of face protection products such as in hood, neck guards, balaclava, meet the requirements of Specification F1506. When fabrics are designed into the protection provided for eye or face protective products, the arc rating of fabric system is first determined by Test Method F1959/F1959M.

1.2.2 The arc rating of the eye or face protective product which requires fabric to provide protection to the face or head will not be higher than the lower arc rating of either the fabric system or the shield/visor assembly.

1.3 The values stated in SI units shall be regarded as standard except as noted. Within the text, alternate units are shown in brackets. The values stated in each system may not be exact equivalents; therefore, alternate systems must be used independently of the other. Combining values from the systems described in the text may result in nonconformance with the method.

1.4 This standard does not purport to describe or appraise the effect of the electric arc fragmentation or propulsion of parts of equipment or molten metal splatter, deposited from the pressure wave containing molten metals and possible fragments of other materials except to the extent that heat energy transmission due to these arc explosion phenomena is reduced by test specimens.

<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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1.5 This standard shall not be used to describe or appraise the fire hazard or fire risk of materials, products, or assemblies under actual fire conditions. However, results of this test may be used as elements of a fire assessment which takes into account all of the factors which are pertinent to an assessment of the fire hazard of a particular end use.

1.6 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.* For specific hazards see Section 11.

1.7 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

### 2. Referenced Documents

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

C177 Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus

D123 Terminology Relating to Textiles

D4391 Terminology Relating to The Burning Behavior of Textiles

F1494 Terminology Relating to Protective Clothing

F1506 Performance Specification for Flame Resistant and Electric Arc Rated Protective Clothing Worn by Workers Exposed to Flames and Electric Arcs

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

#### 2.2 ANSI/IEEE Standards:

IEEE Standard Dictionary of Electrical and Electronics Terms<sup>3</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> Available from Institute of Electrical and Electronics Engineers, Inc. (IEEE), 445 Hoes Ln., Piscataway, NJ 08854-4141, <http://www.ieee.org>.

**ANSI/ISEA Z87.1, American National Standard for Occupational and Educational Personal Eye and Face Protection Devices**<sup>4</sup>

### 3. Terminology

3.1 For definitions of other textile terms used in this specification, refer to Terminologies **D123**, **D4391**, **F1494** and the IEEE Standard Dictionary of Electrical and Electronics Terms.

#### 3.2 Definitions:

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

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

3.2.3 *arc duration*, *n*—time duration of the arc, *s*.

3.2.4 *arc energy*, *n*—sum of the instantaneous arc voltage values multiplied by the instantaneous arc current values multiplied by the incremental time values during the arc, *J*.

3.2.5 *arc gap*, *n*—distance between the arc electrodes, cm [in.].

3.2.6 *arc rating*, *n*—value attributed to materials that describes their performance to exposure to an electric arc discharge,  $\text{J}/\text{cm}^2$  [ $\text{cal}/\text{cm}^2$ ].

3.2.6.1 *Discussion*—The arc rating is expressed in  $\text{J}/\text{cm}^2$  [ $\text{cal}/\text{cm}^2$ ] and is derived from the determined value of *ATPV* or *EBT* (should a material system exhibit a breakopen response below the *ATPV* value) or the Arc Rating Limit. It can be expressed in short form as either  $AR_{ATPV}$ ,  $AR_{EBT}$  or  $AR_{Lim}$ .

3.2.7 *arc thermal performance value (ATPV)*, *n*—in arc testing, the incident energy of a fabric or material that results in 50 % probability that sufficient heat transfer through the specimen is predicted to cause the onset of a second-degree skin burn injury based on the Stoll curve.<sup>5</sup>

3.2.8 *arc rating limit ( $AR_{Lim}$ )*, *n*—the maximum arc thermal energy protection that has been assigned to the product based on the manufacturer's specifications after verification with testing or limits of detection of the test method.

3.2.8.1 *Discussion*—For hoods, the  $AR_{Lim}$  could be a limit made by the test laboratory based on the equipment limits of the energy exposure ( $418.4 \text{ J}/\text{cm}^2$  [ $100 \text{ cal}/\text{cm}^2$ ] in many laboratories) or the producer may deliberately specify an incident energy value, which may be lower than the arc rating (*ATPV* or *EBT*) of the material or material assembly for the evaluation of the finished product. In this case, testing may deliberately be carried out only at incident energy exposures lower than the projected arc rating of the material or material assembly provided the system meets the visual assessment and all performance criteria.

3.2.9 *arc voltage*, *n*—voltage across the gap caused by the current flowing through the resistance created by the arc gap (*V*).

3.2.10 *asymmetrical arc current*, *n*—the total arc current produced during closure; it includes a direct component and a symmetrical component, *A*.

3.2.11 *blowout*, *n*—the extinguishing of the arc caused by a magnetic field.

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

3.2.12.1 *Discussion*—The specimen is considered to exhibit breakopen when any hole in the material or fabric is at least  $1.6 \text{ cm}^2$  [ $0.5 \text{ in.}^2$ ] in area or at least  $2.5 \text{ cm}$  [ $1.0 \text{ in.}$ ] in any dimension. For textile materials, single threads across the opening or hole do not reduce the size of the hole for the purposes of this test method. In multiple layer specimens, if some of the layers are ignitable, breakopen occurs when these layers are exposed.

3.2.12.2 *Discussion*—A system having multi-layer fabric or multi-layer shields may exhibit formation of holes (ablation) of the outermost layers. Breakopen is not considered attained until the formation of one or more holes has occurred in the innermost layer.

3.2.13 *breakopen threshold energy (EBT)*, *n*—the incident energy on a fabric or material that results in a 50 % probability of breakopen.

3.2.13.1 *Discussion*—This is the value in  $\text{J}/\text{cm}^2$  [ $\text{cal}/\text{cm}^2$ ] determined by use of logistic regression analysis representing the energy at which breakopen of the layer occurred.

3.2.14 *dripping*, *n*—in electric arc testing, a material response evidenced by flowing of a specimen's material of composition.

3.2.14.1 *Discussion*—Dripping is exhibited by either the fabric material or faceshield material, or other parts of eye or face protective products.

3.2.15 *heat flux*, *n*—the thermal intensity indicated by the amount of energy transmitted per area and time  $\text{W}/\text{m}^2$  [ $\text{cal}/\text{cm}^2\text{s}$ ].

3.2.16 *incident energy monitoring sensors*, *n*—sensors mounted on each side of each head, using calorimeters, not covered by specimens, used to measure incident energy.

3.2.17 *incident exposure energy ( $E_i$ )*, *n*—in arc testing, the total incident energy delivered to monitor calorimeter sensors from the arc exposure,  $\text{J}/\text{cm}^2$  [ $\text{cal}/\text{cm}^2$ ].

3.2.17.1 *Discussion*—in an arc test exposure, incident exposure energy for a specimen is the average of the measured incident energy from the respective two monitor sensors adjacent to the test specimen.

3.2.18 *material response*, *n*—material response to an electric arc is indicated by the following terms: breakopen, melting, dripping, deformation, afterflame time, shrinkage, and electric arc ignition.

<sup>4</sup> Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, <http://www.ansi.org>.

<sup>5</sup> Derived from Stoll, A. M., and Chianta, M. A., "Method and Rating System for Evaluations of Thermal Protection," *Aerospace Medicine*, Vol 40, 1969, pp. 1232-1238 and Stoll, A. M., and Chianta, M. A., "Heat Transfer through Fabrics as Related to Thermal Injury," *Transactions – New York Academy of Sciences*, Vol 33(7), Nov. 1971, pp. 649-670.

3.2.19 *melting, n—in arc testing*, a material response evidenced by softening of the material.

3.2.20 *peak arc current, n*—maximum value of the AC arc current, *A*.

3.2.21 *RMS arc current, n*—root mean square of the AC arc current, *A*.

3.2.22 *shrinkage, n—in testing eye or face protective products*, a material response evidenced by reduction in specimen size.

3.2.23 *X/R ratio, n*—the ratio of system inductive reactance to resistance. It is proportional to the *L/R* ratio of time constant, and is, therefore, indicative of the rate of decay of any DC offset. A large *X/R* ratio corresponds to a large time constant and a slow rate of decay.

#### 4. Ordering Information

4.1 The following items should be considered by the purchaser when buying eye or face protective products under this specification and included, as necessary, in purchasing documents:

4.1.1 Arc Rating of the eye or face protective products,  $\text{J}/\text{cm}^2$  [ $\text{cal}/\text{cm}^2$ ],

4.1.2 Type of material in the window of the eye or face protective product,

4.1.3 Thickness of the eye or face protective product, mm [in.],

4.1.4 Type and weight,  $\text{g}/\text{m}^2$  [ $\text{oz}/\text{yd}^2$ ] of hood fabric material in the eye or face protective product for hoods,

4.1.5 Type and material of fasteners (buttons, snaps, zippers or hook and loop fasteners),

4.1.6 Style and design or catalog number,

4.1.7 Special identification markings (optional), and

4.1.8 Notation of conformance to this specification.

#### 5. Physical Requirements

5.1 The faceshield window, safety spectacle or goggle in the eye or face protective product shall meet the requirements of ANSI/ISEA Z87.1. Requirements include: Flammability, Corrosion Resistance, Optical, Cleanability, Markings, Penetration, Minimum Thickness, Drop ball, High Mass, and High Velocity.

5.2 *Scratch Resistance*—Manufacturer shall certify if scratch resistant coating is applied to window of eye or face protective product.

5.3 *Fogging Resistance*—Manufacturer shall certify if anti-fog coating is applied to window of eye or face protective product.

5.4 *For Hoods, Fabric Material Physical Requirements*—Fabric Material in the hood shall meet the requirements of Specification **F1506**.

#### 6. Performance Requirements

6.1 The stitching, thread, findings, fasteners, or other components used to manufacture the eye or face protective product shall not degrade the flame resistance or thermal performance of the eye or face protective products.

6.2 Eye or face protective products shall conform to the requirements of Section 7 for thermal resistance to an electric arc exposure.

6.3 The results for all performance requirements and subjective material evaluations shall be provided. Subjective material evaluations for at least two arc exposures at or above the arc rating shall be reported. This report shall be made available to the purchaser of eye or face protective product meeting this specification by the eye or face protective product manufacturer.

NOTE 1—Example tables for reporting the test results and subjective material evaluation are shown in **Table 1** and **Table 2**.

6.4 Products tested for full face protection shall have an interface that is designed to prevent burns to parts of the face not represented by sensors on the test mannequin head.

NOTE 2—If goggles as part of a full face protective system are tested for full face protection, the system shall not have gaps in areas which are not sensed, such as the nose, around the eyes, etc. The interface shall include the full face and be designed to provide the same performance over the whole face area from the chin area all over the head.

6.5 Products tested for full face protection which have removable parts shall be labeled or designed to make removal or use without proper assembly clear to the end user. Removable faceshields, faceplates, goggles or other systems and the properly matched hood or other protective parts of the system shall be designed and marked in such a way that the proper replacement parts are evident to the end user.

#### 7. Thermal Performance Requirements

7.1 The eye or face protective product shall be tested for thermal resistance to an electric arc exposure by the use of this test method. Test parameters shall be  $8 \pm 1$  kA arc current, 30 cm [12 in.] electrode gap, stainless steel electrodes, 30 cm [12 in.] distance between the arc center line and the mouth sensor surface. Modified test parameters may also be used and the results reported on an optional basis.

NOTE 3—This test method is a design test.

7.2 For hoods, the arc rating of the fabric material shall be determined according to Test Method **F1959/F1959M** and reported.

7.3 The arc rating of the eye or face protective product shall be equal to or greater than  $4.0 \text{ cal}/\text{cm}^2$  [ $16.74 \text{ J}/\text{cm}^2$ ].

7.4 Systems having an arc rating below  $20 \text{ cal}/\text{cm}^2$  [ $83.7 \text{ J}/\text{cm}^2$ ] shall not exhibit ignition or melting and dripping below  $20 \text{ cal}/\text{cm}^2$  [ $83.7 \text{ J}/\text{cm}^2$ ].

7.5 *For Procedure A*—System having an arc rating equal or higher than  $20 \text{ cal}/\text{cm}^2$  [ $83.7 \text{ J}/\text{cm}^2$ ] shall not exhibit ignition or melting and dripping within the mix zone of the iterative procedure.

7.6 *For Procedure B*—System having an arc rating equal or higher than  $20 \text{ cal}/\text{cm}^2$  [ $83.7 \text{ J}/\text{cm}^2$ ] shall not exhibit ignition or melting and dripping in any of the exposures in the verification testing.