Designation: F2621/F2621M – 21

Standard Practice for Determining Response Characteristics and Design Integrity of Arc Rated Finished Products and Evaluating other Products in an Electric Arc Exposure[1]

This standard is issued under the fixed designation F2621/F2621M; 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.

1. Scope

1.1 This practice identifies protocols for use in conducting arc testing on finished products intended for use as thermal protection by workers who may be exposed to electric arc hazards.

1.1.1 The practice is also used for other components which can be exposed to electric arc, but which do not require an arc rating.

1.1.1.1 If items are tested and they do not meet the appropriate standard, it is the responsibility of the specimen submitter to provide this information for indication in the test report.

1.2 Arc Rated protective items are typically tested using this practice to evaluate the performance of the interface area between the product and the other arc flash PPE or to evaluate zippers and other findings.

1.3 When evaluating arc rated PPE with non-arc rated PPE for due diligence (such as respirators, etc.), this practice does not result in an arc rating for non-arc rated components or products shall be clearly indicated as having no arc rating.

1.4 This practice is not intended to produce an arc rating and does not replicate in all types of arc exposures.

1.5 This practice is used with the following standards:

1.5.1 Protective fabric materials receive arc ratings from Test Method F1959/F1959M.

1.5.2 Face protective products receive arc ratings from Test Method F2178.

1.5.3 Gloves receive arc ratings from Test Method F2675.

1.5.4 Rainwear materials, findings and closures are specified by Specification F1891.

1.5.5 Garments are specified by Specification F1506.

1.6 The test specimens used in this practice are typically in the form of arc-rated finished products. These arc-rated finished products may include, but are not limited to, single layer garments, multi-layer garments or ensembles, cooling vests, gloves, sleeves, chaps, rainwear, balaclavas, faceshields, and hood assemblies with hood shield windows. Non-arc rated finished products may be included when part of a flame-resistant system, or for evaluating heat transmission through the finished product for incident reenactment, or for evaluation of products needed but not available as arc rated (such as respirators, etc.)

1.7 The arc rated finished product specimens are new products as sold or products which have been used for the intended purpose for a designated time.

1.8 This practice is used to determine the response characteristics or design integrity of arc-rated materials, products, or assemblies in the form of finished products when exposed to radiant and convective energy generated by an electric arc under controlled laboratory conditions.

1.9 This practice can be used to determine the integrity of closures and seams in arc exposures, the protective performance of arc-rated products in areas where garment overlap occurs or where heraldry reflective trim or other items are used, and response characteristics such as afterflame time, melting, dripping, deformation, shrinkage, ignition, or other damage, or combination thereof, of fabrics, systems of fabrics, flammable undergarments when included as part of a system, sewing thread, findings, and closures.

1.10 This practice can be used for incident reenactment, training demonstrations, and material/design comparisons.

1.11 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system are not necessarily exact equivalents; therefore, to ensure conformance with the standard, each system shall be used independently of the other, and values from the two systems shall not be combined.

1.12 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] This practice 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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1.13 This standard does not purport to describe or appraise the effect of the electric arc fragmentation explosion and subsequent molten metal splatter, which involves the pressure wave containing molten metals and possible fragments of other materials except to the extent that evidence of projectile damage is assessed and reported.

1.14 *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 precautions, see Section 7.

1.15 *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:*[2]

D123 Terminology Relating to Textiles

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

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

F1891 Specification for Arc and Flame Resistant Rainwear

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

F2178 Specification for Arc Rated Eye or Face Protective Products

F2675 Test Method for Determining Arc Ratings of Hand Protective Products Developed and Used for Electrical Arc Flash Protection

2.2 *IEC Standards:*[3]

IEC 61482-1-2 Live working--Protective clothing against the thermal hazards of an electric arc, Part 2 Requirements

3. Terminology

3.1 *Definitions:*

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

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

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

3.1.4 *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.

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

3.1.6 *arc rated finished product, n*—a commercial product used for arc flash protection in the form as it is sold and used.

3.1.7 *arc rating, n*—value attributed to materials that describes their performance to exposure to an electric arc discharge, J/cm^2 (cal/cm^2).

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

3.1.8 *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.

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

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

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

3.1.12 *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.

3.1.12.1 *Discussion*—The specimen is considered to exhibit breakopen when any hole is at least 1.6 cm^2 [0.5 in.^{2}] 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 purpose of this practice. In multiple layer finished product specimens of flame resistant materials, all the layers must exhibit breakopen in order to meet the definition.

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

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

3.1.14 *calorimeter, n*—a device used in which the heat measured causes a change in state.

3.1.14.1 *Discussion*—The determination of heat energy, as a consequence of an electrical arc exposure, is made in this procedure by measuring the change in temperature of an exposed copper slug of specific geometry and mass during finite time intervals.

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

3.1.16 *closure, n*—the point on supply current wave from where arc is initiated.

[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.

[3] Available from International Electrotechnical Commission (IEC), 3, rue de Varembé, 1st floor, P.O. Box 131, CH-1211, Geneva 20, Switzerland, https://www.iec.ch.