



Designation: F 1939 – 99a

Standard Test Method for Radiant Protective Performance of Flame Resistant Clothing Materials¹

This standard is issued under the fixed designation F 1939; 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 test method covers a means of measuring the effect of radiant heat exposure at the standard levels of (a) 0.5 or (b) 2.0 cal/cm² · s (21 or 84 kW/m²) on a fabric specimen or a fabric assembly specimen.

1.2 The radiant protective performance (RPP) rating is calculated.

1.2.1 This value is not intended to be used as a performance specification.

1.2.2 The effects of the radiant energy exposure on the specimen may be observed and reported.

1.3 This test method is recommended for use with fabrics that are flame resistant and that are used in the manufacture of protective clothing.

1.4 This test method is not recommended for use with fabrics or with other textile materials that are not flame resistant, and that may or may not ignite and continue to burn from exposure to the radiant heat flux.

1.5 This test method measures and describes the response of materials, products, or assemblies to heat and flame under controlled conditions, but does not by itself incorporate all factors required for fire hazard or fire risk assessment of the materials, products, or assemblies under actual fire conditions.

1.6 The values stated in customary units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units.

1.7 *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 1776 Practice for Conditioning Textiles for Testing

E 457 Test Method for Measuring Heat-Transfer Rate Using a Thermal Capacitance (Slug) Calorimeter

F 1494 Terminology Relating to Protective Clothing

3. Terminology

3.1 *Definitions:*

3.1.1 *break-open, n*—in testing thermal protective materials, response evidenced by the formation of a hole in the material during the thermal exposure that may result in direct contact of the heat sensor with the exposure energy.

3.1.2 *burn injury, n*—burn damage that occurs at various levels of depth within human tissue.

3.1.2.1 *Discussion*—Burn injury in human tissue occurs when the tissue is heated and kept at an elevated temperature for a critical period of time. The amount of burn injury, first-, second-, or third-degree depends upon both the level of the elevated temperature and the duration of time. Material performance in this test method is related to the second-degree burn injury and is determined by the amount of thermal energy transmitted through the specimen that is sufficient to cause a second-degree burn. A second-degree burn involves irreversible damage of the epidermis/dermis interface.

3.1.3 *burn time intersection, n*—in testing of thermal protective materials, the point where the energy transferred through the specimen and the energy required to predict a second-degree burn are equal, as indicated by the point where the sensor response curve on the recorder chart crosses the curve of the human tissue burn tolerance criteria overlay; or if

¹ This test method is under the jurisdiction of ASTM Committee F-23 on Protective Clothing and is the direct responsibility of Subcommittee F23.80 on Radiant Energy Exposure Test.

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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.



the data are processed with a computer software program, a similar result achieved by comparison of the heat transferred through the specimen and the human tissue tolerance to heat.

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

3.1.5 *dripping, n*—a material response evidenced by flowing and formation of falling droplets.

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

3.1.7 *flame-retardant-treated, adj*—having been processed with a flame retardant.

3.1.8 *heat flux, n*—the thermal intensity indicated by the amount of energy transmitted per unit area and per unit time; $\text{cal}/\text{cm}^2\cdot\text{s}$ (kW/m^2).

3.1.9 *human tissue burn tolerance, n*—in the testing of thermal protective materials, the amount of thermal energy predicted to cause a second-degree burn injury in human tissue.

3.1.10 *ignition, n*—the initiation of combustion.

3.1.11 *inherent flame-resistance, n*—as applied to textiles, flame resistance that derives from an essential characteristic of the fiber from which the textile is made.

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

3.1.12.1 *Discussion*—Liquid in this context indicates evidence of material flow and dripping, or both. These observations may be made after conclusion of the test exposure.

3.1.13 *radiant protective performance (RPP), n*—in testing of thermal protective materials, the heat transfer characteristics of the material during the test exposure.

3.1.14 *radiant protective performance (RPP) rating, n*—in testing of thermal protective materials, the amount of the exposure energy resulting in heat transfer through the test material that predicts a second-degree burn injury in human tissue; cal/cm^2 (kJ/m^2).

3.1.15 *response to heat exposure, n*—in testing the thermal resistance of thermal protective materials, the observable response of the textile to the energy exposure as indicated by break-open, melting, dripping, charring, embrittlement, shrinkage, sticking, and ignition.

3.1.16 *second-degree burn injury, n*—irreversible burn damage at the epidermis/dermis interface in human tissue (Synonym—second-degree burn).

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

3.1.18 *sticking, n*—a material response evidenced by softening and adherence of the material to the surface of itself or another material.

3.1.19 *thermal duration, n*—in the testing of thermal protective clothing, the total time that a material is exposed to heat energy.

3.1.20 *thermal transfer threshold, n*—in the testing of thermal protective clothing, the point at which the heat transferred through the specimen from the thermal exposure has accumulated to the level that a burn injury is imminent.

3.1.21 *thermal transfer threshold time, n*—in the testing of thermal protective clothing, the duration of time from the start of the exposure to the thermal transfer threshold.

3.1.22 For the definitions of protective clothing terms used in this method, refer to Terminology F 1494, and for other textile terms used in this method, refer to Terminology D 123.

4. Summary of Test Method

4.1 A vertically positioned test specimen is exposed to a radiant heat source with an exposure heat flux of either (a) 0.5 or (b) 2.0 $\text{cal}/\text{cm}^2\cdot\text{s}$ (21 or 84 kW/m^2).

4.2 The transfer of heat from the heat source through the test specimen is measured using a heat sensor. The RPP rating of the fabric is calculated from the exposure energy and the thermal transfer threshold time.

4.3 The observations of the thermal response of the specimen resulting from the exposure may be noted.

5. Significance and Use

5.1 Heat transfer is a phenomenon that is contingent upon several critical variables.

5.1.1 Distance, size, and intensity of the heat source are significant in determining the exposure level and the required thermal protection. This test method specifies exposure levels of (a) 0.5 or (b) 2.0 $\text{cal}/\text{cm}^2\cdot\text{s}$ (21 or 84 kW/m^2) to cover two potential hazards.

5.1.2 Air movement at the face of the specimen can affect the intensity of the exposure. Minimizing the convective air currents between the radiant source and the test specimen will aid in the repeatability of the results.

5.2 This test method maintains the specimen in a static, vertical position and does not involve movement, except that resulting from the exposure.

5.3 A higher radiant protective performance rating indicates a longer time to reach the thermal transfer threshold and, therefore, greater protection.

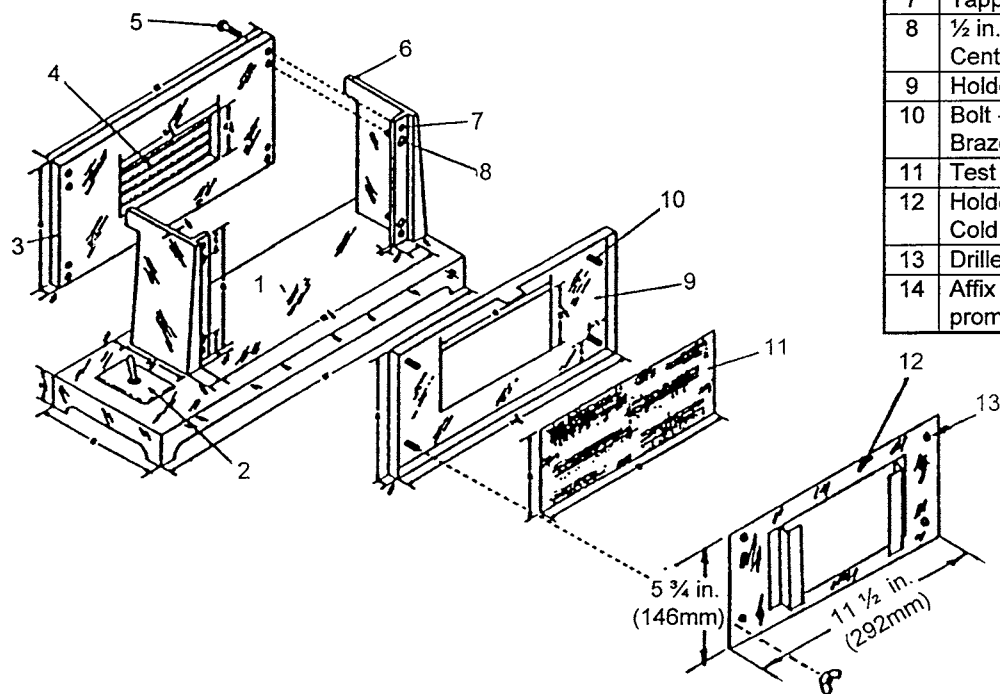
5.4 This test method may be used to measure the relative performance of different materials for garments intended to provide protection from radiant energy, such as proximity fire entry suits, Method A and molten metal protective clothing, Method B.

5.5 This test method is not recommended for acceptance testing of commercial shipments because its between laboratory precision has not been determined.

6. Apparatus and Materials

6.1 *General Arrangement*—The apparatus shall consist of a vertically oriented radiant heat source, specimen holder assembly, protective shutter, sensor assembly, and recorder. The arrangement of the radiant heat source, specimen holder, and protective shutter is shown in Fig. 1.

6.1.1 *Radiant Heat Source*—The vertically oriented radiant heat source shall be in accordance with Fig. 1 and shall consist of a bank of five, 500 W infrared, tubular, translucent quartz lamps having a 5.0-in. (127-mm) lighted length and a mean overall length of 8 3/4 in. (222 mm). The lamps shall be mounted on 3/8 ± 1/64-in. (9.5 ± 0.4-mm) centers so that the lamp surfaces are approximately 1/64-in. (0.4-mm) apart. The bank or array of lamps shall be mounted and centered behind a 2 1/4 × 5 1/2-in. (63.5 × 140-mm) cut-out that is positioned in the center of a 1/2-in. (12.7-mm) thick, 3 3/8-in. (86-mm) wide



1	Cast Aluminum Apparatus Body
2	Toggle Switch - DPST
3	Transite - Smooth Surfaces
4	5 Quartz Lamps - 500 T 3 115-125V
5	Screw - 10-24 3/4 in. (19mm)
6	Legs for Horizontal Test Position
7	Tapped 10-24
8	1/2 in. (12.7mm) D Imbedded Magnet Center Screw Fastening
9	Holder - 20 Gage Cold Rolled Steel
10	Bolt - 3/16 in. (4.76mm) D 1/2 in. (12.7mm) Brazed Flush
11	Test Sample
12	Holder Plate - 20 Gage Cold Rolled Steel
13	Drilled Holes - 3/8 in. (9.5mm) D
14	Affix "DANGER - May Be Hot" labels in prominent locations on apparatus

FIG. 1 Expanded View of Radiant Protective Performance Test Apparatus

by 11-1/2 in. (292-mm.) long transite board as shown in Fig. 2. The quartz lamps shall be heated electrically, and the power

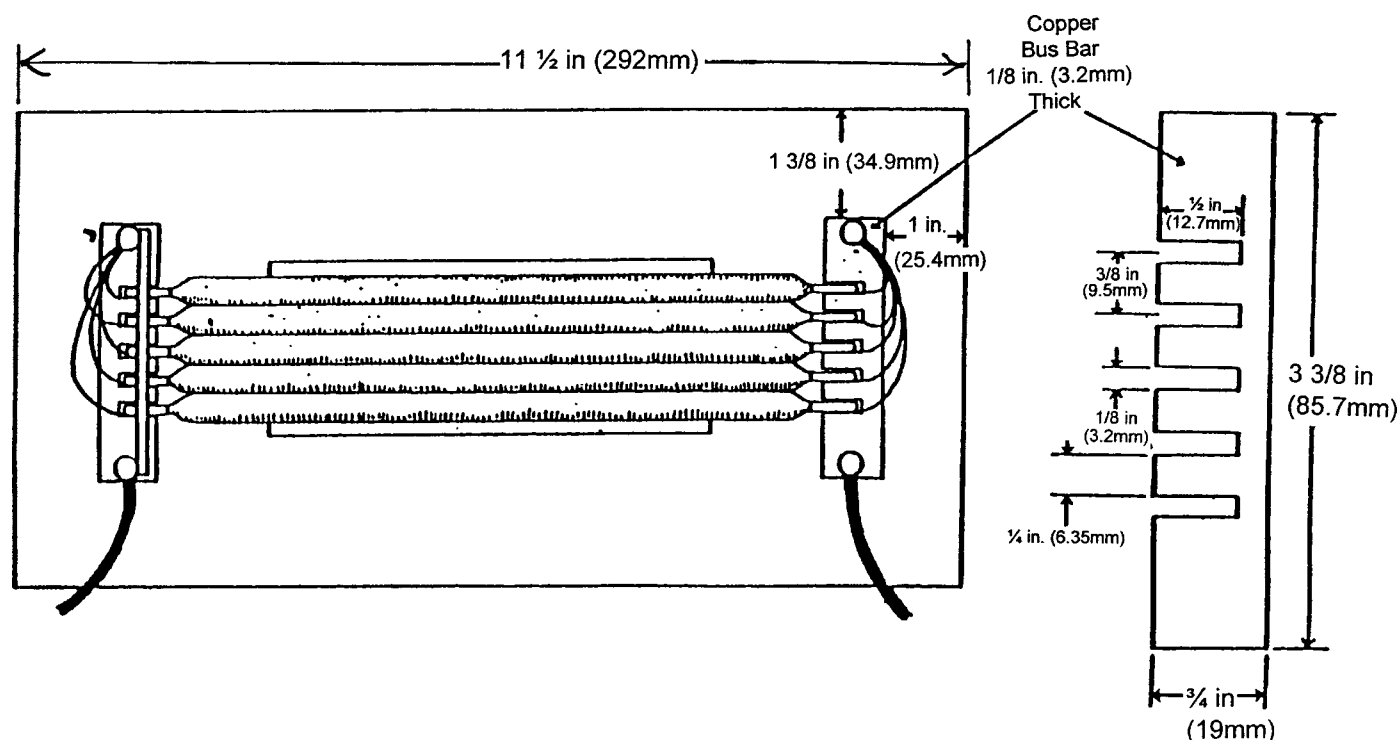


FIG. 2 Position of Quartz Lamps on Transite