Designation: F1930 – 00 (Reapproved 2008)

Standard Test Method for Evaluation of Flame Resistant Clothing for Protection Against Flash Fire Simulations Using an Instrumented Manikin[1]

This standard is issued under the fixed designation F1930; 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 quantitative measurements and subjective observations that characterize the performance of single layer garments or protective clothing ensembles in a simulated flash fire environment having controlled heat flux, flame distribution, and duration. This test method is extremely complex and requires a high degree of technical expertise in both the test setup and operation.

1.1.1 Heat transmitted to each sensor location on the surface of an instrumented manikin is converted to show the corresponding predicted degree of burn injury to human tissue.

1.1.2 The sum of these values can then be converted to a percentage to show the total area of predicted burn injury.

1.1.2.1 Use of the predicted burn injury to evaluate the heat transferred to the manikin does not constitute a material's performance specification.

1.1.3 The visual and physical changes to the single layer garment or protective clothing ensemble are recorded to aid in understanding how the burn injury results can be interpreted.

1.2 The measurements obtained and observations noted can only apply to the particular garment(s) or ensemble(s) tested using the specified heat flux, duration, and flame distribution.

1.3 This standard should be used to measure and describe the response of materials, products, or assemblies to heat and flame under controlled conditions and should 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-hazard assessment or a fire-risk assessment which takes into account all of the factors which are pertinent to an assessment of the fire hazard or fire risk of a particular end use.

1.4 This test method is a fire-test-response test method.

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

1.6 *This standard does not purport to address 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]

D123 Terminology Relating to Textiles

D1835 Specification for Liquefied Petroleum (LP) Gases

F1494 Terminology Relating to Protective Clothing

2.2 *AATCC Standard:*

Test Method 135 Dimensional Changes in Automatic Home Laundering of Woven and Knit Fabrics[3]

2.3 *Canadian Standards:*[4]

CAN/CGSB-4.2 No. 58-M90 Textile Test Methods Colourfastness and Dimensional Change in Domestic Laundering of Textiles

CAN/CGSB-3.14 M88 Liquefied Petroleum Gas (Propane)

3. Terminology

3.1 *Definitions:*

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

3.1.1.1 *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.

3.1.2 *flame distribution*, *n—in the flash fire testing of clothing*, a spatial distribution of incident flames from test facility burners to provide a controlled heat flux over the manikin surface.

[1] This test method is under the jurisdiction of ASTM Committee F23 on Personal Protective Clothing and Equipment and is the direct responsibility of Subcommittee F23.80 on Flame and Thermal.

Current edition approved Dec. 15, 2008. Published March 2009. Originally approved in 1999. Last previous edition approved in 2000 as F1930 - 00. DOI: 10.1520/F1930-00R08.

[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 American Association of Textile Chemists and Colorists (AATCC), P.O. Box 12215, Research Triangle Park, NC 27709, http://www.aatcc.org.

[4] Available from Standards Council of Canada (SCC), 270 Albert Street, Suite 200, Ottawa ON K1P 6N7, Canada, http://www.scc.ca.

3.1.3 *instrumented manikin*, *n*—a model representing an adult-size human and fitted with sensors on the surface for use in testing.

3.1.3.1 *Discussion*—The instrumented manikin used in flash fire testing of clothing is fitted with at least 100 heat sensors, excluding hands and feet.

3.1.4 *predicted total area of burn injury*, *n—in the flash fire testing of clothing*, the sum of areas represented by the sensors that calculate at least a second degree burn injury.

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

3.1.6 *second-degree burn injury area*, *n—in the flash fire testing of clothing*, the sum of the areas represented by sensors that calculate a burn injury at the epidermis/dermis interface in human tissue. (Synonym second-degree burn area)

3.1.7 *heat sensor*, *n*—a device capable of measuring incident heat to the manikin's surface under test conditions and creating data that can be processed by a computer program to assess burn injury.

3.1.8 *thermal protection*, *n*—the property that characterizes the overall performance of a garment or protective clothing ensemble relative to how it prevents the transfer of heat that is sufficient enough to cause burn injury.

3.1.8.1 *Discussion*—In flash fire testing of clothing, thermal protection of a garment or ensemble and the consequential predicted burn injury (second-degree or third-degree), can be quantified by the measured sensor response that indicates how well the garment or protective clothing ensemble blocks heat from the manikin surface. In addition to the measured sensor response, the physical response and degradation is an observable phenomenon that can be correlated to the sensor calculations and is useful in understanding garment or protective clothing ensemble thermal protection.

3.1.9 *third-degree burn injury*, *n*—the irreversible burn damage at the dermis/subcutaneous interface in human tissue (Synonym third-degree burn).

3.1.10 *third-degree burn injury area*, *n—in the flash fire testing of clothing*, the sum of the areas represented by sensors that calculate a burn injury at the dermis/subcutaneous interface in human tissue. (Synonym third-degree burn area)

3.1.11 For definitions of other protective clothing related terms used in this test method, refer to Terminology F1494. For definitions for other textile related terms used in this test method, refer to Terminology D123.

4. Summary of Test Method

4.1 The test method evaluates the protective performance of the materials of construction and design of the test specimen, which is either a garment or an ensemble. The test specimen is placed on an adult-size manikin at ambient atmospheric conditions and exposed to a laboratory flash fire simulation with controlled heat flux, duration, and flame distribution. The test procedure, data acquisition, results calculations, and preparation of the test report are performed with computer hardware and software programs. Heat, which is transferred through the test specimen during and after the exposure, is measured by sensors. These measurements are used to calculate the second-degree, third-degree, and total burn injury areas resulting from the flash fire exposure. Identification of the test specimen, test conditions, comments and remarks about the test purpose, and response of the test specimen to the exposure are recorded and are included as part of the report. The performance of the test specimen is indicated by the calculated burn injury area and the way the specimen responds to the test exposure.

5. Significance and Use

5.1 This test method can be used to measure and compare the thermal protection provided by different materials, garments, clothing ensembles, and systems.

5.2 This test method provides a measurement of garment and clothing ensemble performance on a stationary upright manikin.

5.2.1 This test method is not intended to be a quality assurance test.

5.2.2 The effects of body position and movement are not addressed in this test method.

5.3 The measurement of the thermal protection provided by clothing is complex and dependent on the apparatus and techniques used. It is not practical in a test method of this scope to establish details sufficient to cover all contingencies. Departures from the instructions in this test method may lead to significantly different test results. Technical knowledge concerning the theory of heat transfer and testing practices is needed to evaluate if, and which, departures from the instructions given in this test method are significant. Standardization of the test method reduces, but does not eliminate, the need for such technical knowledge. Any departures should be reported with the results.

6. Apparatus

6.1 *Instrumented Manikin*—An upright manikin that is in the shape and size of an adult male human form shall be used. (see Fig. 1)

6.1.1 *Size and Shape*—The manikin shall be constructed with a head, chest/back, abdomen/buttocks, arms, hands, legs, and feet. The manikin's dimensions should correspond to those required for standard sizes of garments because deviations in fit will affect the results. A male manikin consisting of the sizes given in Table 1 has been found satisfactory to evaluate garments or protective ensembles.

6.1.2 The manikin should be constructed of flame resistant, thermally stable, nonmetallic materials.

6.2 *Apparatus for Burn Injury Assessment*:

6.2.1 *Manikin Construction*—At least 100 heat sensors shall be distributed as uniformly as possible in each area on the manikin as given in Table 2.

6.2.2 *Heat sensor construction*—Each heat sensor shall have the capacity to measure the incident heat flux over a range from 0.0 to 4.0 cal/cm^2·s (167 kW/m^2). This range permits the use of the sensors to set the exposure level by directly exposing the manikin to the flames in a test without the garment and also having the capability to measure the heat transfer to the manikin with exposure of the test garment or protective clothing ensemble.

6.2.2.1 The sensors shall be constructed of a material with known thermal characteristics that can be used to indicate heat flux and temporal variation received by the sensors. The outer