~~Designation:F1930–00 (Reapproved 2008)~~ Designation: F1930 – 11

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

~~1.1This 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.~~

~~1.1.1Heat 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.~~

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

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

~~1.1.3The 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.~~

~~1.2The 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.~~

~~1.3This 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.~~

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

~~1.5The 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.*~~

1.1 This test method is used to provide predicted human skin burn injury for single layer garments or protective clothing ensembles mounted on a stationary instrumented manikin which are then exposed in a laboratory to a simulated fire environment having controlled heat flux, flame distribution, and duration. The average exposure heat flux is 84 kW/m^2(2 cal/s•cm^2), with durations up to 20 seconds.

1.2 The visual and physical changes to the single layer garment or protective clothing ensemble are recorded to aid in understanding the overall performance of the garment or protective ensemble and how the predicted human skin burn injury results can be interpreted.

1.3 The skin burn injury prediction is based on a limited number of experiments where the forearms of human subjects were exposed to elevated thermal conditions. This forearm information for skin burn injury is applied uniformly to the entire body except for the hands and feet. The hands and feet are not included in the skin burn injury prediction.

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

[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.~~

Current edition approved Feb. 1, 2011. Published March 2011. Originally approved in 1999. Last previous edition approved in 2008 as F1930 - 00(2008). DOI:10.1520/F1930–11.

1.5 This standard is used to measure and describe 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 This method is not a fire-test-response test method.

1.7 The values stated in SI units are to be regarded as standard. The values given in parentheses are mathematical conversions to inch-pound units or other units commonly used for thermal testing. If appropriate, round the non-SI units for convenience.

1.8 *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.*

1.9 Fire testing is inherently hazardous. Adequate safeguards for personnel and property shall be employed in conducting these tests.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D123 Terminology Relating to Textiles

D1835 Specification for Liquefied Petroleum (LP) Gases

D5219 Terminology Relating to Body Dimensions for Apparel Sizing

E511 Test Method for Measuring Heat Flux Using a Copper-Constantan Circular Foil, Heat-Flux Transducer

F1494 Terminology Relating to Protective Clothing

2.2 ~~*AATCC Standard:*~~ *AATCC Standards:*[3]

Test Method 135~~Dimensional Changes in Automatic Home Laundering of Woven and Knit Fabrics~~ Dimensional Changes of Fabrics after Home Laundering

Test Method 158 Dimensional Changes on Dry-Cleaning in Perchloroethylene: Machine Method

2.3 *Canadian Standards:*[4] ~~*CAN/CGSB-4.2 No. 58-M90Textile Test Methods Colourfastness and Dimensional Change in Domestic Laundering of Textiles*~~

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

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

2.4 *NFPA Standards:*[5]

NFPA 54 National Fuel Gas Code, 2009 Edition

NFPA 58 Liquefied Petroleum Gas Code 2008 Edition

NFPA 85 Boiler and Combustion Systems Hazards Code, 2007 Edition

NFPA 86 Standard for Ovens and Furnaces, 2007 Edition

3. Terminology

~~3.1~~

3.1 For definitions of terms used in this test method use the following documents. For terms related to textiles refer to Terminology D123, for terms related to protective clothing refer to Terminology F1494 and for terms related to body dimensions refer to Terminology D5219.

3.2 *Definitions:*

~~3.1.1~~

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

~~3.1.1.1~~—*thermal damage which occurs to human skin at various depths and is a function of local temperature and time.*

3.2.1.1 *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~~—*Burn injury in human tissue occurs when the tissue is heated above a critical temperature (44°C (317.15 K) or 111°F). Thermal burn damage to human tissue depends on the magnitude of the temperature rise above the critical value and the duration that the temperature is above the critical value. The degree of burn injury (second or third degree) depends on the maximum depth within the skin layers to which tissue damage occurs. The first-degree burn injury is considered minor relative to second-degree and third-degree burn injuries. It is not included in the evaluation of test specimens in this test method (see Appendix X1).*

---

[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.~~

[4] Available from Standards Council of Canada, Suite 1200, 45 O'Conor St., Ottawa, Ontario, K1P 6N7.

~~[5] The sole source of supply of the combination total calorimeter/radiometer, Model No. C-1803-A-15-072, known to the committee at this time is HyCal Engineering, 12105 Los Nietos Rd., Santa Fe Springs, CA 90670. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend.~~

[5] Available from National Fire Protection Association (NFPA), 1 Batterymarch Park, Quincy, MA 02169-7471, http://www.nfpa.org.

3.2.2 *fire exposure*, *n*—in the fire testing of clothing, the fire exposure is a propane-air diffusion flame with a controlled heat flux and spatial distribution, engulfing the manikin for a controlled duration.

3.2.2.1 *Discussion*—The flames are generated by propane jet diffusion burners. Each burner produces a reddish-orange flame with accompanying black smoke (soot).

3.2.3 *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.~~

~~3.1.3~~*—in the fire testing of clothing, a spatial distribution of incident flames from burners to provide a controlled heat flux over the surface area of the manikin.*

3.2.4 *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~~*—a structure designed and constructed to represent an adult-size human and which is fitted with thermal energy (heat flux) sensors on its surface.*

3.2.4.1 *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*—The manikin is fabricated to specified dimensions from a high temperature resistant material. The instrumented manikin used in fire testing of clothing is fitted with at least 100 thermal energy (heat flux) sensors, distributed over the manikin surface. The feet and hands are not normally fitted with sensors. If the feet and hands are equipped with sensors, it is up to the user to define a procedure to interpret the results.

3.2.5 *predicted second-degree 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*—in the fire testing of clothing, a calculated second-degree burn injury to skin based on measurements made with a thermal energy sensor.

3.2.5.1 *Discussion*—For the purposes of this standard, predicted second-degree burn injury is defined by the burn injury model parameters (see Section 12 and Appendix X1). Some laboratories assign an area to each sensor over which the same burn injury prediction is assumed to occur, others do not.

3.2.6 *predicted third-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*—in the fire testing of clothing, a calculated third-degree burn injury to skin based on measurements made with a thermal energy sensor.

3.2.6.1 *Discussion*—For the purposes of this standard, predicted third-degree burn injury is defined by the burn injury model parameters (see Section 12 and Appendix X1). Some laboratories assign an area to each sensor over which the same burn injury prediction is assumed to occur, others do not.

3.2.7 *predicted total burn injury*, *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*—in the fire testing of clothing, the manikin surface area represented by all thermal energy sensors registering a predicted second-degree or predicted third-degree burn injury, expressed as a percentage.

3.2.8 *second-degree burn injury*, *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~~*—in the fire testing of clothing, complete necrosis (living cell death) of the epidermis skin layer.*

3.2.9 *thermal energy sensor*, *n*—a device capable of measuring directly the incident heat flux at its surface or one which gives an output which is used to calculate the incident heat flux.

3.2.9.1 *Discussion*—Types of sensors which have been used successfully include slug calorimeters, surface and buried temperature measurements and thin film heat flux gauges. Some types of sensors approximate the thermal inertia of human skin and some do not. The known sensors in current use have relatively small detection areas. An assumption is made for the purposes of this method that thermal energy measured in these small areas can be extrapolated to larger surrounding surface areas so that the overall manikin surface can be approximated by a minimum number of sensors. The resulting sensors predicted burn injury applies to the extrapolated coverage area. Some laboratories assign different coverage areas to each sensor over which the same burn injury prediction is assumed to apply, others do not (see 6.2.1.1).

3.2.10 *thermal protection*, *n*—the property that characterizes the overall performance of a garment or protective clothing ensemble relative to how it ~~prevents~~retards the transfer of heat that is sufficient ~~enough~~ to cause a predicted second-degree or predicted third-degree burn injury.

~~3.1.8.1~~3.2.10.1 *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~~*—Thermal protection of a garment or ensemble and the consequential predicted burn injury (second-degree and third-degree), is quantified from the response of the thermal energy sensors and use of the skin burn injury prediction model. In*