Designation: F955 – 15 (Reapproved 2021)

Standard Test Method for Evaluating Heat Transfer Through Materials for Protective Clothing Upon Contact with Molten Substances[1]

This standard is issued under the fixed designation F955; 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 the evaluation of materials' thermal resistance to heat transfer when exposed to a molten substance pour.

1.1.1 This test method was validated using molten substances of aluminum, brass, and iron. The test shall be permitted to be adapted for use with other substances.

1.2 This test method is applicable to materials from which finished primary protective apparel articles are made.

1.3 This test method does not measure the flammability of materials, nor is it intended for use in evaluating materials exposed to any other thermal exposure.

1.4 Use this test method to measure and describe the properties of materials, products, or assemblies in response to molten substance pour under controlled laboratory conditions and shall not be used to describe or appraise the thermal hazard or fire risk of materials, products, or assemblies under actual conditions. However, it is acceptable to use results of this test as elements of a thermal risk assessment which takes into account all the factors that are pertinent to an assessment of the thermal hazard of a particular end use.

1.5 *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.* Specific hazard statements are given in Section 8.

1.6 *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

E457 Test Method for Measuring Heat-Transfer Rate Using a Thermal Capacitance (Slug) Calorimeter

F1002 Performance Specification for Protective Clothing and Materials for Use by Workers Exposed to Specific Molten Substances and Related Thermal Hazards

F1494 Terminology Relating to Protective Clothing

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *break-open*—in testing thermal protective material, a response evidenced by the formation of a hole in the material which allows the molten substance to pass through the material.

3.1.2 *charring*—the formation of carbonaceous residue as the result of pyrolysis or incomplete combustion.

3.1.3 *dripping*—a material response evidenced by flowing of the polymer.

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

3.1.5 *heat flux*—the thermal intensity indicated by the amount of energy transmitted divided by area and time, W/m^2 (cal/cm^2 s).

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

3.1.7 *ignition*—the initiation of combustion.

3.1.8 *melting*—a material response evidenced by softening of the polymer.

3.1.9 *primary protective clothing*—protective clothing designed to be worn for work activities during which significant exposure to molten substance splash, radiant heat, and flame is likely to occur.

[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.

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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.

3.1.9.1 *Discussion*—Primary protective clothing is used in work activities that include charging, tapping, and pouring, during which work is carried out in close proximity to molten substances and hot surfaces where contact with either is likely.

3.1.10 *response to molten substance pour*—in testing thermal protective material, the observed effect of molten substance contact on textile properties or deterioration of the material.

3.1.11 *shrinkage*—a decrease in one or more dimensions of an object or material.

3.1.12 *thermal end point*—in the testing of thermal protective materials, the point where the copper slug calorimeter sensor response (heat energy measured) intersects with a predicted skin burn injury model.

3.2 For definitions of other textile terms used in this test method, refer to Terminology D123.

4. Summary of Test Method

4.1 A material specimen is mounted on a vertical incline and is exposed to a molten substance pour of prescribed minimum temperature, volume, pour rate, and vertical height.

4.2 The amount of heat energy that is transmitted through the test specimen during and after the molten substance exposure is measured using two copper slug calorimeters. The heat transport response is assessed versus the Stoll curve, an approximate human tissue tolerance predictive model that projects the onset of a second-degree skin burn injury as manifested by a blister (see 12.2).

4.3 A specific set of subjective evaluations is performed on the test specimen response to the molten substance exposure using a standardized rating scale for appraisal (found in Annex A1).

5. Significance and Use

5.1 Workers who have the potential to be exposed to molten metal contact shall be permitted to wear protective clothing using materials that have been evaluated for heat transfer using this test method.

5.2 This test method rates materials that are intended for primary protective clothing against potential molten substance contact for their thermal insulating properties and their reaction to the test exposure.

5.3 The protective performance, as determined by this test method, will relate to the actual end-use performance only to the degree that the end-use exposure is identical to the exposure used in the test method.

5.4 Visual inspection of the specimen subjectively notes the material's resistance to molten substance contact.

6. Apparatus

6.1 The test apparatus consists of four major components as follows:

6.1.1 An inclined specimen mounting and exposure board with two copper slug calorimeter thermal sensors and supports,

6.1.2 A pouring crucible and pouring mechanism,

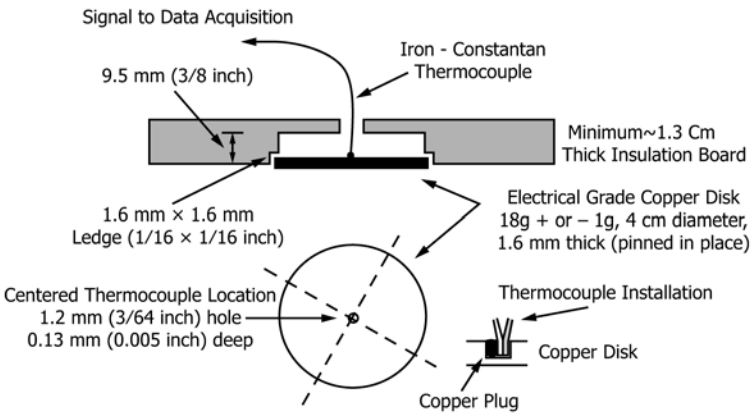
6.1.3 A furnace for melting the test metal, and

6.1.4 Instruments for measuring test conditions and test results.

6.2 *Sensor Construction:*

6.2.1 Each copper slug calorimeter shall be 18 ± 1 g, 40 mm diameter and 1.6 mm thick, and shall be constructed from electrical grade copper with a single 30 gage, iron/constantan thermocouple wire and shall be installed as identified in Fig. 1.

6.2.2 The exposed surface of each copper slug calorimeter shall be painted with a thin coating of a flat black high-temperature spray paint with an emissivity of 0.9. The painted



NOTE 1—Sensor Construction—Place a straight, bare tip thermocouple wire into the hole located in the center of the copper disk. Place a short "copper plug" into the center hole with the thermocouple junction by clipping a section of bare copper wire of appropriate diameter that, when combined with the thermocouple wire, will just fit into the center hole. Use a center punch to mechanically wedge the wire bundle into place. Peen around the hole to further secure the thermocouple into the copper disk. Take care not to cut the thermocouple wire during this assembly process. Check the electrical continuity and thermal response prior to using the completed copper slug calorimeter.

FIG. 1 Sensor Construction