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Designation: F 955 – 96

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 F 955; 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 molten substance pour by describing means of measuring heat transfer.

NOTE 1—As used in this test method, the term *molten substance* refers to the three compositions (aluminum, brass, and iron) for which the procedure was validated. The test design may be adapted for use with other substances not validated as part of the test method.

1.2 This test method is applicable to materials from which finished 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 exclusive of the molten substance itself (see Note 1).

1.4 This test method should be used to measure and describe the properties of materials, products, or assemblies in response to molten substance pour under controlled laboratory conditions and should not be used to describe or appraise the thermal hazard or fire risk of materials, products, or assemblies under actual conditions. However, results of this test may be used 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 and health practices and determine the applicability of regulatory limitations prior to use.* Specific hazard statements are given in Section 8.

2. Referenced Documents

2.1 *ASTM Standards:*

D 123 Terminology Relating to Textiles[2]

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*—in testing thermal protective material, a response evidenced by flowing of the fiber 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 per unit area and per unit time ($cal/cm^2 s$) ($watts/cm^2$).

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

3.1.7 *ignition*—the initiation of combustion.

3.1.8 *melting*—in testing thermal protective material, a response evidenced by softening of the material, resulting in a nonreversible change.

3.1.9 *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.

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

3.1.11 *thermal end point*—in testing of thermal protective materials, the point of where the sensor response on the recorder chart intersects the human tissue burn tolerance criteria overlay.

3.2 For definitions of other textile terms used in this test method, refer to Terminology D 123.

4. Summary of Test Method

4.1 The test exposes a material used in the fabrication of protective apparel to a molten substance under standardized conditions and measures with a copper calorimeter the amount of heat transmitted through the test specimen.

4.2 Comparison of data from this test method with related information on the tolerance of human skin to heat absorption permits estimation of the protective capacity of the material tested.

4.3 The effect of the molten substance contact with the specimen is observed and recorded.

[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 Molten Substances.

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[2] *Annual Book of ASTM Standards*, Vol 07.01.

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5. Significance and Use

5.1 Workers may be exposed to contact with molten substances. The clothing used should provide some protection. Whether personal injury results from such contact depends on the resistance of the material from which the clothing is made to molten substance contact and the amount of heat transferred through the material to the wearer.

5.2 This test method rates materials, that are intended for 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.

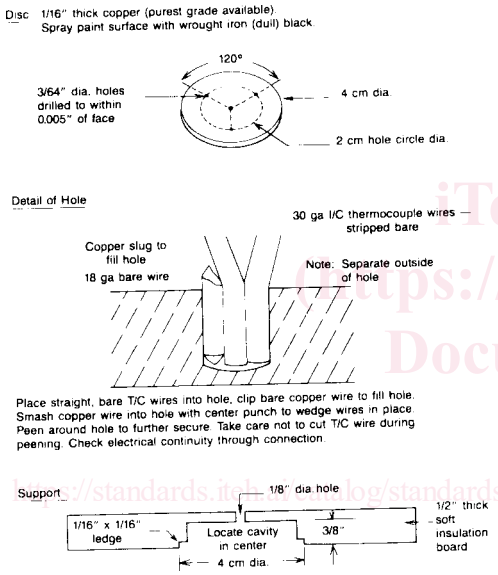
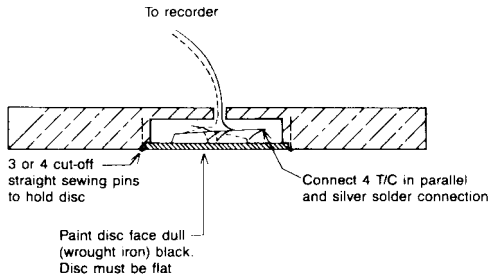


FIG. 1 Sensor Construction



Heat flux (q)

$$q = \frac{\text{mass x heat capacity copper x temperature rise}}{\text{area of disc x time}}$$

$$= \frac{mC_p\,\Delta T}{A\,\Delta\theta}$$

C_p = 0.0942 cal/g °C
= 0.0523 cal/g °F

If disc weighs 18g
q = 0.0135 ΔT/10 s °C
q = 0.0075 ΔT/10 s °F

Heat flux (g)

$$g = \frac{\text{mass} \times \text{heat capacity copper} \times \text{temperature rise}}{\text{area of disc} \times \text{time}}$$

$$= \frac{mC_p\Delta T}{A\Delta\theta}$$

C_p = 0.0942 cal/gr °C
= 0.0523 cal/gr °F

If disc weighs 18 g
q = 0.0075 ΔT/10 s °F
= 0.0135 ΔT/10 s °C

FIG. 2 Assembly

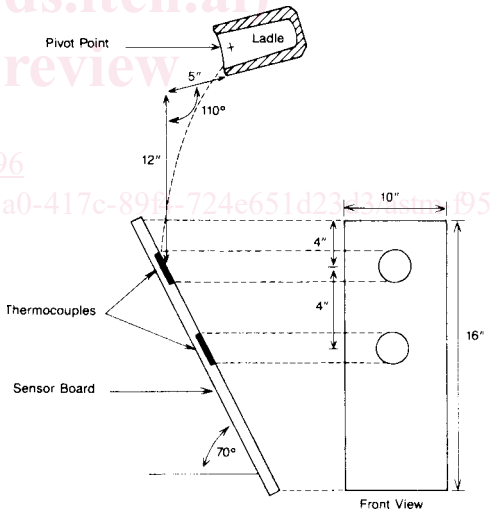


FIG. 3 Schematic of Test Apparatus

6. Apparatus

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

6.1.1 A sensor board with two calorimeters and support stand,

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*—Copper calorimeter mounted in an insulating block and constructed as described in Figs. 1 and 2.

6.3 *Sensor Board*—Fabricated of flame and heat resistant material[3] with two copper calorimeters mounted as shown in Fig. 3. The sensor board should be nominally 16 by 10 in. The relationship between the pouring ladle position and the calorimeters is critical. Means should be provided for attaching the test materials to the top of the sensor board in a manner such that the test specimen will cover both sensors and extend at least 1 in. beyond all edges. During tests, the sensor board shall be at an angle of 70° from the horizontal. Details of mounting thermocouple leads in the copper calorimeters are illustrated in Fig. 1 and of the mounting of the calorimeter in the sensor board in Fig. 2.

6.4 *Pouring Crucible*—The pouring crucible shall be suitable for the substance being poured and for handling temperatures up to at least 100°F above the pouring temperature. Crucible sizes appropriate for specific substances are shown in

[3] Marinite which is available from Manville Corp., P.O. Box 5108, Denver, CO 80217 has been found satisfactory.

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