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Standard Test Method for Liquid Penetration Resistance of Protective Clothing or Protective Ensembles Under a Shower Spray While on a Mannequin[1]

This standard is issued under the fixed designation F 1359; 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.

INTRODUCTION

Personnel in industry and emergency response can be exposed to numerous chemicals capable of causing harm upon contact with the human body. The deleterious effects of these chemicals can range from acute trauma such as skin irritation and burn, to chronic degenerative disease such as cancer. Since engineering controls cannot eliminate all possible exposures, attention is often placed on reducing the potential for direct skin contact through the use of protective clothing.

Protective clothing is available in a variety of constructions, configurations and materials, and is designed to provide various levels of protection against many hazards. Protective clothing offering the highest level of chemical protection is constructed to prevent any contact of solid, liquid, or gaseous chemicals with the wearer. Test Method F 1052 evaluates the integrity and construction of the vapor protective ensembles by way of an internal pressure test. In some applications, chemical protective clothing need only isolate the wearer from splashes of liquids. This test method evaluates the integrity of the construction and configuration of liquid-penetration-resistant protective clothing or protective ensembles with a shower-spray test.

Resistance of materials used in protective clothing to chemical permeation should be evaluated by Test Method F 739 for continuous contact and Test Method F 1383 for intermittent contact (that is, splash), or by Test Method F 1407 using the permeation cup method. Resistance of protective clothing materials to liquid penetration should be determined by Test Method F 903.

Physical properties of materials used in the construction of protective clothing can be determined using a variety of test methods including, Test Methods D 751 for dimensions, weight, breaking strength, elongation, burst, tear resistance, and hydrostatic resistance; Test Method D 2582 for puncture propagation tear resistance; Test Method D 4157 for abrasion resistance; Test Method F 392 for flexural fatigue; Test Method F 1358 for flammability, as well as many others.

1. Scope

1.1 This test method measures the ability of protective clothing or protective ensembles to resist liquid penetration in the form of a shower spray with surfactant-treated water.

1.2 This test method measures the liquid penetration resistance of the construction and configuration of the overall protective clothing or protective ensemble, but especially of seams, closures, and interfaces with other components such as gloves, boots, hoods, and respiratory protective equipment. It is intended that this test method be used to assess the liquid penetration resistance of protective clothing and protective ensembles as received from the manufacturer and worn in accordance with their instructions.

1.3 Resistance of materials used in protective clothing to permeation or penetration can be determined in accordance with Test Methods F 739 and F 903, respectively.

1.4 The integrity of vapor protective ensembles is measured by its ability to maintain positive internal pressure with Test Method F 1052.

1.5 The values in SI units or in other units shall be regarded separately as standard. The values stated in each system must be used independently of the other, without combining values in any way.

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[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 F23.30 on Chemicals.

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1.6 *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 751 Test Methods for Coated Fabrics

D 2582 Test Method for Puncture-Propagation Tear Resistance of Plastic Film and Thin Sheeting

D 4157 Test Method for Abrasion Resistance of Textile Fabrics (Oscillatory Cylinder Method)

F 392 Test Method for Flex Durability of Flexible Barrier Materials

F 739 ~~Test Method for Resistance of Protective Clothing Materials to Permeation by Liquids or Gases Under Conditions of Continuous Contact~~ Test Method for Permeation of Liquids and Gases through Protective Clothing Materials under Conditions of Continuous Contact

F 903 Test Method for Resistance of Materials Used in Protective Clothing to Penetration by Liquids

F 1052 ~~Practice for Pressure Testing of Gas-Tight Totally Encapsulating Chemical Protective Suits~~ Test Method for Pressure Testing Vapor Protective Ensembles

F 1358 Test Method for Effects of Flame Impingement on Materials Used in Protective Clothing Not Designated Primarily for Flame Resistance

F 1383 ~~Test Method for Resistance of Protective Clothing Materials to Permeation by Liquids or Gases Under Conditions of Intermittent Contact~~ Test Method for Permeation of Liquids and Gases through Protective Clothing Materials under Conditions of Intermittent Contact

F 1407 Test Method for Resistance of Chemical Protective Clothing Materials to Liquid Permeation—Permeation Cup Method

3. Terminology

3.1 *Definitions:*

3.1.1 *liquid splash protective clothing*, *n*— protective clothing used to protect the wearer from liquid splashes of chemicals.

3.1.2 *liquid splash protective ensemble*, *n*— protective ensemble used to protect the wearer from liquid splashes of chemicals.

3.1.3 *penetration*, *n*—for chemical-resistant clothing, in a protective clothing material or item, the process by which a solid, liquid, or gas moves through closures, seams, interstices, and pinholes or other imperfections on a non-molecular level.

3.1.4 *permeation*, *n*—the process by which a chemical moves through a protective clothing material on a molecular level.

3.1.4.1 *Discussion*—Permeation involves the following: (*1*) sorption of molecules of the chemical into the contacted (challenge side) surface of the material, (*2*) diffusion of the sorbed molecules in the material, and (*3*) desorption of the molecules from the opposite (collection side) surface of the material.

3.1.5 *protective clothing*, *n*—apparel used for the purpose of isolating parts of the body from contact with a potential hazard.

3.1.6 *protective ensemble*, *n*—the combination of protective clothing with respiratory protective equipment, hoods, helmets, gloves, boots, communication systems, cooling devices, and other accessories intended to protect the wearer from a potential hazard when worn together.

3.1.6.1 *Discussion*—For evaluating liquid penetration resistance, the protective ensemble includes only those clothing items or accessories which are necessary to provide resistance to liquid penetration.

3.1.7 *vapor protective ensemble*, *n*—a chemical protective ensemble used to protect the wearer from chemical liquids, vapors, and gases.

4. Summary of Test Method

4.1 A test specimen (protective clothing or protective ensemble) is placed on a mannequin that is already dressed in a liquid-absorptive garment covering portions of the mannequin form that are of interest.

4.2 Water, treated to achieve a surface tension of 0.032 ± 0.002 N/m (32 ± 2 dynes/cm) is sprayed at the test specimen from five nozzles positioned in a specific configuration with respect to the specimen. The specimen is exposed to the liquid spray for a period of 15 min in each of four specimen orientations.

4.3 Liquid penetration resistance is determined by the absence of liquid inside the specimen or on the inner liquid-absorptive garment.

4.4 The test specimen is rated as passing if liquid does not penetrate and as failing if liquid does penetrate.

5. Significance and Use

5.1 This test method evaluates the ability of the construction and configuration of protective clothing or protective ensembles to resist liquid penetration. In most cases, the conditions used in this test method will not represent actual end-use conditions.

[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.

5.2 The one-hour duration of the test is not intended to simulate user exposure to splashes of liquid chemical but rather to provide sufficient time for enough liquid to penetrate to make visual detection easier.

5.3 A nontoxic, non-foaming surfactant is added to water for this test method to simulate liquids of lower surface tensions. Liquids of specific interest can be simulated by treating water to achieve an equivalent surface tension.

5.4 For protective clothing with water-repellent surfaces, the lower surface tension liquid will aid in the evaluation of the construction and configuration of the garment because it is not repelled but wets the protective clothing. This is especially useful for reusable garments whose water-repellent surface interferes with the evaluation of their construction and configuration when new, but is diminished after wearing and washing.

5.5 Fluorescent or colored dyes may be added to the water to enhance detection of liquid penetration into the protective clothing or protective ensemble.

5.6 This test method can be used by both manufacturers and end users to assess liquid penetration resistance. Manufacturers can use this test method to evaluate quality of construction and effectiveness of clothing and ensemble configurations.

5.7 The clothing or ensemble shall be sized to fit the mannequin. It is important that the clothing fit the mannequin well since detection of liquid penetration requires as much contact as possible between the clothing or ensemble and the inner liquid-absorptive garment.

5.8 Results on a mismatched size of clothing or ensemble shall not be used to generalize about a particular construction or configuration. Mannequin fit potentially affects liquid penetration resistance determinations.

5.9 There is no known limit to the kind of protective clothing or protective ensembles that can be evaluated with this test method.

5.10 In some cases protective clothing or protective ensembles that show no liquid penetration during this test method will still fail to protect wearers against specific chemicals due to the material degradation, penetration, or permeation or the toxicity associated with the vapor of liquid chemicals.

5.11 In some cases protective clothing or protective ensembles that show no liquid penetration during this test method will still fail to protect wearers in specific circumstances as, for example, deluge or immersion.

6. Apparatus

6.1 *Human-Form Mannequin,* an appropriately sized human-form mannequin shall be selected for testing the protective clothing or protective ensemble. The selected mannequin should provide as much contact with the protective clothing or protective ensemble as possible. The mannequin shall have a water-resistant coating. The mannequin shall have straight arms and legs with the arms at the mannequin's sides.

6.2 *Liquid-Absorptive Inner Garment* —An inner garment shall cover all areas of the mannequin that are of interest as an aid to observe liquid penetration. The inner garment shall be constructed of fabric that is finish free and that is easily watermarked. Select an inner garment that contacts the test garment as closely as possible. Users of this test method may also use more sophisticated equipment for detecting liquid penetration.

6.3 *Shower System*— The shower system shall consist of five low-flow shower head nozzles, and a pressurized liquid supply. The five nozzles shall be oriented with respect to the mannequin as specified in Fig. 1. The nozzles shall conform to the

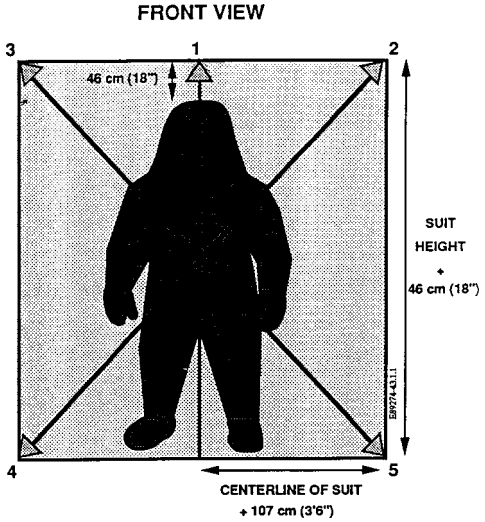

FIG. 1 Positions of Shower Nozzles