



Standard Test Method for Liquid Penetration Resistance of Protective Clothing or Protective Ensembles Under a Shower Spray While on a Mannequin¹

This standard is issued under the fixed designation F1359/F1359M; 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 F1052 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 F739 for continuous contact and Test Method F1383 for intermittent contact (that is, splash), or by Test Method F1407 using the permeation cup method. Resistance of protective clothing materials to liquid penetration should be determined by Test Method F903.

Physical properties of materials used in the construction of protective clothing can be determined using a variety of test methods including, Test Methods D751 for dimensions, weight, breaking strength, elongation, burst, tear resistance, and hydrostatic resistance; Test Method D2582 for puncture propagation tear resistance; Test Method D4157 for abrasion resistance; Test Method F392 for flexural fatigue; Test Method F1358 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 F739 and F903, respectively.

1.4 The integrity of vapor protective ensembles is measured by its ability to maintain positive internal pressure with Test Method F1052.

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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1.5 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.

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

D751 Test Methods for Coated Fabrics

D2582 Test Method for Puncture-Propagation Tear Resistance of Plastic Film and Thin Sheeting

D4157 Test Method for Abrasion Resistance of Textile Fabrics (Oscillatory Cylinder Method)

F392 Test Method for Flex Durability of Flexible Barrier Materials

F739 Test Method for Permeation of Liquids and Gases through Protective Clothing Materials under Conditions of Continuous Contact

F903 Test Method for Resistance of Materials Used in Protective Clothing to Penetration by Liquids

F1052 Test Method for Pressure Testing Vapor Protective Suits

F1358 Test Method for Effects of Flame Impingement on Materials Used in Protective Clothing Not Designated Primarily for Flame Resistance

F1383 Test Method for Permeation of Liquids and Gases through Protective Clothing Materials under Conditions of Intermittent Contact

F1407 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.

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

3.1.3 *penetration, n*—for chemical protective clothing, the movement of substances through voids in protective clothing materials or items on a nonmolecular level.

3.1.3.1 *Discussion*—Voids include gaps, pores, holes and imperfections in closures, seams, interfaces and protective clothing materials. Penetration does not require a change of state; solid chemicals move through voids in materials as solids, liquids as liquids and gases as gases. Penetration is a distinctly different mechanism from permeation.

3.1.4 *permeation, n*—for chemical protective clothing, the movements of chemicals as molecules through protective

clothing materials by the processes of (1) absorption of the chemical into the contact surface of the materials, (2) diffusion of the absorbed molecules throughout the material, and (3) desorption of the chemical from the opposite surface of the material.

3.1.4.1 *Discussion*—Permeation is a distinctly different mechanism from penetration.

3.1.5 *protective clothing, n*—an item of clothing that is specifically designed and constructed for the intended purpose of isolating all or part of the body from a potential hazard; or, isolating the external environment from contamination by the wearer of the clothing

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.

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, or both.

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.

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.

5.2.1 It is permissible to specify shorter test durations. The duration of exposure in each mannequin orientation must be the same.

5.2.2 The choice of different test duration is partly based on the number of layers in the specimen being tested, some of which serve to absorb the surfactant-treated test liquid and result in attenuating the severity of the liquid challenge to the specimen.

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.

5.3 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

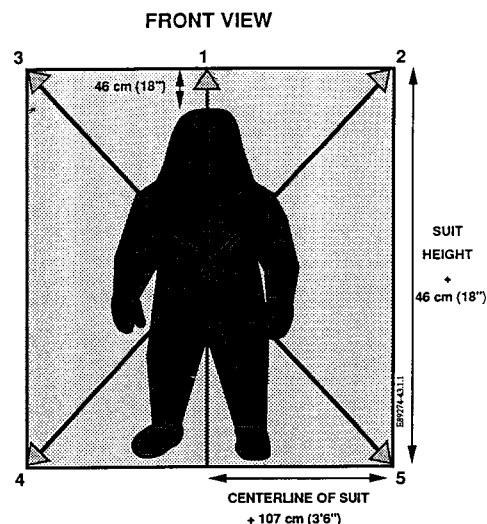


FIG. 1 Positions of Shower Nozzles

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 specifications given in Fig. 2.³ The pressurized liquid supply shall be delivered at 3.0 ± 0.2 L/min [48 ± 3 gal/h] through each nozzle.

6.4 *Stopwatch*, or other appropriate timing device.

7. Precautions

7.1 Conduct the test method in an area designed to collect liquid runoff.

7.2 Keep unprotected observers from being exposed to the test liquid.

7.3 After testing, and before returning the specimen to service or storage, ensure the following:

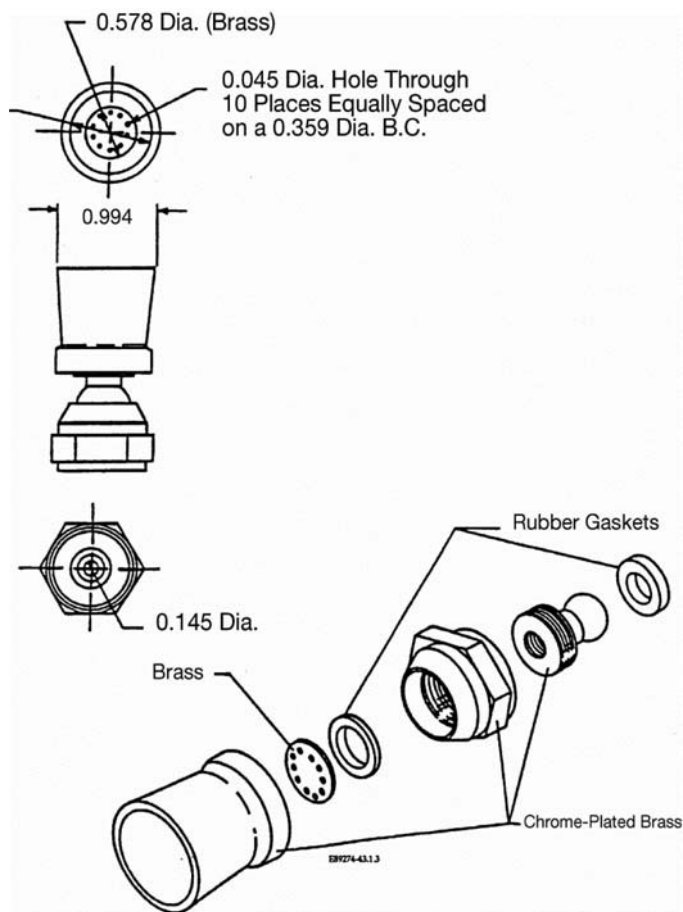
- 7.3.1 The specimen is dry,
- 7.3.2 The specimen is clean, and
- 7.3.3 All parts are positioned correctly and secured tightly.

8. Specimen Preparation

8.1 Protective clothing or protective ensemble components, shall be tested as received and in accordance with the manufacturer's instructions. Duct tape or other nonuniform methods for closing or sealing, or both, interfaces shall not be used.

8.2 Parts of the protective clothing or protective ensemble that are not to be tested shall be suitably blocked off to prevent liquid from penetrating those areas. For example, in the case of ensembles without gloves, block off the outer end of the sleeves with waterproof tape or some other sealant to prevent liquid penetration at the hands.

³ Type #SS1B and SS1C nozzles meet this requirement. Available from Whedon Products, Inc., 212 Andover Dr., West Hartford, CT 06107.



NOTE 1—All dimensions are in inches (1 in. = 25.4 mm). All dimensions are approximate to the nearest 0.01 inch.

FIG. 2 Shower Nozzle Specifications

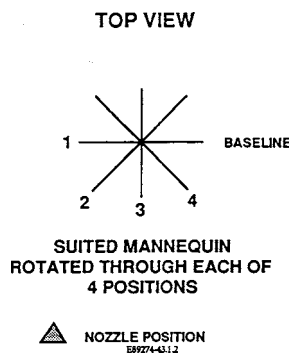
9. Procedure

9.1 Prior to each test, inspect the liquid-absorptive inner garment and protective clothing or protective ensemble (and other ensemble components and equipment to be tested) for total dryness before using.

9.2 Put the liquid-absorptive inner garment on the mannequin. The inner garment shall cover all areas of the mannequin that are of interest.

9.3 Put the protective clothing or protective ensemble to be tested over the inner garment on the mannequin in accordance with the manufacturer's instructions. Place and attach additional ensemble components and equipment on the mannequin in accordance with the manufacturer's directions.

9.4 Block off from exposure to the liquid spray any areas of the mannequin or protective clothing or protective ensemble not being evaluated. For example, tie or tape a plastic bag over the mannequin's head. Ties or tape, or both, shall not extend more than 2.5 cm [1 in.] past the edge of the protective clothing or protective ensemble.



NOTE 1—Mannequin torso shall be oriented with the shoulders parallel to the indicated orientation.

FIG. 3 Orientation of Suited Mannequin Exposure

9.5 Add a sufficient amount of a nontoxic, non-foaming surfactant to the water supply to achieve a surface tension of 0.032 ± 0.002 N/m (32 ± 2 dynes/cm).⁴

9.6 Expose the suited mannequin to the liquid spray for a period of 60 min, 15 min in each of four orientations shown in Fig. 3. Spray liquid at the rate of 3.0 ± 0.2 L/min [48 ± 3 gal/h] through each nozzle simultaneously. Ensure that each nozzle is not partly plugged or closed at the start of each test.

9.6.1 Alternatively expose the suited mannequin for a different period of time divided into four equal periods for exposing the mannequin in each of the four orientations.

9.7 At the end of the liquid spray period, remove excess liquid from the surface of the test garment. Paper toweling is one method that works well.

9.8 Inspect the protective clothing or protective ensemble within 10 min of the end of the liquid spray period for evidence of liquid penetration. Determine liquid penetration by one of the following procedures:

9.8.1 Remove the protective clothing or protective ensemble in a dry area and any other ensemble components or equipment from the mannequin and examine the inner garment, garment liners, and garment interior for signs of wetness. Record these areas as locations of wetness.

9.8.2 If a dye is added to the liquid, remove the protective clothing or protective ensemble and any other ensemble components or equipment from the mannequin, and examine the inner garment, garment liners, and garment interior for the appearance of any dye-colored areas. Record these areas as locations of wetness.

9.8.3 If a fluorescent dye is added to the liquid, examine the inner garment, garment liners, and garment interior under ultraviolet lighting in a dark room for fluorescing areas. Record these areas as locations of wetness.

⁴ A 0.1 weight % solution of Surfynol 104H with water gives a surface tension of approximately 33.8 dynes/cm. Available from Air Products and Chemical, Inc., Performance Chemicals, Box 538, Allentown, PA 18105.



9.9 Record any protective clothing or protective ensemble as passing if no areas of wetness are observed. If there are areas of wetness, record the protective clothing or protective ensemble as failing.

9.9.1 Distinguish whether wetness occurs on the interior of the protective clothing or on the liquid-absorptive garment, and the specific areas and relative amounts of wetness in estimated surface area of the protective clothing or liquid-absorptive garment showing wetness.

9.9.2 Identify the location and describe the specific areas of leakage observed for the protective clothing or protective ensemble, if leakage is noted. As part of the description, indicate the relative amount of leakage that is noted in terms of observed wetted area on the inner absorptive garment or the interior of the garment, as applicable.

NOTE 1—Photographs or diagrams are suggested as a means for documenting the areas of protective clothing or protective ensemble leakage.

9.9.3 Describe the probable reason for each failure, if possible.

10. Report

10.1 State that the protective clothing or protective ensemble was tested in accordance with Test Method F1359.

10.2 Report the following information.

10.2.1 *Description of the Protective Clothing or Protective Ensemble*—Include unique identification number, identifying brand name, manufacturer, date of purchase, date of manufacture if available, size, materials of construction, and unique clothing features, for example, special fittings to accommodate respiratory equipment.

10.2.2 *Description of Ensemble Components (if applicable)*—Include the type of item, unique identification

number, identifying brand name, date of purchase, date of manufacture if available, size, materials of construction, and method of attachment.

10.2.3 *Description of the Area Tested*—Any area of the protective clothing or protective ensemble blocked off from exposure to the liquid spray and the reason that the particular area was not tested.

10.2.4 *Liquid Test Agent Used*—Identify the type of surfactant, brand name, identification number, concentration, and surface tension of the liquid test agent.

10.2.5 *Determination Technique*—Describe the procedure for determining liquid penetration.

10.2.6 *Test Result*—Report the test result as pass or fail.

10.2.7 *Description of Leakage Areas*—Report the specific areas of leakage observed for the protective clothing or protective ensemble, if found to fail, by identifying both the specific locations and relative amount of leakage observed. Note if the failure was observed on the garment interior or on the liquid-absorptive garment and probable reasons for each failure. Include any photographs or diagrams showing the leakage as part of the report.

11. Precision and Bias

11.1 No statement is made about either the precision or bias of Test Method F1359 for measuring liquid penetration resistance since the result merely states whether there is conformance to the criteria for success specified in the procedure.

12. Keywords

12.1 liquid penetration resistance; liquid splash protective clothing; liquid splash protective ensembles; protective clothing; protective ensemble; shower spray test

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