



Standard Test Method for Resistance of Chemical Protective Clothing Materials to Liquid Permeation—Permeation Cup Method¹

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INTRODUCTION

Workers involved in the production, use, and transportation of chemicals can be exposed to numerous compounds capable of causing harm upon contact with the human body. The deleterious effects of these chemicals can range from acute trauma, such as dermatitis or burns, to chronic degenerative disease, such as cancer or pulmonary fibrosis. Since engineering controls may not eliminate all possible exposures, attention is often given to reducing the potential for direct skin contact through the use of protective clothing that resists degradation, penetration, and permeation.

This test method provides a simple, gravimetric means for measuring the resistance of clothing materials to permeation by liquid chemicals. Permeation testing by a more sophisticated procedure and penetration testing are addressed by separate methods: Test Methods F739 and F903, respectively. Test Methods for measuring the effects of chemicals on the physical properties of rubbers, plastics, and coated fabrics may be found in Test Method D471, Test Method D543, and Test Methods D751, respectively. Guide F1001 designates 21 chemicals for use with these tests.

1. Scope

1.1 This test method measures the barrier effectiveness of a specimen of protective clothing upon continuous contact with a liquid.

1.1.1 *Procedure A*—For use when a value for the cumulative amount of chemical permeated in 1 h is desired.

1.1.2 *Procedure B*—For use when breakthrough detection time and permeation rate values are desired.

1.2 Although not addressed herein, the effect of the test chemical on the clothing material can be determined by comparing the weight or other physical properties of the specimen before and after the permeation test.

1.3 The values stated in SI units are to be regarded as standard. The values given in parentheses are mathematical conversions to inch-pound units that are provided for information only and are not considered standard.

1.4 *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 applica-*

bility of regulatory limitations prior to use. Specific precautionary statements are given in Section 2.

2. Referenced Documents

2.1 *ASTM Standards*:²

D471 Test Method for Rubber Property—Effect of Liquids

D543 Practices for Evaluating the Resistance of Plastics to Chemical Reagents

D751 Test Methods for Coated Fabrics

E105 Practice for Probability Sampling of 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

F1001 Guide for Selection of Chemicals to Evaluate Protective Clothing Materials

2.2 *Federal Standard*:

No. 191, Method 5030.2 Measurement of the Thickness of Materials³

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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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 Standardization Documents Order Desk, DODSSP, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5098, <http://dodssp.daps.dla.mil>.

3. Terminology

3.1 Definitions:

3.1.1 *breakthrough detection time, n*—the elapsed time measured from the initial exposure to the test chemical to the sampling time that immediately precedes the sampling time at which the test chemical is first detected.

3.1.1.1 *Discussion*—In this method, the sampling time is the time of weighing.

3.1.2 *cumulative permeation, n*—the total mass of chemical that permeates during a specified time from when the material is first contacted.

3.1.3 *degradation, n*—a deleterious change in one or more properties of a material.

3.1.4 *penetration, n*—for *chemical protective clothing*, the movement of substances through voids in protective clothing materials or item on a non-molecular level.

3.1.4.1 *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 the material as solids, liquids as liquids and gases as gases. Penetration is a distinctly different mechanism from permeation.

3.1.5 *permeation, n*—for *chemical protective clothing*, the movement of chemicals as molecules through protective clothing materials items by the processes of: (1) absorption of the chemical into the contact surface of the material, (2) diffusion of the absorbed molecules throughout the material, and (3) desorption of the chemical from the opposite surface of the material.

3.1.5.1 *Discussion*—Permeation is a distinctly different mechanism from penetration

3.1.6 *protective clothing material, n*—any element, constituent, or substance from which protective clothing is composed or can be made.

3.1.7 *steady-state permeation rate, n*—a constant rate of permeation that occurs after breakthrough when all forces affecting permeation have reached equilibrium.

3.1.8 *test chemical, n*—the solid, liquid, gas, or mixture thereof, used to evaluate the performance of a protective clothing material.

3.1.8.1 *Discussion*—In this test method, the test chemical is a liquid and can be either one component (that is, a neat liquid) or have several components (that is, a mixture).

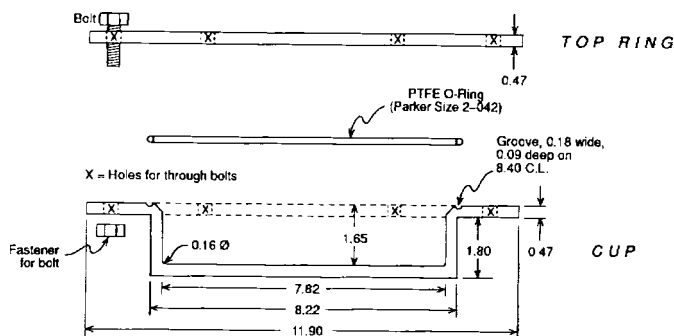
3.1.9 *time interval, n*—the time between weighings of the permeation cup.

4. Summary of Test Method

4.1 The resistance of a protective clothing material to permeation by a test chemical is assessed by measuring the cumulative permeation, breakthrough detection time, and permeation rate through replicate specimens of the material.

4.2 A clothing material specimen is secured over the mouth of a shallow cup that holds the test chemical. The normally outside surface of the material faces the chemical; the other side is open to the atmosphere. See Fig. 1.

4.3 The cup assembly is weighed, inverted, and reweighed at predetermined time intervals to determine the amount of



NOTE—Dimensions in centimetres.

FIG. 1 ASTM Permeation Cup

chemical that permeates the material and subsequently evaporates to the atmosphere.

4.4 Based on the amount of chemical lost from the cup during the exposure period, the breakthrough detection time, permeation rate, and cumulative mass of chemical permeating the clothing material are calculated.

4.5 Detection of permeation requires sufficient volatility of the test chemical, and the appropriate combination of analytical balance and weighing interval.

4.5.1 See Section 10 for volatility test.

4.5.2 The likelihood of detecting chemical permeation increases as (1) the sensitivity of the balance is increased and (2) the time between weighings and the length of the test are increased.

4.6 In extreme cases the chemical could so severely degrade the clothing material that the chemical will drip or otherwise flow from the inverted cup.

5. Significance and Use

5.1 This test method establishes a standard procedure for rapidly (in 1 h or less) determining the chemical resistance of specimens of protective clothing materials. This test method can be used to rank materials as to their suitability for use with liquids of known or unknown composition.

5.2 The breakthrough detection time, permeation rate, or cumulative permeation can be used to identify protective clothing materials that are more likely to limit potential exposures to chemicals. Longer breakthrough detection times and lower cumulative amounts permeated and permeation rates are characteristics of materials that are better barriers to the test chemical.

5.3 In general this test method is less sensitive than Test Method F739 coupled with sensitive analytical procedures. In cases where the chemical of concern is highly toxic and contact of even a very small amount with the skin may be detrimental to health, the permeation cup method is not recommended. Use Test Method F739.

5.4 Upon permeating the clothing material, the chemical must evaporate in order for a weight loss to occur and permeation to be detected. Consequently, the test method may not be applicable for chemicals having low volatility (that is, vapor pressure). The vapor pressure below which this test method is not applicable has not been determined.