



Designation: F 739 – 99a

Standard Test Method for Resistance of Protective Clothing Materials to Permeation by Liquids or Gases Under Conditions of Continuous Contact¹

This standard is issued under the fixed designation F 739; 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

Workers involved in the production, use, and transportation of liquid and gaseous 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 skin irritation and burn, to chronic degenerative disease such as cancer. Since engineering controls may not eliminate all possible exposures, attention is often placed on reducing the potential for direct skin contact through the use of protective clothing that resists permeation, penetration, and degradation.

This test method is used to measure the resistance to permeation under the conditions of continuous contact of the clothing material by the test chemical. Resistance to permeation under the condition of intermittent contact with the test chemical should be determined by Test Method F 1383. Resistance to penetration should be determined by Test Method F 903. Procedures for measuring the effects of liquid chemicals on the physical properties (that is, degradation) of rubbers, plastics, and coated fabrics are found in Test Method D 471, Test Method D 543, and Test Method D 751, respectively.

1. Scope

1.1 This test method measures the resistance of protective clothing materials to permeation by liquid or gaseous chemicals under the condition of continuous contact.

1.1.1 *Procedure A*—For use when the test chemical is a liquid that is either volatile or soluble in water.

1.1.2 *Procedure B*—For use when the test chemical is a gas.

1.2 *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 precautionary statements are given in Section 7.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 471 Test Method for Rubber Property—Effect of Liquids²

D 543 Test Method for Evaluating the Resistance of Plastics

to Chemical Reagents³

D 751 Test Methods for Coated Fabrics⁴

E 105 Practice for Probability Sampling of Materials⁵

E 171 Specification for Standard Atmospheres for Conditioning and Testing Flexible Barrier Materials⁶

E 177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods⁵

E 691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method⁵

F 903 Test Method for Resistance of Materials Used In Protective Clothing Materials to Penetration by Liquids⁷

F 1001 Guide for Selection of Chemicals to Evaluate Protective Clothing Materials⁷

F 1194 Guide for Documenting the Results of Chemical Permeation Testing on Materials Used In Protective Clothing Materials⁷

F 1383 Test Method for Resistance of Protective Clothing Materials to Permeation by Liquids or Gases Under Conditions of Intermittent Contact⁷

2.2 *Federal Standard:*

Fed. Std. No. 191, Method 5030.2 Measurement of the

¹ This test method is under the jurisdiction of ASTM Committee F23 on Protective Clothing and is the direct responsibility of Subcommittee F23.30 on Chemical Resistance.

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² *Annual Book of ASTM Standards*, Vol 09.01.

³ *Annual Book of ASTM Standards*, Vol 08.01.

⁴ *Annual Book of ASTM Standards*, Vol 09.02.

⁵ *Annual Book of ASTM Standards*, Vol 14.02.

⁶ *Annual Book of ASTM Standards*, Vol 15.09.

⁷ *Annual Book of ASTM Standards*, Vol 11.03.

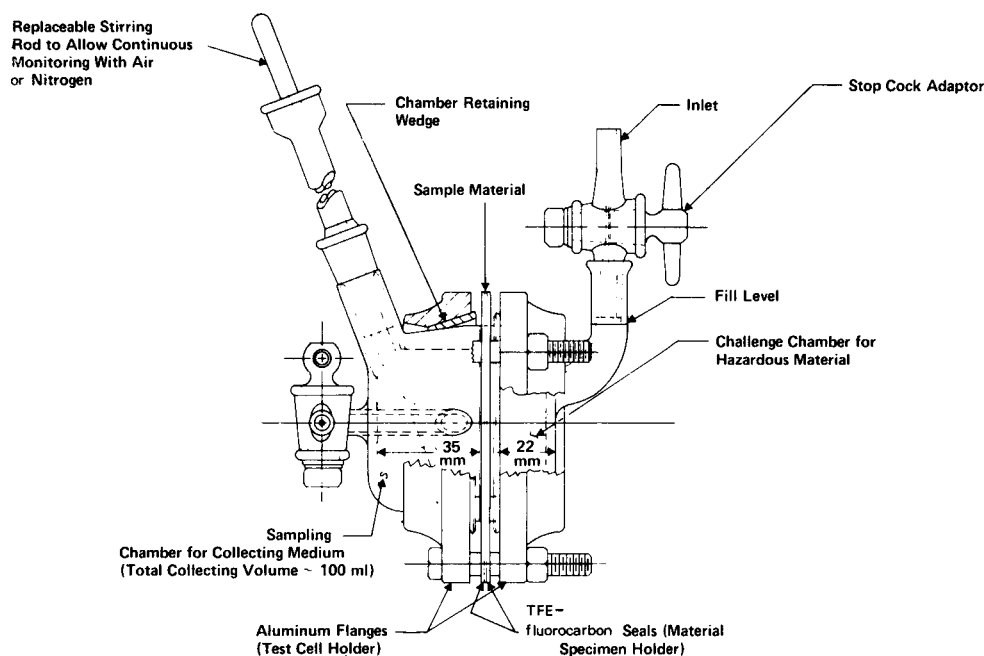


FIG. 1 ASTM Permeation Test Cell

Thickness of Materials⁸

3. Terminology

3.1 Definitions:

3.1.1 *analytical technique, n*—a procedure whereby the concentration of the test chemical in a collection medium is quantitatively determined.

DISCUSSION—These procedures are often specific to individual chemical and collection medium combinations. Applicable techniques include UV (ultraviolet) and IR (infrared) spectrophotometry, gas and liquid chromatography, colorimetry, length-of-stain detector tubes, and radionuclide tagging/detection counting.

3.1.2 *breakthrough detection time, n*—the elapsed time measured from the start of the test to the sampling time that immediately precedes the sampling time at which the test chemical is first detected (see Fig. 5).

DISCUSSION—The breakthrough detection time is dependent on the sensitivity of the method (see Appendix X1).

3.1.3 *closed-loop, adj*—refers to a testing mode in which the collection medium volume is fixed.

3.1.4 *collection medium, n*—a liquid or gas that does not affect the measured permeation and in which the test chemical is freely soluble or adsorbed to a saturation concentration greater than 0.5 weight or volume percent.

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

3.1.6 *minimum detectable mass permeated, n*—the smallest mass of permeant that is detectable with the complete permeation test system.

DISCUSSION—This value is not necessarily the sensitivity of the analytical instrument.

3.1.7 *minimum detectable permeation rate, n*—the lowest rate of permeation that is measurable with the complete permeation test system.

DISCUSSION—This value is not necessarily the sensitivity of the analytical instrument.

3.1.8 *normalized breakthrough detection time, n*—in an open-loop test, the time at which the permeation rate reaches 0.1 $\mu\text{g}/\text{cm}^2/\text{min}$. In a closed-loop test, the time at which the mass of chemical permeated reaches 0.25 $\mu\text{g}/\text{cm}^2$.

3.1.9 *open loop, adj*—refers to a testing mode in which fresh collection medium flows continuously through the collection chamber of the test cell.

3.1.10 *penetration, n*—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 nonmolecular level.

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

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.

⁸ Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

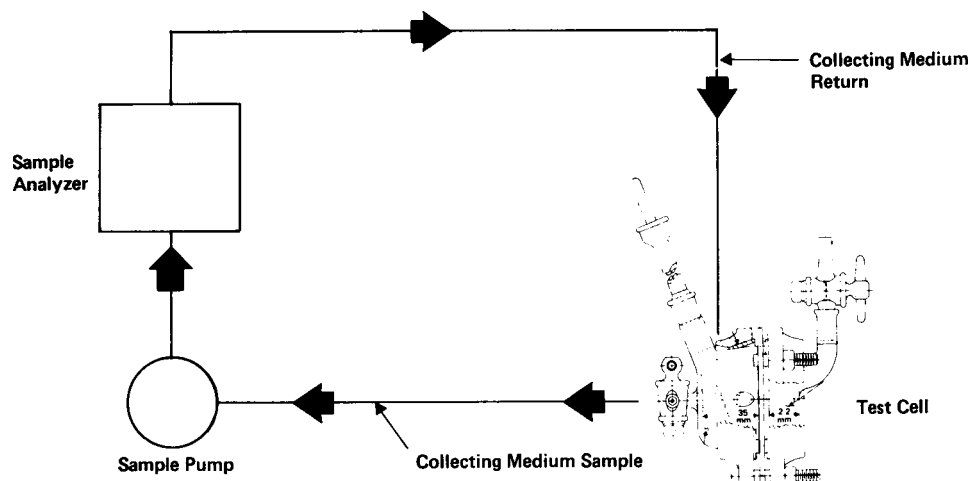


FIG. 2 Example Set-up for Continuous Collecting Medium Sample Withdrawal, Analysis, and Return

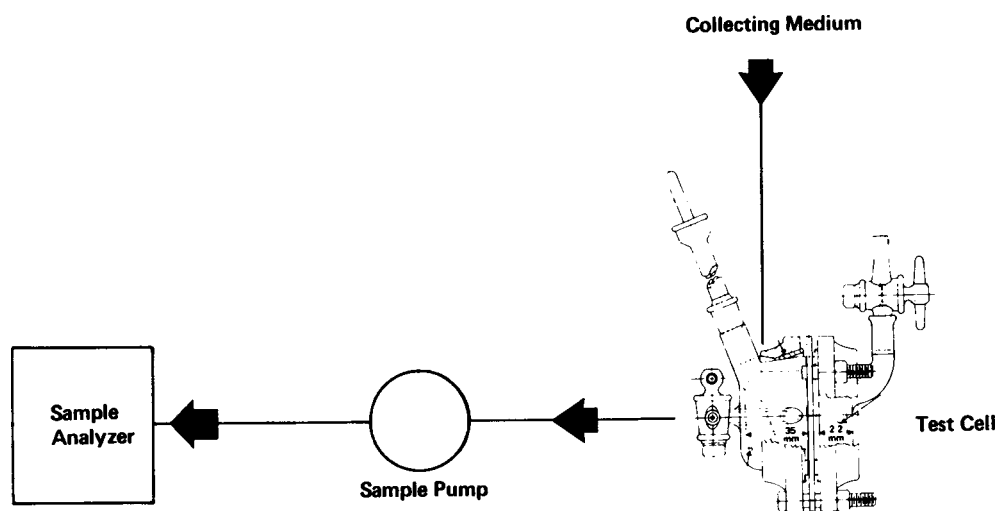


FIG. 3 Example Set-up for Continuous Flow of Fresh Collecting Medium

3.1.12 *protective clothing material, n*—any material or combination of materials used in an item of clothing for the purpose of isolating parts of the body from a potential hazard.

DISCUSSION—In this test method the particular hazard is permeation of a hazardous chemical.

3.1.13 *steady-state permeation, n*—the constant rate of permeation that occurs after breakthrough when the chemical contact is continuous and all forces affecting permeation have reached equilibrium.

3.1.14 *test chemical, n*—the liquid or gas that is used to challenge the protective clothing material specimen.

DISCUSSION—The liquid or gas may be either one component (for example, a neat liquid or gas) or have several components (for example, a mixture).

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 breakthrough detection time, normalized breakthrough detection time, and subsequent permeation rate through replicate specimens of the material.

4.2 In the permeation test apparatus, the protective clothing material specimen partitions the test chemical from the collection medium.

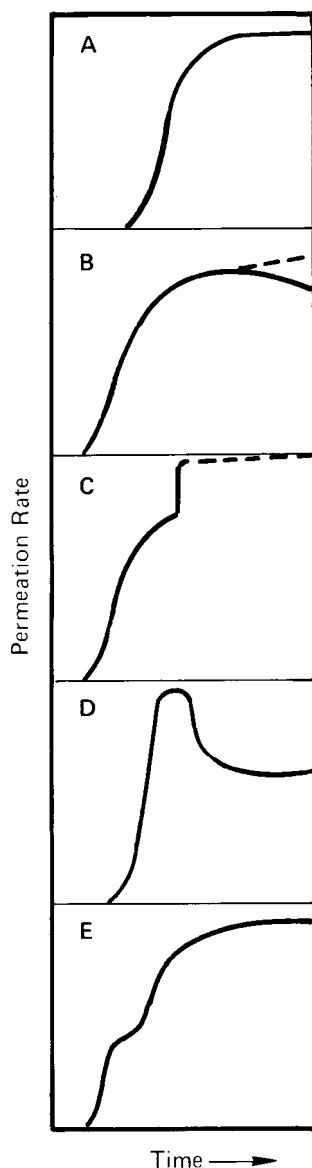
4.2.1 The collection medium, which may be liquid or gas, is analyzed quantitatively for its concentration of the chemical and thereby the amount of that chemical that has permeated the barrier as a function of time after its initial contact with the material.

4.2.2 By either graphical representation or appropriate calculations, or both, the breakthrough detection time, normalized breakthrough detection time, and the permeation rate of the test chemical are determined.

5. Significance and Use

5.1 This test method is normally used to evaluate flat specimens from finished items of protective clothing and from materials that are candidates for items of protective clothing.

5.1.1 Finished items of protective clothing include gloves, arm shields, aprons, suits, hats, boots, respirators, and the like.



NOTE—Fig. 4 shows five types of permeation behavior. Type A, the most typical, where the permeation rate stabilizes at a “steady state” value. Type B behavior is due to the material specimen being structurally modified by the chemical resulting in an increase or decrease in permeation rate. Type C behavior occurs when the material specimen exhibits a sudden, very large increase in rate. Type D response happens when there is moderate to heavy swelling of the material specimen although the permeation rate eventually stabilizes. Type E response can occur when there is a high degree of swelling.

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FIG. 4 Five Types of Permeation Behavior

5.1.2 The phrase “specimens from finished items” encompasses seamed or other discontinuous regions as well as the usual continuous regions of protective clothing items.

5.2 The breakthrough detection time, normalized breakthrough time, and permeation rate are key measures of the effectiveness of a clothing material as a barrier to the test chemical. Such information is used in the comparison of clothing materials during the process of selecting clothing for

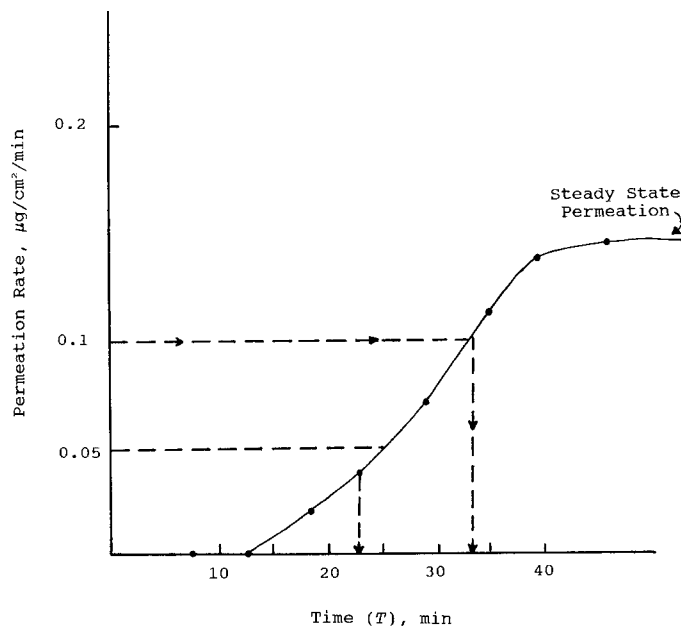


FIG. 5 The Breakthrough Detection Time for a method sensitivity of $0.05 \mu\text{g}/\text{cm}^2/\text{min}$ is 23 minutes. The Normalized Breakthrough Detection Time is 33 minutes. The Steady State Permeation Rate is approximately $0.15 \mu\text{g}/\text{cm}^2/\text{min}$.

protection from hazardous chemicals. Long breakthrough detection times and normalized breakthrough detection times and low permeation rates are characteristics of better barriers.

NOTE 1—At present, no quantitative information exists about acceptable levels of dermal contact. Therefore, the data obtained using this test method cannot be used to infer safe exposure levels.

5.3 The sensitivity of the test method in detecting low permeation rates or amounts of the test chemical that permeate is determined by the combination of the analytical technique and collection system selected, and the ratio of material specimen area to collection medium volume or flow rate.

5.3.1 A sensitive analytical technique permits quantitative detection of the test chemical in the collection medium at concentrations as low as parts per billion.

5.3.2 Higher ratios of material specimen area to collection medium volume or flow rate permit earlier detection of breakthrough and detection of lower permeation rates because higher concentrations of the test chemical in the collection medium will develop in a given time period, relative to those that would occur at lower ratios.

5.4 Comparison of results requires specific information on the test cell, procedures, and analytical techniques. Results obtained from closed-loop and open-loop testing may not be directly comparable.

5.4.1 The sensitivity of an open-loop system is characterized by its minimum detectable permeation rate. A method for determining this value is presented in Appendix X1.

5.4.2 The sensitivity of a closed-loop system is characterized by its minimum detectable mass permeated.

5.5 A group of chemicals for use in permeation testing is given in Guide F 1001.