



Designation: F 1383 – 99a

# Standard Test Method for Resistance of Protective Clothing Materials to Permeation by Liquids or Gases Under Conditions of Intermittent Contact<sup>1</sup>

This standard is issued under the fixed designation F 1383; 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 condition of intermittent contact of the protective clothing material with liquid or gaseous chemicals. Resistance to permeation and penetration under conditions of continuous contact should be determined by Test Methods F 739 and F 903, respectively. Methods for measuring the effects of the continuous contact of chemicals on the physical properties (that is, degradation) of rubbers, plastics, and coated fabrics are found in Test Methods D 471, Test Method D 543, and Test Method D 751, respectively.

## 1. Scope

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

NOTE 1—The liquid must be volatile or soluble in water.

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 hazard statements are given in Section 3.1.*

## 2. Referenced Documents

### 2.1 ASTM Standards:<sup>2</sup>

D 471 Test Method for Rubber Property—Effect of Liquids

D 543 Practices for Evaluating the Resistance of Plastics to Chemical Reagents

D 751 Test Methods for Coated Fabrics

E 105 Practice for Probability Sampling of Materials

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

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

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

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

### 2.2 Federal Standard:

Fed. Std. No. 191, Method 5030.2 Measurement of the Thickness of Materials<sup>3</sup>

## 3. Terminology

### 3.1 Definitions:

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

<sup>1</sup> This test method is under the jurisdiction of ASTM Committee F23 on Protective Clothing and is the direct responsibility of Subcommittee F23.30 on Chemicals.

Current edition approved June 10, 1999. Published August 1999. Originally published as F 1383 – 92. Last previous edition F 1383 – 99.

<sup>2</sup> 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.

<sup>3</sup> Available from Standardization Documents Order Desk, Bldg 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

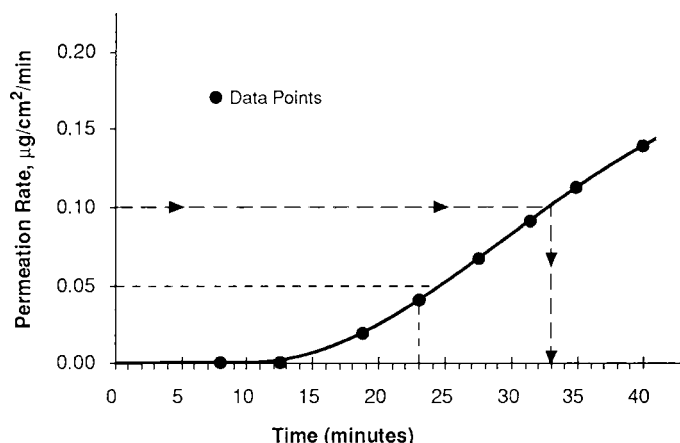


**FIG. 1 The Breakthrough Detection Time for a Method Sensitivity of 0.05 µg/cm²/min is 23 min. The Normalized Breakthrough Detection Time is 33 min.**

3.1.1.1 *Discussion*—These procedures are often specific to individual chemical and collection medium combinations. Applicable techniques can include ultraviolet (UV) and infrared (IR) 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. 1).

3.1.2.1 *Discussion*—The breakthrough detection time is dependent on the sensitivity of the method.

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 %.

3.1.5 *contact time, n*—in an intermittent contact test, the duration during each cycle that the challenge side chamber of the permeation cell is filled with the test chemical.

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

3.1.6.1 *Discussion*—Quantification of cumulative permeation enables the comparison of permeation behaviors under different intermittent and continuous contact conditions.

3.1.7 *cycle time, n*—in an intermittent contact test, the interval of time from the start of one contact period to the start of the next contact period.

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

3.1.9 *minimum detectable mass permeated, n*—the smallest mass of test chemical that is detectable with the complete permeation test system. This value is not necessarily the sensitivity of the analytical instrument.

3.1.10 *minimum detectable permeation rate, n*—the lowest rate of permeation that is measurable with the complete permeation test system. This value is not necessarily the sensitivity of the analytical instrument.

3.1.11 *normalized breakthrough detection time, n*—in an open-loop system, the time at which the permeation rate reaches 0.1 µg/cm²/min (see Fig. 1). In a closed-loop test, the time at which the mass of chemical permeated reaches 0.25 µg/cm².

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

3.1.13 *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 non-molecular level.

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

3.1.14.1 *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.

3.1.15 *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.

3.1.15.1 *Discussion*—In this test method the particular hazard is permeation of a hazardous chemical.

3.1.16 *purge time, n*—in an intermittent contact test, the time immediately following the termination of the contact time when the test chemical is removed from the challenge side chamber and air or nitrogen is blown over the outside surface of the protective clothing material.

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

3.1.17.1 *Discussion*—The liquid or gas may be either one component (that is, a neat liquid or gas) or have several components (that is, a mixture).

## 4. Summary of Test Method

4.1 The resistance of a protective clothing material to a test chemical is measured in a permeation test in which replicate clothing specimens are intermittently contacted with the chemical.

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

4.2.1 Contact of the test chemical with the clothing material's outside surface is made intermittent by periodically adding and removing the test chemical from the challenge chamber of the test cell.

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

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



## 5. Significance and Use

5.1 This test method is used to measure chemical permeation through specimens of protective clothing under the condition of intermittent contact of a test chemical with the specimen. In many applications, protective clothing is contacted intermittently to chemicals, not continuously as is tested by Test Method F 739.

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

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

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

5.3 In some cases, it may be of interest to compare permeation behaviors that occur under conditions of intermittent contact with those that occur during continuous contact. Test Method F 739 is recommended for measuring permeation under the conditions of continuous contact of the test chemical with the clothing specimen.

5.4 The breakthrough detection time, normalized breakthrough detection time, and the cumulative permeation 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 protection from hazardous chemicals. Long breakthrough detection times and normalized breakthrough detection times and low cumulative permeation are characteristics of better barriers.

NOTE 2—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.

5.5 The sensitivity of the test method in detecting low permeation rates or amounts of the test chemical permeated is determined by the combination of: (1) the analytical technique and collection system selected, and (2) the ratio of material specimen area to collection medium volume or flow rate.

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

5.5.2 Higher ratios of material specimen area to collection medium volume or flow rate permit earlier detection of permeation 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.

5.5.3 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.

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

5.6 Comparison of results of tests performed with different permeation test systems requires specific information on the test cell, procedures, contact and purge times, and analytical techniques. Results obtained from closed-loop and open-loop testing may not be directly comparable.

5.7 A group of chemicals that is recommended for use in permeation testing is given in Guide F 1001.

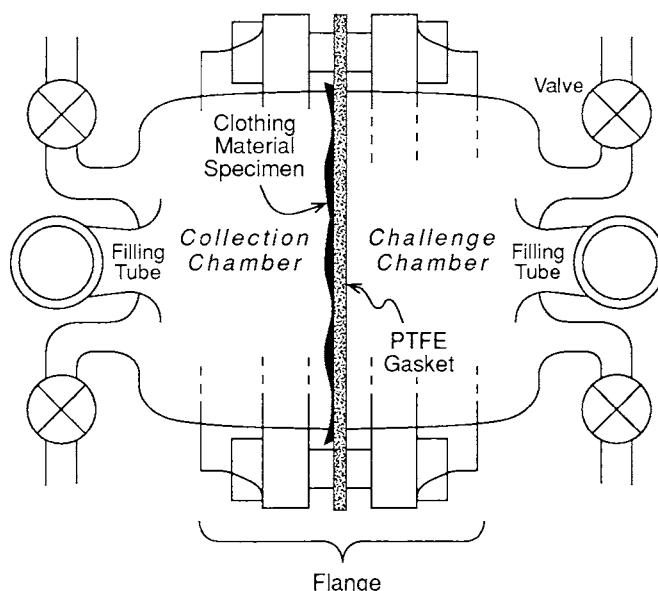


FIG. 2 ASTM Permeation Cell Configured for Intermittent Contact Testing (Top View)

## 6. Apparatus

6.1 *Thickness Gage*, suitable for measuring thicknesses to the nearest 0.02 mm (or the nearest 0.001 in.), as specified in Fed. Std. No. 191 Method 5030.2, shall be used to determine the thickness of each protective clothing material specimen tested.

6.2 *Analytical Balance*, readable and reproducible to  $\pm 0.5$  mg shall be used to determine weight per unit area of each test specimen.

6.3 *Test Cell*—The test apparatus consists of a two-chambered cell for contacting the specimen with the test chemical on the specimen's normally outside surface and with a collection medium on the specimen's normal inside surface.

6.3.1 The test cell<sup>4</sup>, as shown in Fig. 2, is constructed of two sections of straight glass pipe, each nominally sized to a 51 mm (2.0 in.) diameter.<sup>5</sup> Materials other than glass may be used. Such materials would be required for tests involving chemicals (for example, hydrofluoric acid) which are incompatible with glass. Each pipe section is 35 mm (1.4 in.) or less in length as described in 6.3.1.5.

6.3.1.1 One end of each glass section is sealed closed (for example, with a glass disk equivalent in quality to that of the glass of the original sections).

6.3.1.2 The opposite end of each glass section retains the as-manufactured flared end.

6.3.1.3 Inlet and outlet ports with appropriate stopcock valves are added to each glass section as shown.

6.3.1.4 When assembled, the two glass sections are joined by flanges.<sup>6</sup> A PTFE gasket is used at the joint.<sup>7</sup>

<sup>4</sup> The test cell as shown in Fig. 2 is available from Pesce Lab Sales, P.O. Box 235, 226 Birch St., Kennet Square, PA 19348.

<sup>5</sup> Sections of borosilicate glass pipe, available from Corning Glass, Catalog No. 72-0702 (1-in. length), or equivalent, have been found suitable for this purpose.

<sup>6</sup> Flanges, available from Corning Glass, Catalog Nos. 72-9062 (aluminum) or 72-9654 (cast iron), have been found suitable for this purpose.