This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.

Designation: F1296 – 08 (Reapproved 2023)

Standard Guide for Evaluating Chemical Protective Clothing[1]

This standard is issued under the fixed designation F1296; 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

ASTM Committee F23 was established in 1976 for the purpose of producing standards for use in the evaluation of protective clothing. A significant number of these standards have applied to protection against chemicals. Chemical protective clothing ranges from aprons and gloves to totally encapsulating ensembles. Chemical protective clothing is widely used throughout in several different applications including the general industry, the chemical process industry, oil refining, agriculture, hazardous materials remediation, and emergency response.

The effective development and selection of chemical protective clothing requires information on several aspects of the clothing, including chemical resistance, physical integrity, comfort, and fit. Some of these characteristics can be evaluated using swatches of the materials from which the clothing is fabricated. Other characteristics require testing of the finished items of clothing. Committee F23 has developed test methods for both types of evaluations.

The successful use of Committee F23's standards requires an awareness and understanding of each standard as well as the interrelationship of the standards.

The successful application of chemical protective clothing requires the careful matching of the proper level of protection and performance characteristics of clothing with the potential hazard and the functional requirements of the tasks to be performed while wearing the clothing.

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1. Scope

1.1 This guide is intended to aid in the application of standards for the development, specification, and selection of chemical protective clothing with the ultimate goal of maintaining the safety and health of workers who come into contact with hazardous chemicals.

1.2 This guide provides a short description of each referenced standard and then makes specific recommendations for the use of these standards. The referenced standards are organized under the following headings: Material Chemical Resistance, Material Physical Properties, Seam and Closure Performance, and Overall Clothing Performance.

1.3 No protocol can ensure the selection of protective clothing that guarantees worker protection. The purpose of testing is to generate data and information that will allow the selection of the most appropriate clothing. Ultimately, clothing selection is based on technical evaluation of available information and professional assessment of risk.

1.4 The values stated 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.

1.5 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

[1] This guide 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.

Current edition approved June 1, 2023. Published June 2023. Originally approved in 1991. Last previous edition approved in 2015 as F1296 – 08 (2015). DOI: 10.1520/F1296-08R23.

[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.

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D747 Test Method for Apparent Bending Modulus of Plastics by Means of a Cantilever Beam (Withdrawn 2019)[3]
D751 Test Methods for Coated Fabrics
D1630 Test Method for Rubber Property—Abrasion Resistance (Footwear Abrader)
D2582 Test Method for Puncture-Propagation Tear Resistance of Plastic Film and Thin Sheeting
D3389 Test Method for Coated Fabrics Abrasion Resistance (Rotary Platform Abrader)
D4157 Test Method for Abrasion Resistance of Textile Fabrics (Oscillatory Cylinder Method)
D4966 Test Method for Abrasion Resistance of Textile Fabrics (Martindale Abrasion Tester Method)
D5034 Test Method for Breaking Strength and Elongation of Textile Fabrics (Grab Test)
D5151 Test Method for Detection of Holes in Medical Gloves
D5587 Test Method for Tearing Strength of Fabrics by Trapezoid Procedure
D6413/D6413M Test Method for Flame Resistance of Textiles (Vertical Test)
F392/F392M Practice for Conditioning Flexible Barrier Materials for Flex Durability
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
F1052 Test Method for Pressure Testing Vapor Protective Suits
F1154 Practices for Evaluating the Comfort, Fit, Function, and Durability of Protective Ensembles, Ensemble Elements, and Other Components
F1186 Classification System for Chemicals According to Functional Groups
F1194 Guide for Documenting the Results of Chemical Permeation Testing of Materials Used in Protective Clothing
F1291 Test Method for Measuring the Thermal Insulation of Clothing Using a Heated Manikin
F1301 Practice for Labeling Chemical Protective Clothing
F1342/F1342M Test Method for Protective Clothing Material Resistance to Puncture
F1358/F1358M Test Method for Effects of Flame Impingement on Materials Used in Protective Clothing Not Designated Primarily for Flame Resistance
F1359/F1359M Test Method for Liquid Penetration Resistance of Protective Clothing or Protective Ensembles Under a Shower Spray While on a Manikin
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
F1461 Practice for Chemical Protective Clothing Program
F1494 Terminology Relating to Protective Clothing
F1790/F1790M Test Method for Measuring Cut Resistance of Materials Used in Protective Clothing with CPP Test Equipment
F2061 Practice for Chemical Protective Clothing: Wearing, Care, and Maintenance Instructions
F2130 Test Method for Measuring Repellency, Retention, and Penetration of Liquid Pesticide Formulation Through Protective Clothing Materials

2.2 *ANSI Standard:*[4]

ANSI Z41 American National Standard for Personal Protection—Protective Footwear

2.3 *ANSI/ISEA Standard:*[5]

ANSI/ISEA 105 American National Standard for Hand Protection Selection Criteria

2.4 *NFPA Standards:*[6]

NFPA 1991 Standard on Vapor-Protective Ensemble for Hazardous Materials Emergencies
NFPA 1992 Standard on Liquid Splash-Protective Ensemble and Clothing for Hazardous Materials Emergencies
NFPA 1994 Standard on Protective Ensemble for Chemical/Biological Terrorism Incidents

2.5 *Federal Regulations:*[7]

29 CFR Part 1910.120 Hazardous Waste Operations and Emergency Response: Final Rule, *Federal Register*, Vol 54, Mar. 6, 1989, p. 9317, as amended in *Federal Register*, Vol 55, Apr. 13, 1990, p. 14073; *Federal Register*, Vol 56, Apr. 18, 1991, p. 15382 and *Federal Register*, Vol 59, Aug. 22, 1994, p. 43270
29 CFR Part 1910.132 General Requirements of Subpart I—Personal Protective Equipment, *Federal Register*, Vol 39, Jun. 27, 1974, p. 23502, as amended in *Federal Register*, Vol 59, Apr. 6, 1994, p. 16334 and *Federal Register*, Vol 59, July 1, 1994, p. 33910
29 CFR Part 1910.1000 Air Contaminants, *Federal Register*, Vol. 39, June 27, 1974

2.6 *American Conference of Governmental Industrial Hygienists:*[8]

TLVs® and BEIs®: Threshold Limit Values for Chemical Substances and Physical Agents; Biological Exposure Indices

3. Terminology

3.1 *Definitions:*

[3] The last approved version of this historical standard is referenced on www.astm.org.

[4] Available from National Safety Council (NSC), 1121 Spring Lake Dr., Itasca, IL 60143-3201, http://www.nsc.org.

[5] Available from Industrial Safety Equipment Association, 1901 North Moore Street, Suite 808, Arlington, VA 22209.

[6] Available from National Fire Protection Association (NFPA), 1 Batterymarch Park, Quincy, MA 02169-7471, http://www.nfpa.org.

[7] Available from U.S. Government Printing Office Superintendent of Documents, 732 N. Capitol St., NW, Mail Stop: SDE, Washington, DC 20401, http://www.access.gpo.gov.

[8] Available from American Conference of Governmental Industrial Hygienists, Inc. (ACGIH), 1330 Kemper Meadow Dr., Suite 600, Cincinnati, OH 45240, http://www.acgih.org.

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3.1.1 *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.

3.1.2 For definitions of other terms related to protective clothing used in this guide, refer to Terminology F1494.

4. Significance and Use

4.1 The standards under the jurisdiction of Committee F23 and other technical committees can be used individually or as part of an integrated protocol in the development, selection, specification, and use of chemical protective clothing.

4.2 The standards are intended as a means by which information can be requested, generated, and reported in a consistent, comparable manner.

4.3 The suggested evaluation and test methods are recommended guidelines only. Test methods offer procedures for evaluating chemical protective clothing at standardized conditions to allow comparison.

4.4 The information on clothing performance must be combined with professional judgment and a clear understanding of the clothing application to provide the best protection to the worker. All chemical protective clothing use must be based on a hazard assessment to determine the risks for exposure to chemicals and other hazards. Conduct hazard assessments in accordance with 29 CFR 1910.132.

4.5 Chemical protective clothing intended for use during hazardous materials emergencies shall be evaluated against and conform to NFPA 1991, Standard on Vapor-Protective Ensemble for Hazardous Materials Emergencies, or NFPA 1992, Standard on Liquid Splash-Protective Ensemble and Clothing for Hazardous Materials Emergencies, as appropriate for the type of emergency. For emergencies involving release of chemical agents during terrorism incidents, chemical protective clothing shall be evaluated against and conform to NFPA 1994, Standard on Protective Ensemble for Chemical/Biological Terrorism Incidents.

4.6 Recommendations for labeling chemical protective clothing are provided in Practice F1301, recommendations for implementing a chemical protective clothing program are provided in Practice F1461, and recommendations for preparing care and maintenance instructions are provided in Practice F2061.

4.7 Appendix X1 is an example of how several of the referenced standards can be combined into a protocol to select the most suitable chemical protective clothing for a given application. Briefly, the process is one of defining the requirements of the application and then (by testing) eliminating those candidates that are unsuitable.

4.8 Appendix X2 provides a chart to cross reference U.S. Standards with European and International Standards. This chart shows only analogous standards for measuring the same property or evaluating the similar chemical protective clothing and does not imply that results from different tests will be comparable.

5. Evaluation of Material Chemical Resistance

5.1 *Applicable Standards:*

5.1.1 *Test Method F739 (Resistance of Protective Clothing Materials to Permeation by Liquids or Gases Under Conditions of Continuous Contact)*—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.

5.1.1.1 In the permeation test apparatus, the protective clothing material specimen separates the test chemical from the collection medium. The liquid or gas collection medium is analyzed quantitatively for the challenge chemical concentration that permeates through the test specimen as a function of time after it contacts the material.

5.1.1.2 Test Method F739 permits several configurations of the test, including the choice of collection media, detection systems, the test temperature, and length of the test.

5.1.2 *Test Method F1383 (Resistance of Protective Clothing Materials to Permeation by Liquids or Gases Under Conditions of Intermittent Contact)*—This test method is a variation of Test Method F739 and is used to measure breakthrough detection time and permeation rate through specimens of protective clothing under the conditions of intermittent contact of the test chemical with the specimen.

5.1.2.1 Test Method F1383 is designed to simulate the type of chemical exposures where chemical contact occurs through periodic exposure or through repeated splashes depending on the type of task in which the clothing wearer is involved.

5.1.2.2 Test Method F1383 permits several options for specifying the frequency and length of chemical contact with the material specimens. Because chemical contact with the specimen is varied, the test method specifies the reporting of cumulative permeation as opposed to permeation rate. One of the options for using Test Method F1383 is to measure the length of time for a specific chemical to permeate through a candidate clothing material after a single "splash" exposure followed by a saturated vapor exposure. This test protocol can simulate how clothing is exposed during actual use.

5.1.3 *Test Method F1407 (Resistance of Chemical Protective Clothing Materials to Liquid Permeation—Permeation Cup Method)*—In this test method, permeation of chemicals through a clothing specimen is measured gravimetrically. The chemical is placed in a shallow cup and the clothing specimen clamped over the top of the cup. The interior surface of the clothing surface is left open to air. The cup assembly is weighed periodically, and from the change in weight, the permeation rate calculated and the breakthrough time estimated. The clothing material specimen is also observed for visible changes in appearance that would indicate chemical degradation.

5.1.3.1 Physical properties of the clothing specimen can be measured before and after the exposure as another means for assessing chemical resistance.

5.1.3.2 Test Method F1407 is applicable to chemicals with sufficiently high vapor pressure such that they will readily evaporate upon permeation through the clothing material. The

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test cannot distinguish the permeation of different chemicals from a chemical mixture.

5.1.4 *Test Method F903 (Resistance of Materials Used In Protective Clothing to Penetration by Liquids)*—This test method is used to evaluate the barrier effectiveness of protective clothing materials against liquids.

5.1.4.1 In penetration resistance testing, a material specimen is subjected to a liquid contact for a specified time and pressure sequence and observed for visible penetration of the liquid. If the liquid passes through the material, the material fails the test for resistance to penetration of the liquid. Test Method F903 permits the use of techniques such as the use of blotter paper and dyes to enhance the visual detection of penetration. Results are reported as "pass" or "fail."

5.1.4.2 Test Method F903 specifies four different time and pressure sequences representing different types of exposure scenarios. The test method also permits the use of a support screen for lightweight or elastomeric films.

5.1.5 *Test Method F2130 (Measuring Repellency, Retention, and Penetration of Liquid Pesticide Formulation Through Protective Clothing Material)*—This test method measures repellency, retention, and penetration of a known volume of liquid pesticide when applied to protective clothing material. No external hydrostatic or mechanical pressure is applied to the test specimen during or after the application of the liquid pesticide. Test Method F2130 is designed to measure performance of protective clothing materials at two levels of contamination. A low level of contamination is achieved by applying the 0.1 mL liquid formulation and a high level of contamination is achieved by applying 0.2 mL.

5.1.6 *Classification F1186 (Classification System for Chemicals According to Functional Groups)*—This classification provides a method of categorizing chemicals by their function group, which is helpful in grouping permeation resistance test data for large numbers of chemicals and materials.

NOTE 1—Chemical resistance data are available for only a very small fraction of the chemicals for which protective clothing is used. However, for chemicals for which no data are available, knowledge of the chemical class can sometimes give insight into the expected resistance of prospective clothing material. Hazard analyses must be performed in accordance with 29 CFR 1910.132.

5.1.7 *Guide F1194 (Documenting the Results of Chemical Permeation Testing of Materials Used in Protective Clothing)*—This guide establishes a format and the details for completely reporting permeation resistance test results. The guide assists with the development of a chemical permeation resistance database. This guide is also intended to encourage thorough and consistent documentation of permeation testing and its results.

5.1.8 *Guide F1001 (Selection of Chemicals to Evaluate Protective Clothing Materials)*—This guide lists recommended challenge chemicals to be used in testing programs to evaluate chemical protective clothing materials. The guide contains a list of 15 liquids and six gases representing many different classes of chemicals, such as inorganic acids, bases, ketones, aldehydes, amines, and hydrocarbons. These chemicals serve as a useful means for comparing the performance of protective clothing materials against a common set of chemicals.

5.2 *Recommended Use of Standards:*

5.2.1 This guide lists recommended challenge chemicals to be used in testing programs to evaluate chemical protective clothing materials. The guide contains a list of 15 liquids and six gases representing many different classes of chemicals, such as inorganic acids, bases, ketones, aldehydes, amines, and hydrocarbons. These chemicals serve as a useful means for comparing the performance of protective clothing materials against a common set of chemicals.

NOTE 2—ANSI/ISEA 105 provides a test method for the evaluation of chemical degradation resistance for glove materials. While chemical degradation resistance information is used extensively for gloves and for some chemical protective splash suits and footwear, chemical degradation resistance information does not provide an assessment of the clothing barrier performance. Rather, chemical degradation resistance information can only be used to exclude a material from further consideration.

5.2.2 The type of chemical resistance testing recommended for evaluating materials used in chemical protective clothing will depend on several factors including:

5.2.2.1 The physical state of the chemical(s).

5.2.2.2 The likelihood for exposure and the exposure scenario (that is, control and extent of exposure, duration, work mission, environmental conditions, other hazards and influences, etc.).

5.2.2.3 The hazards of the chemical and consequences of exposure.

5.2.3 Permeation resistance testing in accordance with Test Method F739 or Test Method F1383 is recommended for chemicals which are gases, liquids that produce vapors, or any chemical that presents a high hazard for skin exposure.

5.2.3.1 Permeation resistance testing is generally recommended for evaluating gloves since the hands are most likely to come in contact with chemicals.

5.2.3.2 When the expected exposure to chemicals is continuous, Test Method F739 should be applied for evaluating protective clothing materials.

5.2.3.3 If exposure is intermittent and no change of clothing occurs, Test Method F1383 should be applied with a contact time, purge time, and frequency representative of the expected exposure.

5.2.3.4 In specifying permeation resistance testing, the minimum test parameters should include the test chemical, its concentration (if not 100 %), the method of contact (continuous or intermittent), the test temperature, and the duration of the test.

5.2.3.5 Permeation resistance test results should be documented using Guide F1194.

5.2.4 Permeation resistance testing in accordance with Test Method F1407 is recommended for field testing or as a preliminary test to the more costly Test Method F739.

5.2.5 Penetration resistance testing in accordance with Test Method F903 is recommended when the chemical is a liquid but is not a known or suspected carcinogen, or has a "skin" notation, as indicated in either the American Conference of Governmental Industrial Hygienist TLVs and BEIs (Threshold Limit Values for Chemical Substances and Physical Agents; Biological Exposure Indices) or in 29 CFR 1910.1000.

5.2.5.1 Penetration resistance testing is generally not appropriate for chemicals that are volatile under the conditions of use

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where contact with the vapor at the exposure concentration is considered unacceptable.

5.2.5.2 Penetration resistance testing is generally appropriate when the exposure to low-hazard liquid chemicals is limited and occurs in the form of splashes.

5.2.5.3 In specifying penetration resistance testing, the minimum test parameters should include the test chemical and the time and pressure sequence.

5.2.6 Penetration and repellency testing of protective clothing for use in agricultural operations against pesticide formulations should be evaluated in accordance with Test Method F2130.

5.2.7 Specimens for chemical resistance testing should be representative of the materials used in the construction of protective clothing.

5.2.7.1 Where practical, specimens should be taken from protective clothing items. Areas that include seams should also be tested.

5.2.7.2 For gloves and footwear, specimens should be taken from the thinnest portion of the gloves and boots that yields the appropriately sized specimens.

5.2.7.3 Where different materials are used in the construction of the protective clothing item, each different material should be tested for chemical resistance.

5.2.8 Protective clothing materials should be evaluated against each chemical of interest.

5.2.8.1 The chemical(s) should be tested in the same state and concentration, and at the same temperature as is expected for the exposure.

5.2.8.2 Chemical exposures that occur in the form of mixtures should involve testing of the mixture itself.

NOTE 3—If permeation testing is conducted using a mixture, a method for separation must be used to determine which chemicals permeate the protective clothing materials and their respective breakthrough times and permeation rates.

5.2.8.3 If a protective clothing material is being evaluated for general chemical resistance, then testing should be performed using the chemicals specified in Guide F1001. Permeation resistance testing should be performed for all 21 chemicals, while penetration resistance testing should be performed only for the 15 liquid chemicals listed in Guide F1001.

NOTE 4—NFPA 1992 recommends the use of penetration resistance testing only for those chemicals which do not have a skin notation and which are not actual or suspected carcinogens.

6. Evaluation of Material Physical Properties

6.1 *Applicable Standards:*

6.1.1 *Test Method D5034 (Breaking Strength and Elongation of Textile Fabrics—Grab Test)*—This test evaluates the tensile (breaking) strength of textile materials and can be applied to many types of protective clothing materials, excluding gloves and other unsupported elastomeric materials. Tensile strength is reported in both directions for anisotropic materials.

6.1.2 *Test Method D5587 (Tearing Strength of Fabrics by Trapezoid Procedure)*—This test method evaluates the tear strength of textile materials and can be applied to many types of protective clothing materials, excluding gloves and other unsupported elastomeric materials. In this test method, tear strength is measured on a specimen that has a small cut along one side and the tear strength is the average force required to continue the tear of the specimen. Tear strength is reported in both directions for anisotropic materials.

6.1.3 *Test Method D751 (Methods of Testing Coated Fabrics)*—This standard includes a collection of test methods appropriate for coated fabrics, but which may also be applied to different types of protective clothing fabrics. Test methods of interest include methods for evaluating burst strength, seam strength, and blocking resistance. The burst strength method is conducted using a tensile testing machine and measures the force to push a 25 mm ball through the specimen. Seam strength is conducted in a manner similar to tensile strength testing, but the specimen includes a seam bisecting the long axis.

6.1.4 *Test Method D2582 (Puncture-Propagation Tear Resistance of Plastic Film and Thin Sheeting)*—This test method evaluates the resistance of plastic materials to a snagging like puncture and tear. In this test method, the material specimen is clamped onto a holder of a special test apparatus and a weighted carriage including a puncture probe falls by the force of gravity such that the probe strikes the fabric, puncturing the material and then causing it to tear. The length of the tear is related to the force that causes the puncture and tear. Puncture propagation tear resistance is reported in both directions for anisotropic materials.

6.1.5 *Test Method D4157 (Abrasion Resistance of Textile Fabrics—Oscillatory Cylinder Method)*—This test method evaluates the abrasion resistance of textiles using a specified abradant, material specimen tension, abradant pressure, and number of abradant cycles in an oscillatory motion. The test method can be applied to different types of protective clothing materials.

6.1.6 *Test Method D4966 (Test Method for Abrasion Resistance of Textile Fabrics—Martindale Abrasion Tester Method)*—This test method evaluates the abrasion resistance of textiles using a special abrasion test apparatus, which rubs an abradant under a specified pressure in a highly specific motion against the specimen. The test method can be applied to different types of protective clothing materials.

6.1.7 *Test Method F392/F392M (Flex Durability of Flexible Barrier Materials)*—This test method evaluates the deterioration of a barrier fabric due to repeated flexing of the material in a special device. The flexing device both compresses and twists the material over a stroke and 440° angle.

6.1.8 *Test Method D747 (Apparent Bending of Modulus of Plastics by Means of a Cantilever Beam)*—This test method evaluates the stiffness of plastic materials by using a device to measure the bending modulus of a material specimen. The test method can also be applied to different types of protective clothing materials and evaluate stiffness at cold temperatures when the testing is performed in controlled environment.

6.1.9 *Test Method F1358/F1358M (Effects of Flame Impingement on Materials Used in Protective Clothing Not Designated Primarily for Flame Resistance)*—This test method is intended to determine the ignition resistance and burning characteristics of materials used in protective clothing, where

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flame resistance is not the primary form of protection designated. A test specimen is exposed to a flame for 3 s. If the material ignites, the after-flame time, afterglow time, and bum distance are measured. If the material does not ignite, the test is repeated on the same specimen using a flame exposure period of 12 s. Flame resistance is reported in both directions for anisotropic materials.

6.1.9.1 When flame resistance is the primary protection offered by the protective clothing, Test Method D6413/D6413M should be used.

6.1.10 *Test Method F1342/F1342M (Protective Clothing Material Resistance to Puncture)*—This test method evaluates puncture resistance against protective clothing materials. It is not intended to measure puncture resistance of all types of punctures encountered using protective clothing materials. The test method involves a procedure where a puncture probe representative of a nail is used for puncturing specimens perpendicular to material surface. There is no supporting structure under the material specimen.

6.1.11 *Test Method F1790/F1790M (Measuring Cut Resistance of Materials Used in Protective Clothing)*—This test method assesses the cut resistance of a material when exposed to a cutting edge under specified loads. This test method only addresses that range of cutting hazards that are related to a cutting action across the surface of the material. It is not representative of any other cutting hazard to which the material may be exposed.

6.1.12 *Test Method D3389 (Coated Fabrics Abrasion Resistance—Rotary Platform, Double-Head Abrader)*—This test method measures the abrasion resistance of rubber-coated fabrics by abrading the material on rotary platform abrader with two abrasion wheels. The test method involves a specified type of abrasion wheel and load for counting the number of abrasion cycles until wearthrough of the coating has occurred.

6.1.13 *ANSI/ISEA 105, American National Standard for Hand Protection Selection Criteria*—This standard addresses the classification and testing of hand protection for specific performance properties related to chemical and industrial applications.

6.1.14 *ANSI Z41, American National Standard for Personal Protection—Protective Footwear*—This standard provides performance requirements and test methods for protective footwear, including impact and compression resistance, sole puncture resistance, and other properties.

6.1.15 *Test Method D1630 (Rubber Property-Abrasion Resistance—Footwear Abrader)*—This test method uses a specific test apparatus, abradant, and test conditions to determine the number of revolutions (cycles) to abrade 2.5 mm of thickness from footwear sole materials.

6.2 *Recommended Use of Standards for Protective Garments:*

6.2.1 Materials used in protective garments should be evaluated for tensile strength in accordance with Test Method D5034, tear strength in accordance with Test Method D5587 (using the five highest peaks technique for interpreting results), burst strength in accordance with Test Method D751 (using the tension testing machine with ring clamp), and puncture propagation tear resistance in accordance with Test Method D2582.

6.2.2 Materials used in protective garments can be evaluated for their durability by subjecting materials specimens to preconditions prior to chemical resistance testing, such as abrasion and repeated flexing.

6.2.2.1 Wear of protective garment materials by abrasion can be simulated using either Test Method D4157 or Test Method D4966. In these tests, the number of abrasion cycles with a specific abradant and test conditions should be chosen to simulate the type of abrasion consistent with expected clothing use. Specimens should then be taken from abraded samples for chemical resistance testing.

6.2.2.2 Wear of protective garment materials by repeated flexing can be simulated using Test Method F392/F392M. The number of flexing cycles and flexing condition should be chosen to simulate the type of flexing consistent with expected clothing use. Specimens should then be taken from center of flexed samples for chemical resistance testing.

6.2.3 If concerns exist related to the performance of protective garments in hot environments and the possible melting of the material, evaluate garment materials for blocking resistance in accordance with Test Method D751.

6.2.4 If concerns exist related to the performance of protective garments in cold environments, evaluate garment materials at the lowest possible use temperature in accordance with Test Method D747.

6.2.5 If concerns exist related to the performance of protective garments in situations where the potential for flame impingement could occur, evaluate garment materials for flame resistance in accordance with Test Method F1358/F1358M.

6.3 *Recommended Use of Standards for Chemical Protective Gloves:*

6.3.1 Glove materials should be evaluated for cut resistance in accordance with Test Method F1790/F1790M, puncture resistance in accordance with Test Method F1342/F1342M, and abrasion resistance in accordance with Test Method D3389 using the conditions and system of classifying test results established in ANSI/ISEA 105, American National Standard for Hand Protection Selection Criteria.

6.4 *Recommended Use of Standards for Chemical Protective Footwear:*

6.4.1 Where appropriate, protective footwear upper materials should be evaluated for cut resistance in accordance with Test Method F1790/F1790M, puncture resistance in accordance with Test Method F1342/F1342M, and abrasion resistance in accordance with Test Method D3389. Abrasion resistance testing per Test Method D3389 should be performed using the H-18 calibrase wheel and a load of 1000 g to determine the number of cycles until wearthrough of the barrier layer is noted.

6.4.2 Where appropriate, protective footwear toe sections should be evaluated for impact and compression resistance in accordance with ANSI Z41, American National Standard for Personal Protection—Protective Footwear. The specific class of performance should be indicated.

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6.4.3 Where appropriate, protective footwear soles should be evaluated for puncture resistance in accordance with ANSI Z41, American National Standard for Personal Protection—Protective Footwear and abrasion resistance in accordance with Test Method D1630.

7. Evaluation of Clothing Seam and Closure Performance

7.1 Where chemical protective garments, gloves, or footwear incorporate seams, seams should be evaluated for chemical resistance when warranted by the hazard and risk assessment. Representative seams should be tested when exposure to the clothing wearer can occur due to failure of the seam to provide the same barrier performance as the clothing material.

7.2 Garment seams should be evaluated for strength in accordance with Test Method D751 using the procedures for seam strength.

7.3 Garment closures should be evaluated for chemical resistance when not covered by a protective flap or other means to prevent chemical exposure.

7.4 Garment closures should be evaluated for strength in accordance with Test Method D751 using the procedures for seam strength.

8. Evaluation of Overall Clothing Performance

8.1 *Applicable Standards:*

8.1.1 *Test Method F1052 (Pressure Testing Vapor Protective Ensembles)*—This test method evaluates the integrity of chemical protective suits in maintaining a fixed, positive pressure. This capability is related to the ability of the suit to prevent the inward leakage of gases or vapors.

8.1.1.1 The test apparatus is attached to the suit to permit inflation to the pre-test suit expansion pressure for removal of suit wrinkles and creases and to equalize/stabilize the air temperatures internal and external to the vapor protective ensemble. The pressure is lowered to the test pressure and monitored for 4 min. If the pressure drop is more than 20 %, the suit fails the test and is removed from service.

8.1.1.2 Test Method F1052 generally only applies to full-body chemical protective clothing that totally encapsulates the wearer in combination with attached gloves and footwear or bootie feet. Test Method F1052 is useful both as a quality control evaluation in the manufacture of chemical protective suits and in the field testing of chemical protective suits by users to determine their continued integrity.

8.1.2 *Test Method F1359/F1359M (Liquid Penetration Resistance of Protective Clothing or Protective Ensembles Under a Shower Spray While on a Mannequin)*—This test method evaluates the ability of protective clothing or protective ensembles to resist liquid penetration. It is suitable for evaluating specific configurations and design features, particularly seams, closures, and interfaces between different clothing items.

8.1.2.1 A test specimen is placed on a mannequin that is dressed in a liquid-absorptive garment covering portions of the mannequin form that are of interest. Water treated with a surfactant 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 or other conditions as specified. The test specimen is rated as passing if liquid does not penetrate and as failing if liquid does penetrate.

8.1.2.2 In most cases, the conditions used in Test Method F1359/F1359M will not represent actual end-use conditions. The test is not intended to simulate user exposure to splashes of liquid chemicals but rather to provide sufficient time for enough liquid to penetrate to make visual inspection easier.

8.1.3 *Test Method D5151 (Detection of Holes in Medical Gloves)*—This test method uses a simple approach to evaluate the integrity of medical gloves for hole by filling the glove with 1000 mL of water and observing for leakage on the surface of the gloves 2 min later. The test method can be adapted for evaluating chemical protective gloves and footwear.

8.1.4 *Practice F1154 (Qualitatively Evaluating the Comfort, Fit, Function, and Integrity of Chemical Protective Suit Ensembles)*—These practices establish standard procedures for quantitatively evaluating the performance characteristics of chemical protective suit ensembles in terms of comfort, fit, function, and overall integrity. The procedures involve human test subjects who rate their ability to perform specific exercises. Ensemble or clothing integrity is evaluated both before and after the exercises to determine if any loss of integrity occurs.

8.1.4.1 Option A evaluates the integrity of the suit and in materials and seams by subjecting the suit to manned exercise scenarios. The exercise routine includes kneeling, squatting, twisting, reaching overhead, and crawling.

8.1.4.2 Option B evaluates the function of the suit by observing the ability of a test subject to perform routine work tasks while wearing the suit. Routine tasks involve lifting boxes, moving a 55 gal drum, operating an overhead valve, using a wrench, using a screwdriver, and climbing a ladder.

8.1.5 *Test Method F1291 (Measuring the Thermal Insulation of Clothing Using a Heated Manikin)*—This test method can be used to quantify and compare the insulation provided by different garments and clothing systems. For example, variations in the design and fabric used in garments can be evaluated. The effects of garment layering, closure, and fit can be measured for clothing ensembles. The insulation values for ensembles can be used in models that predict the physiological responses of people in different environmental conditions.

8.2 *Recommended Use of Standards:*

8.2.1 Chemical protective clothing intended for protecting against chemicals in the form of gases or vapors, or in situations where extreme hazards exist for any contact with a specific chemical or chemicals, should be evaluated for integrity against gases and vapors. It is further recommended this chemical protective clothing be tested for inward leakage of gases and vapors.

8.2.1.1 Vapor protective suits should be evaluated using Test Method F1052.

8.2.1.2 Special fixtures may be created to permit the individual evaluation of chemical protective gloves and footwear.

8.2.2 Chemical protective clothing intended to prevent liquid exposure should be evaluated for its integrity to prevent the inward leakage of liquids.

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ASTM F1296-08(2023)