NFPA®

1990

Standard for Protective Ensembles for Hazardous Materials and CBRN Operations

2022

Includes
NFPA 1991 | NFPA 1992 | NFPA 1994

NFPA®

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Standard for Protective Ensembles for Hazardous Materials and CBRN Operations

2022 Edition

NFPA, 1 Batterymarch Park, Quincy, MA 02169-7471
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NFPA® 1990

Standard for

Protective Ensembles for Hazardous Materials and CBRN Operations

2022 Edition

This edition of NFPA 1990, *Standard for Protective Ensembles for Hazardous Materials and CBRN Operations*, was prepared by the Technical Committees on Hazardous Materials Protective Clothing and Equipment and Emergency Medical Services Protective Clothing and Equipment and released by the Correlating Committee on Fire and Emergency Services Protective Clothing and Equipment. It was issued by the Standards Council on July 4, 2021, with an effective date of July 24, 2021.

This edition of NFPA 1990 was approved as an American National Standard on July 24, 2021.

Origin and Development of NFPA 1990

NFPA 1990, which is a consolidation of NFPA 1991, NFPA 1992, and NFPA 1994, provides users, manufacturers, test laboratories, and certification authorities with one source of information for the product performance requirements for Hazmat/CBRN ensembles and ensemble elements.

In 1985, the National Transportation Safety Board (NTSB) issued Report I-004-5 on a hazardous materials incident that occurred in Benicia, CA. In that report, the NTSB recommended that standards be developed for hazardous materials protective clothing. The United States Department of Transportation (DOT) issued a position requesting that private sector standards be written on hazardous chemical protective clothing, specifically by NFPA. DOT asked other governmental agencies to assist and participate in the private sector standards development system.

The Environmental Protection Agency, United States Coast Guard (USCG), Federal Emergency Management Agency (FEMA), and Occupational Safety and Health Administration (OSHA) either adopted position statements modeled after the DOT position or endorsed the DOT position. The NFPA Standards Council approved a project for the development of those standards and assigned the project to the Technical Committee on Fire Service Protective Clothing and Equipment. The Technical Committee then established a Subcommittee on Hazardous Materials Chemical Protective Clothing, which began work in March 1986 with representatives from USCG, FEMA, and OSHA participating.

This resulted in the first editions of NFPA 1991, NFPA 1992, and NFPA 1993 being published with an effective date of February 5, 1990. NFPA 1993, intended for hazardous materials support functions, was discontinued in 2000, as many of its requirements were incorporated into NFPA 1992.

The first edition of NFPA 1994 was released in August 2001 to answer the need for personal protective equipment for fire and emergency services personnel operating at domestic terrorism incidents involving dual-use industrial chemicals, chemical terrorism agents, or biological terrorism agents. NFPA 1994 was the first standard in the set to introduce levels of protection to reduce the safety and health risks to personnel during assessment, extrication, rescue, triage, and treatment operations.

Due to the distinct similarities in the user communities of these documents, they became part of the first round of the Emergency Response and Responder Safety document consolidation project as approved by the NFPA Standards Council.

Between 2012 and 2020, a tremendous effort was made by the Technical Committee to evaluate every test method, including its implementation, application, and endpoints, to ensure that they were operationally relevant to the user community and could be reproduced. This process incorporated interlaboratory and intra-laboratory validation efforts and allowed for the seamless merger of NFPA 1991, NFPA 1992, and NFPA 1994 into the new NFPA 1990 product.

This first edition of NFPA 1990 fully consolidates the three remaining chemical protective clothing standards under one title but retains their autonomy for the purposes of certification and

use. While the individual standards are fully integrated within NFPA 1990, it is still possible to certify a product against any of the individual standards.

Principal Changes

NFPA 1991, 1990 edition:

- First edition addressed vapor-protective ensembles.
- Challenged the primary suit materials used for protection against chemical permeation following ASTM F1001, *Standard Guide for Selection of Chemicals to Evaluate Protective Clothing Materials*, which detailed the classes of chemicals encountered during hazardous materials emergencies.
- Developed performance requirements to reflect simulated use conditions.
- Included ensemble-level tests for airtight integrity and water penetration.
- Incorporated material testing for burst strength, tear strength, abrasion resistance, flammability resistance, cold temperature performance, and flexural fatigue to ensure ensemble materials could afford adequate protection in the operational environment.

NFPA 1992, 1990 edition:

- First edition addressed liquid splash-protective ensembles.
- Challenged primary suit materials for protection against chemical penetration following ASTM F1001, which detailed the liquids that were not toxic to the skin nor contained suspected carcinogens.
- Developed performance requirements to reflect simulated use conditions.
- Introduced ensemble-level test for water penetration.
- Incorporated material testing for burst strength, tear strength, abrasion resistance, flammability resistance, cold temperature performance, and flexural fatigue to ensure ensemble materials could afford adequate protection in the operational environment.

NFPA 1993, 1990 edition:

- First edition addressed liquid splash ensembles specific to support functions outside the hot zone, such as decontamination, remedial cleanup, or training in controlled and known environments.
- Included many of the same requirements as NFPA 1992, with the exceptions that no flame resistance requirement was applied to primary materials and lower physical property criteria were established for ensemble materials.

NFPA 1991, 1994 edition:

- Expanded chemical battery characteristics to include four additional gases.
- Expanded gastight integrity requirement to every suit.
- Introduced new test for maximum suit pressure and ventilation.
- Added design and performance criteria for visors, gloves, and footwear.
- Added optional flash fire and liquified gas requirements.
- Introduced concept of replaceable gloves and footwear.

NFPA 1992, 1994 edition:

- Established design and performance criteria for gloves and footwear.
- Added concept of replaceable gloves and footwear.

NFPA 1991, 2000 edition:

- Introduced CBRN option with establishment of inward leakage test and use of cumulative permeation for chemical warfare agent permeation.
- Changed glove and footwear physical property requirements significantly.

NFPA 1992, 2000 edition:

- Opened to include individual ensemble elements (garments, gloves, and footwear) and both encapsulating and non-encapsulating ensembles.
- Changed chemical battery characteristics to use vapor pressure as an additional criterion for determining suitability of test chemicals.
- Removed mandatory flame resistance requirement but retained optional flash fire requirement.
- Reduced seam testing to two chemicals.
- Changed glove and footwear physical property testing significantly.

NFPA 1993, 2000 edition:

- Standard withdrawn, as NFPA 1992 scope was changed to address performance needs covered in NFPA 1993.

NFPA 1994, 2001 edition:

- First edition.
- Established three classes of protection with Class 1 (highest), Class 2 (intermediate), and Class 3 (lowest).
- Set different levels of integrity and material performance for each class consistent with the intended application of the ensemble.

NFPA 1991, 2005 edition:

- Made CBRN requirement mandatory.

NFPA 1992, 2005 edition:

- Minorly changed some test methods and performance criteria.

NFPA 1994, 2007 edition:

- Dropped original Class 1 concept (became part of NFPA 1991).
- Revised ensemble Classes 2 and 3 requirements for use with SCBA and APR/powered air-purifying respirators, respectively.
- Added new Class 4 for particulate hazards with introduction of new whole-suit particulate test.
- Replaced Man-In-Simulant Test (MIST) SF6 as inward leakage test for Class 2 and 3 ensembles.
- Modified chemical battery and chemical warfare agent requirements.

NFPA 1992, 2012 edition:

- Changed chemical battery test.
- Added new footwear slip resistance requirement.
- Introduced optional total heat loss reporting requirement.

NFPA 1994, 2012 edition:

- Made improvements to the MIST evaluation test method.
- Changed permeation testing to cumulative permeation.
- Added new footwear slip resistance requirement.
- Added design requirements to ensure that the ensemble would not invalidate respirator certification.

NFPA 1991, 2016 edition:

- Changed title to include CBRN terrorism incidents.
- Added mandatory requirement for encapsulation of the wearer and their breathing apparatus.
- No longer permitted overcovers and detachable visors for achieving certification of base ensemble criteria (must be permanently attached).
- Prohibited tape from being used to secure or seam components of the ensemble.
- Required protective covers to protect the suit closure.
- Replaced vapor inward leakage test with MIST performed at higher concentration.
- Replaced acrolein and acrylonitrile with cyanogen chloride, hydrogen cyanide, and phosgene as more relevant skin-toxic chemicals.
- Replaced soman (GD) with sarin (GB).
- Replaced impact resistance with burst and puncture/tear testing of visor materials.
- Added field of vision assessment and timed hand insertion/reinsertion into gloves.
- Required ensemble shelf life to be reported.
- Made incremental improvements for test method repeatability and interpretation.

NFPA 1992, 2018 edition:

- Significantly changed in scope whereby it stated that NFPA 1992 protective clothing and ensembles could then be used with known or suspected carcinogens and established the standard as applying to any chemicals that are not gas or vapor-producing liquids at concentrations known to be toxic to the skin.
- Updated chemical challenges to include more operationally relevant chemicals, such as sodium hydroxide and sodium hypochlorite, as well as chemicals known to degrade materials, such as dimethylformamide and tetrachloroethylene.
- Broadened footwear options to allow for more choices.
- Added evaporative resistance as an optional test for reporting the breathability of ensemble garment materials.
- Updated tests to more closely align with operational use and added tests for field of vision or glove-hand insertion/reinsertion.
- Added criteria to address separate hoods and elastomeric materials.
- Made incremental improvements to test methods for repeatability and interpretation.

NFPA 1994, 2018 edition:

- Changed title and scope to match application for both hazardous materials emergencies and CBRN incidents to minimize confusion as to the applicability of the standard for non-terrorism incidents.
- Re-established Class 1 requirements to provide criteria parallel to those in NFPA 1991 and provided practical criteria for barrier performance and overall design for a more form-fitting and tactical product.
- Added ruggedized categories of certification (type R) to Classes 2, 3, and 4 to address the increasing use of the garments in harsher environments, such as those in urban search and rescue and law enforcement applications.
- Updated chemical challenges to represent the vast diversity of chemicals found in the global chemical industry and to cover the breadth of fundamental chemical reactivity principles.
- Addressed material breathability as measured by evaporative resistance and total heat loss by reporting results in Class 2 and Class 2R ensembles and applying specific requirements for Class 3/3R and Class 4/4R ensembles.
- Broadened footwear options to allow for more flexibility when a chemical protective sock is used in coordination with a boot.
- Added criteria to address separate hoods and elastomeric materials.
- Introduced incremental improvements for test methods for repeatability and interpretation.
- Added optional criteria for flash fire protection for all ensemble levels with a minimum level of flame resistance established in Class 1 ensembles.
- Established optional criteria for stealth, including audible signatures and color, to address tactical concerns.

NFPA 1990, 2021 edition:

- First edition of NFPA 1990, which consolidates NFPA 1991, NFPA 1992, and NFPA 1994.
- The scopes of the three standards have been combined and a reference to the new NFPA 1891, *Standard on Selection, Care, and Maintenance of Hazardous Materials Clothing and Equipment*, which was developed in parallel, has been added.
- An updated and uniform set of definitions has been added to provided consistency in terminology throughout the consolidated standard.
- Specific efforts have been made to streamline certification, labeling, design, and performance requirements using a table format to allow for comparisons and efficient referencing relative to each type and class of ensemble.
- Different footwear design and performance criteria are separated to address separate requirements for ensemble socks, full boots, and outer boots.
- A new test for flame break open resistance has been put together based on a government-sponsored study demonstrating the need to address materials that can potentially be compromised by prolonged exposure to flame and radiant heat sources.
- The optional overall ensemble flash fire test has been updated to use a more consistent test platform based on an ASTM test method with changes to the criteria reflecting first responder protection needs. An additional optional test has been added to measure percent body burn if chosen by the manufacturer.
- NFPA 1994 Class 5 ensembles have been added to provide protection for non-skin-toxic chemical threats with flammability hazards building upon NFPA 1951, *Standard on Protective Ensembles for Technical Rescue Incidents*, for its base requirements to allow for ease of dual certification.
- All test methods have been combined into one chapter and modified to address each of the individual standards as needed.
- A new low vapor agent permeation test has been added to address the evaluation of sulfuric acid against Class 1 materials.
- Liquid chemical runoff testing has been established based on an ISO test method for evaluation of Class 5 materials.
- Updated, consolidated annex information is included that shows the relationship of the different ensemble types and classes to OSHA 1910.120, *Hazardous waste operations and emergency response*, ensemble protection levels.

For more information about the ERRS consolidation project see nfpa.org/errs.

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This list represents the membership at the time the Committee was balloted on the final text of this edition. Since that time, changes in the membership may have occurred. A key to classifications is found at the back of the document.

NOTE: Membership on a committee shall not in and of itself constitute an endorsement of the Association or any document developed by the committee on which the member serves.

Committee Scope: This Committee shall have primary responsibility for documents on protective clothing and protective equipment, except respiratory protective equipment, that provides hand, foot, torso, limb, and head protection for fire fighters and other emergency services responders during incidents that involve hazardous materials operations. These operations involve the activities of rescue; hazardous material confinement, containment, and mitigation; and property conservation where exposure to substances that present an unusual danger to responders are present or could occur due to toxicity, chemical reactivity,

decomposition, corrosiveness, or similar reactions. Additionally, this Committee shall have primary responsibility for documents on the selection, care, and maintenance of hazardous materials protective clothing and protective equipment by fire and emergency services organizations and personnel.

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NFPA 1990

Standard for

Protective Ensembles for Hazardous Materials and CBRN Operations

2022 Edition

NOTICE: An asterisk (*) following the number or letter designating a paragraph indicates that explanatory material on the paragraph can be found in Annex A.

A reference in brackets [ ] following a section or paragraph indicates material that has been extracted from another NFPA document. Extracted text may be edited for consistency and style and may include the revision of internal paragraph references and other references as appropriate. Requests for interpretations or revisions of extracted text shall be sent to the technical committee responsible for the source document.

Information on referenced and extracted publications can be found in Chapter 2 and Annex B.

Chapter 1 Administration

1.1* Scope. This standard shall specify the minimum design, performance, testing, documentation, and certification requirements for the following PPE, which is used by emergency responders during hazardous materials emergencies and CBRN terrorism incidents:

(1) Vapor-protective ensembles and ensemble elements for hazardous materials emergencies and CBRN terrorism incidents
(2) Liquid splash-protective ensembles and ensemble elements for hazardous materials emergencies
(3) Hazmat/CBRN protective ensembles and ensemble elements for hazardous materials emergencies and CBRN terrorism incidents

1.1.1 This standard shall specify requirements for new ensembles and new ensemble elements.

1.1.2* This standard shall also specify additional optional criteria for ensembles that provide escape from chemical flash fires encountered during hazardous materials emergencies and CBRN terrorism incidents.

1.1.3* This standard shall also establish requirements for ruggedized hazmat/CBRN protective ensembles or ensemble elements that provide a greater level of physical hazard resistance and increased durability and offer the potential for reuse.

1.1.4 This standard shall also establish additional optional requirements for hazmat/CBRN protective ensembles addressing stealth characteristics.

1.1.5* This standard alone shall not specify requirements for protective clothing for any firefighting applications or protective clothing for protection against ionizing radiation, cryogenic liquid hazards, or explosive atmospheres.

1.1.6* This standard shall not establish requirements for respiratory protection other than the type of respiratory protection that is specified for testing and certification of specific ensembles.

1.1.7 Certification of ensembles and ensemble elements to the requirements of this standard shall not preclude certification to additional appropriate standards where the ensemble or ensemble elements meet all the applicable requirements of each standard.

1.1.8 This standard shall not apply to any accessories that could be attached to a certified product, before or after purchase, that are not necessary for the certified product to meet the requirements of this standard.

1.1.9 This standard shall not be construed as addressing all the safety concerns associated with the use of compliant vapor-protective ensembles and ensemble elements, liquid splash-protective ensembles and ensemble elements, and hazmat/CBRN protective ensembles and ensemble elements. It shall be the responsibility of the persons and organizations that use compliant vapor-protective ensembles and ensemble elements, liquid splash-protective ensembles and ensemble elements, and hazmat/CBRN protective ensembles and ensemble elements to establish safety and health practices and to determine the applicability of regulatory limitations prior to use.

1.1.10 This standard shall not be construed as addressing all the safety concerns, if any, associated with the use of this standard by testing facilities. It shall be the responsibility of the persons and organizations that use this standard to conduct testing of compliant vapor-protective ensembles and ensemble elements, liquid splash-protective ensembles and ensemble elements, and hazmat/CBRN protective ensembles and ensemble elements to establish safety and health practices and to determine the applicability of regulatory limitations prior to using this standard to design, manufacture, or test ensembles.

1.1.11 Nothing herein shall restrict any jurisdiction or manufacturer from exceeding these minimum requirements.

1.2 Purpose.

1.2.1* The purpose of this standard shall be to establish a minimum level of protection for emergency responders during hazardous materials emergencies and CBRN terrorism incidents.

1.2.1.1 The purpose of this standard shall be to establish a minimum level of liquified gas protection as an option for compliant vapor-protective ensembles and compliant ensemble elements.

1.2.1.2 The purpose of this standard shall be to establish a minimum level of limited chemical flash fire protection for escape in the event of a chemical flash fire as an option for compliant vapor-protective ensembles, compliant liquid splash-protective ensembles, and compliant hazmat/CBRN protective ensembles.

1.2.1.3 The purpose of these options shall be to provide emergency response organizations the flexibility to specify these options in their purchase specifications according to the anticipated exposure and expected needs of the emergency response organization.

1.2.2 The purpose of the hazmat/CBRN protective ensemble and ensemble element requirements shall be to establish five levels of hazmat/CBRN protective ensembles and ensemble elements that provide minimum protection of emergency first responder personnel based on what the incident risk analysis indicates is necessary protection for the intended operations.

1.2.2.1 The standard shall establish a level of physical hazard resistance for the ruggedized classes of hazmat/CBRN ensembles and ensemble elements that shall be used for operations requiring ensembles and ensemble elements with increased durability.

1.2.2.2 The purpose of this standard shall be to establish a minimum level of stealth characteristics as an option for compliant hazmat/CBRN ensembles.

1.2.3 Controlled laboratory tests used to determine compliance with the performance requirements of this standard shall not be deemed to be establishing performance levels for all situations to which personnel can be exposed.

1.2.4 This standard is not intended to be utilized for detailed manufacturing or purchase specification, but it shall be permitted to be referenced in purchase specifications as a minimum requirement.

1.3* Application.

1.3.1* This standard shall apply to the design, manufacturing, testing, documentation, and certification of new vapor-protective ensembles and ensemble elements, new liquid splash-protective ensembles and ensemble elements, and new hazmat/CBRN ensembles and ensemble elements and shall be applied as follows:

(1) Chapters 1 through 3, Sections 4.1 and 4.2, Sections 5.1 and 5.2, Sections 6.1 and 6.2, Sections 7.1 and 7.2, Chapter 8, and all related paragraphs of Annex A constitute the 2022 edition of NFPA 1991.
(2) Chapters 1 through 3, Sections 4.1 and 4.3, Section 5.1, Section 5.3, Section 6.1, Section 6.3, Section 7.1, Section 7.3, Chapter 8, and all related paragraphs of Annex A constitute the 2022 edition of NFPA 1992.
(3) Chapters 1 through 3, Sections 4.1 and 4.4, Section 5.1, Section 5.4, Section 6.1, Section 6.4, Section 7.1, Section 7.4, Chapter 8, and all related paragraphs of Annex A constitute the 2022 edition of NFPA 1994.

1.3.1.1* The requirements for Class 1 hazmat/CBRN protective ensembles and ensemble elements shall apply to ensembles designed to provide protection to emergency responders at incidents involving vapor or liquid chemical hazards where the concentrations are at or above immediately dangerous to life and health (IDLH) levels, thus requiring the use of SCBA equipment.

1.3.1.2 The requirements for Class 2 hazmat/CBRN protective ensembles and ensemble elements shall apply to ensembles designed to provide limited protection to emergency responders at hazardous materials emergencies or CBRN terrorism incidents involving vapor or liquid chemical hazards where the concentrations are at or above IDLH levels, thus requiring the use of SCBA equipment.

1.3.1.3 The requirements for Class 3 hazmat/CBRN protective ensembles and ensemble elements shall apply to ensembles designed to provide limited protection to emergency responders at hazardous materials emergencies or CBRN terrorism incidents involving low levels of vapor or liquid chemical hazards, where the concentrations are below IDLH levels, thus permitting the use of air-purifying respirators (APR).

1.3.1.4 The requirements for Class 4 hazmat/CBRN protective ensembles and ensemble elements shall apply to ensembles designed to provide limited protection to emergency responders at CBRN terrorism incidents involving particulate hazards, including biological hazards or radiological particulate hazards, where the concentrations are below IDLH levels, thus permitting the use of APR equipment.

1.3.1.5 The requirements for Class 5 hazmat/CBRN protective ensembles and ensemble elements shall apply to ensembles designed to provide limited protection to emergency responders at CBRN terrorism incidents involving flammable gases not toxic to the skin where the potential exists for chemical flash fires, further requiring the use of SCBA equipment.

1.3.1.6 This edition of NFPA 1990 shall not apply to vapor-protective ensembles and ensemble elements, liquid splash-protective ensembles and ensemble elements, and hazmat/CBRN ensembles and ensemble elements manufactured for compliance with previous editions of NFPA 1991, NFPA 1992, or NFPA 1994.

1.3.2 This standard alone shall not apply to protective clothing for protection against ionizing radiation, cryogenic liquid hazards, or explosive atmospheres.

1.3.3 This standard alone shall not apply to liquid splash-protective ensembles and ensemble elements where a hazardous material is present as a gas or a vapor-producing liquid at vapor concentrations known to be toxic to the skin.

1.3.4 This standard alone shall not apply to protective clothing for any firefighting applications.

1.3.5* This standard shall not apply to the respiratory protection necessary for proper protection of the ensemble.

1.3.6* Requirements of this standard shall not apply to the use of closed-circuit SCBA.

1.3.7* This standard shall not apply to the use requirements for vapor-protective ensembles and ensemble elements, liquid splash-protective ensembles and ensemble elements, and hazmat/CBRN ensembles and ensemble elements; these requirements are specified in NFPA 1500 and NFPA 1891.

1.3.8* This standard shall not apply to the selection, reuse, care, and maintenance of vapor-protective ensembles or ensemble elements, liquid splash-protective ensembles or ensemble elements, or protective ensembles and ensemble elements for hazardous materials emergencies and CBRN terrorism incidents, as these requirements are specified in NFPA 1891.

1.3.9* The requirements of this standard shall not apply to any accessories that could be attached to the product but are not necessary for the product to meet the requirements of this standard.

1.4 Units.

1.4.1 In this standard, SI units shall be followed by an equivalent in U.S. units in parentheses.

1.4.2 The values in SI units shall be regarded as the requirement.

Chapter 2 Referenced Publications

2.1 General. The documents or portions thereof listed in this chapter are referenced within this standard and shall be considered part of the requirements of this document.

2.2 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 704, *Standard System for the Identification of the Hazards of Materials for Emergency Response*, 2022 edition.

NFPA 1500™, *Standard on Fire Department Occupational Safety, Health, and Wellness Program*, 2021 edition.

NFPA 1891, *Standard on Selection, Care, and Maintenance of Hazardous Materials Clothing and Equipment*, 2022 edition.

NFPA 1951, *Standard on Protective Ensembles for Technical Rescue Incidents*, 2020 edition.

NFPA 1971, *Standard on Protective Ensembles for Structural Fire Fighting and Proximity Fire Fighting*, 2018 edition.

NFPA 1977, *Standard on Protective Clothing and Equipment for Wildland Fire Fighting and Urban Interface Fire Fighting*, 2022 edition.

NFPA 1981, *Standard on Open-Circuit Self-Contained Breathing Apparatus (SCBA) for Emergency Services*, 2019 edition.

NFPA 1986, *Standard on Respiratory Protection Equipment for Tactical and Technical Operations*, 2017 edition.

NFPA 1991, *Standard on Vapor-Protective Ensembles for Hazardous Materials Emergencies and CBRN Terrorism Incidents*, 2016 edition.

NFPA 1992, *Standard on Liquid Splash–Protective Ensembles and Clothing for Hazardous Materials Emergencies*, 2018 edition.

NFPA 1994, *Standard on Protective Ensembles for First Responders to Hazardous Materials Emergencies and CBRN Terrorism Incidents*, 2018 edition.

NFPA 1999, *Standard on Protective Clothing and Ensembles for Emergency Medical Operations*, 2018 edition.

2.3 Other Publications.

2.3.1 AATCC Publications. American Association of Textile Chemists and Colorists, P.O. Box 12215, Research Triangle Park, NC 27709.

AATCC Evaluation Procedure 6, *Instrumental Color Measurement*, 2016.

2.3.2 ANSI Publications. American National Standards Institute, Inc., 25 West 43rd Street, 4th floor, New York, NY 10036.

ANSI/ISEA Z87.1, *American National Standard for Occupational and Educational Personal Eye and Face Protection Devices*, 2020.

ANSI/ISEA Z89.1, *American National Standard for Industrial Head Protection*, 2014 (R2019).

2.3.3 ASTM Publications. ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959.

ASTM D412, *Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers — Tension*, 2016.

ASTM D471, *Standard Test Method for Rubber Property — Effect of Liquids*, 2016a.

ASTM D747, *Standard Test Method for Apparent Bending Modulus of Plastics by Means of a Cantilever Beam*, 2010, withdrawn.

ASTM D751, *Standard Test Methods for Coated Fabrics*, 2019.

ASTM D1776/D1776M, *Standard Practice for Conditioning and Testing Textiles*, 2020.

ASTM D2136, *Standard Test Method for Coated Fabrics — Low-Temperature Bend Test*, 2019.

ASTM D2582, *Standard Test Method for Puncture-Propagation Tear Resistance of Plastic Film and Thin Sheeting*, 2016.

ASTM D3884, *Standard Guide for Abrasion Resistance of Textile Fabrics (Rotary Platform, Double-Head Method)*, 2009, reapproved 2017.

ASTM D4157, *Standard Test Method for Abrasion Resistance of Textile Fabrics (Oscillatory Cylinder Method)*, 2013, reapproved 2017.

ASTM D5151, *Standard Test Method for Detection of Holes in Medical Gloves*, 2019.

ASTM D6413/D6413M, *Standard Test Method for Flame Resistance of Textiles (Vertical Test)*, 2015.

ASTM F392/F392M, *Standard Practice for Conditioning Flexible Barrier Materials for Flex Durability*, 2011, reapproved 2015.

ASTM F739, *Standard Test Method for Permeation of Liquids and Gases Through Protective Clothing Materials Under Conditions of Continuous Contact*, 2012e1.

ASTM F903, *Standard Test Method for Resistance of Materials Used in Protective Clothing to Penetration by Liquids*, 2018.

ASTM F1001, *Standard Guide for Selection of Chemicals to Evaluate Protective Clothing Materials*, 2012, reaffirmed 2017.

ASTM F1052, *Standard Test Method for Pressure Testing Vapor Protective Suits*, 2014.

ASTM F1154, *Standard Practices for Evaluating the Comfort, Fit, Function, and Durability of Protective Ensembles, Ensemble Elements, and Other Components*, 2018.

ASTM F1301, *Standard Practice for Labeling Chemical Protective Clothing*, 2018.

ASTM F1342/F1342M, *Standard Test Method for Protective Clothing Material Resistance to Puncture*, 2005, reapproved 2013e1.

ASTM F1358, *Standard Test Method for Effects of Flame Impingement on Materials Used in Protective Clothing not Designated Primarily for Flame Resistance*, 2016.

ASTM F1359/F1359M, *Standard Test Method for Liquid Penetration Resistance of Protective Clothing or Protective Ensembles Under a Shower Spray While on a Manikin*, 2016a.

ASTM F1671, *Standard Test Method for Resistance of Materials Used in Protective Clothing to Penetration by Blood-Borne Pathogens Using Phi-X174 Bacteriophage Penetration as a Test System*, 2013.

ASTM F1790, *Standard Test Method for Measuring Cut Resistance of Materials Used in Protective Clothing*, 2005.

ASTM F1868, *Standard Test Method for Thermal and Evaporative Resistance of Clothing Materials Using a Sweating Hot Plate*, 2017.

ASTM F1930, *Standard Test Method for Evaluation of Flame-Resistant Clothing for Protection Against Fire Simulations Using an Instrumented Manikin*, 2018.

ASTM F2010/F2010M, *Standard Test Method for Evaluation of Glove Effects on Wearer Finger Dexterity Using a Modified Pegboard Test*, 2018.

ASTM F2412, *Standard Test Methods for Foot Protection*, 2018a.

ASTM F2413, *Standard Specification for Performance Requirements for Protective (Safety) Toe Cap Footwear*, 2018.

ASTM F2700, *Standard Test Method for Unsteady-State Heat Transfer Evaluation of Flame Resistant Materials for Clothing with Continuous Heating*, 2008, reapproved 2013.

ASTM F2913, *Standard Test Method for Measuring the Coefficient of Friction for Evaluation of Slip Performance of Footwear and Test Surfaces/Flooring Using a Whole Shoe Tester*, 2019.

2.3.4 FIA Publications. Footwear Industries of America, 1420 K Street, NW, Suite 600, Washington, DC 20005.

FIA Standard 1209, *Whole Shoe Flex*, 1984.

2.3.5 IEC Publications. International Electrotechnical Commission, 3, rue de Varembé, P.O. Box 131, CH-1211 Geneva 20, Switzerland.

IEC 61672-1, *Electroacoustics — Sound level meters — Part 1: Specifications*, 2013.

2.3.6 ISO Publications. International Organization for Standardization, ISO Central Secretariat, BIBC II, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland.

ISO Guide 27, *Guidelines for corrective action to be taken by a certification body in the event of misuse of its mark of conformity*, 1983, confirmed 2014.

ISO 4649, *Rubber, vulcanized or thermoplastic — Determination of abrasion resistance using a rotating cylindrical drum device*, 2017.

ISO 6530, *Protective clothing — Protection against liquid chemicals — Test method for resistance of materials to penetration by liquids*, 2005.

ISO 9001, *Quality management systems — Requirements*, 2015.

ISO 11092, *Textiles — Physiological effects — Measurement of thermal and water-vapour resistance under steady-state conditions (sweating guarded-hotplate test)*, 2014.

ISO/IEC 17011, *Conformity assessment — Requirements for accreditation bodies accrediting conformity assessment bodies*, 2004.

ISO/IEC 17021, *Conformity assessment — Requirements for bodies providing audit and certification of management systems*, 2015.

ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories*, 2017.

ISO/IEC 17065, *Conformity assessment — Requirements for bodies certifying products, processes, and services*, 2012.

2.3.7 NIOSH Publications. National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention, 1600 Clifton Road, Atlanta, GA 30329-4027.

Statement of Standard for NIOSH CBRN APR Testing, 2003.

Statement of Standard for NIOSH CBRN PAPR Testing, 2006.

Statement of Standard for NIOSH CBRN SCBA Testing, 2003.

2.3.8 US Government Publications. US Government Publishing Office, 732 North Capitol Street, NW, Washington, DC 20401-0001.

Federal Test Method Standard 191A, *Textile Test Methods*, 1978.

Title 18, United States Code, Part 2332a, "Use of Weapons of Mass Destruction."

Title 29, Code of Federal Regulations, Part 1910.132, "Personal Protective Equipment: General Requirements."

2.3.9 Other Publications.

Merriam-Webster's Collegiate Dictionary, 11th edition, Merriam-Webster, Inc., Springfield, MA, 2003.

Technical Assessment of the Man-In-Simulant Test Program, National Research Council Report, The National Academies, 500 Fifth St. NW, Washington, DC 20001, 1997.

The Technical Cooperation Program, Chemical Biological Defense Technical Panel 11 on Low Burden, Integrated Protective Clothing, "Final Report: Development of a Standard Vapour Systems Test to Assess the Protection Capability of NBC Individual Protective Ensembles," Appendix G, Defence Research Establishment Suffield Report, Biological and Chemical Defence Review Committee, Suite 405 2-2026, Lanthier Drive, Ottawa, ON, K4N 0N6, April 1997, UNCLASSIFIED.

2.3.10 US Military Publications. US Army Developmental Test Command (DTC), Technology Management Division (CSTE-DTC-TT-M), 314 Longs Corner Road, Aberdeen Proving Ground, MD 21005-5055.

Test Operations Procedure (TOP) 08-2-503, *Low Volatility Agent Permeation (LVAP) Swatch Testing*, 2018.

2.4 References for Extracts in Mandatory Sections. (Reserved)

Chapter 3 Definitions

3.1 General. The definitions contained in this chapter shall apply to the terms used in this standard. Where terms are not defined in this chapter or within another chapter, they shall be defined using their ordinarily accepted meanings within the context in which they are used. *Merriam-Webster's Collegiate*

Dictionary, 11th edition, shall be the source for the ordinarily accepted meaning.

3.2 NFPA Official Definitions.

3.2.1* Approved. Acceptable to the authority having jurisdiction.

3.2.2* Authority Having Jurisdiction (AHJ). An organization, office, or individual responsible for enforcing the requirements of a code or standard, or for approving equipment, materials, an installation, or a procedure.

3.2.3 Labeled. Equipment or materials to which has been attached a label, symbol, or other identifying mark of an organization that is acceptable to the authority having jurisdiction and concerned with product evaluation, that maintains periodic inspection of production of labeled equipment or materials, and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.

3.2.4* Listed. Equipment, materials, or services included in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services, and whose listing states that either the equipment, material, or service meets appropriate designated standards or has been tested and found suitable for a specified purpose.

3.2.5 Shall. Indicates a mandatory requirement.

3.2.6 Should. Indicates a recommendation or that which is advised but not required.

3.2.7 Standard. An NFPA Standard, the main text of which contains only mandatory provisions using the word "shall" to indicate requirements and that is in a form generally suitable for mandatory reference by another standard or code or for adoption into law. Nonmandatory provisions are not to be considered a part of the requirements of a standard and shall be located in an appendix, annex, footnote, informational note, or other means as permitted in the NFPA Manuals of Style. When used in a generic sense, such as in the phrase "standards development process" or "standards development activities," the term "standards" includes all NFPA Standards, including Codes, Standards, Recommended Practices, and Guides.

3.3* General Definitions.

3.3.1 Accessories. An item, or items, that are attached to the certified product that are not necessary to meet the requirements of the standard.

3.3.2 Afterflame. Persistent flaming of a material after the ignition source has been removed.

3.3.3 Afterflame Time. The length of time for which a material, component, or chemical-protective garment continues to burn after the simulated chemical flash fire has ended.

3.3.4 Agents.

3.3.4.1 ***Biological Terrorism Agents.*** Liquid or particulate agents that can consist of a biologically derived toxin or pathogen used to inflict lethal or incapacitating casualties, generally on a civilian population as a result of a terrorist attack.

3.3.4.2 ***CBRN Terrorism Agents.*** The term used to refer to chemical terrorism agents, including chemical warfare agents and toxic industrial chemicals, biological terrorism agents, and radiological particulate terrorism agents. *(See also 3.3.4.1, 3.3.4.3, and 3.3.4.5.)*

3.3.4.3 ***Chemical Terrorism Agents.*** Liquid, solid, gaseous, and vapor chemical warfare agents and toxic industrial chemicals used to inflict lethal or incapacitating casualties, generally on a civilian population as a result of a terrorist attack.

3.3.4.4* ***Chemical Warfare (CW) Agents.*** Liquid, solid, and gas chemical agents (most are liquid) traditionally used during warfare or armed conflict to kill or incapacitate an enemy. *(See also 3.3.4.3 and 3.3.4.6.)*

3.3.4.5* ***Radiological Particulate Terrorism Agents.*** Particles that emit ionizing radiation in excess of normal background levels used to inflict lethal or incapacitating casualties, generally on a civilian population as the result of a terrorist attack.

3.3.4.6 ***Toxic Industrial Chemicals.*** Highly toxic solid, liquid, or gaseous chemicals that have been identified as mass casualty threats that could be used as weapons of terrorism to inflict casualties, generally on a civilian population during a terrorist attack. *(See also 3.3.4.3 and 3.3.4.4.)*

3.3.5 Assembly. The portion of the manufacturing process including, but not limited to, sewing, gluing, laminating, tacking, or other means of attaching whereby materials or component parts are put together to form a portion of the compliant product, or the complete compliant product.

3.3.6 Barrier Layer. The layer of garment material, glove material, footwear material, or hood material designated as primarily contributing to element integrity and chemical/barrier performance.

3.3.7 Boot. See 3.3.35.

3.3.8 Care. Procedures for cleaning, decontamination, and storage of protective clothing and equipment.

3.3.9 CBRN. Chemical, biological, radiological, and nuclear.

3.3.10 CBRN Terrorism Incidents. Situations involving the intentional or accidental release of CBRN warfare agents in civilian areas.

3.3.11 Certification/Certified. A system whereby a certification organization determines that a manufacturer has demonstrated the ability to produce a product that complies with the requirements of this standard, authorizes the manufacturer to use a label on listed products that comply with the requirements of this standard, and establishes a follow-up program conducted by the certification organization as a check on the methods the manufacturer uses to determine continued compliance of labeled and listed products with the requirements of this standard.

3.3.12* Certification Organization. An independent, third-party organization that determines product compliance with the requirements of this standard with a labeling/listing/follow-up program.

3.3.13* Chemical Flash Fire. The ignition of a flammable and ignitible vapor or gas that produces an outward expanding flame front as those vapors or gases burn. This burning and expanding flame front, a fireball, will release both thermal and kinetic energy to the environment.

3.3.14* Chemical-Protection Layer. The material or composite used in an ensemble or clothing for the purpose of providing protection from chemical hazards.

3.3.15 Closure Assembly. The combination of the suit or garment closure and the seam attaching the suit or garment closure to the suit or garment, including any protective flap or cover.

3.3.16 Compliance/Compliant. Meeting or exceeding all applicable requirements of this standard.

3.3.17 Compliant Product. Product that is covered by this standard and has been certified as meeting all applicable requirements of this standard that pertain to the product.

3.3.18* Component(s). Any material, part, or subassembly used in the construction of the compliant product.

3.3.19 Component Part(s). Any material(s) or part(s) used in the construction of a vapor-protective ensemble or ensemble elements.

3.3.20 Composite. The layer or layers of materials or components.

3.3.21 Cryogenic Gas. See 3.3.42.1.

3.3.22* Cryogenic Liquid. A refrigerated liquefied gas having a boiling point below –90°C (–130°F) at atmospheric pressure.

3.3.23 Elastomer. A polymeric material that returns to its original length and shape after stretching.

3.3.24* Elastomeric Interface Material. An exposed elastomeric material, not otherwise used as a garment material, that provides an interface other than seams between components of the ensemble and ensemble elements and, if applicable, the interface between the respirator facepiece and the ensemble or ensemble elements.

3.3.25 Element(s). See 3.3.28, Ensemble Elements.

3.3.26* Emergency Responders. Personnel assigned to organizations that have the responsibility for responding to hazardous materials emergencies and CBRN terrorism incidents.

3.3.27 Encapsulating Ensemble. A type of ensemble that completely covers the wearer and the wearer's respirator.

3.3.28 Ensemble Elements. Individual items of compliant protective clothing and equipment designed to provide minimum protection of specific areas of the body from some, but not all, risks occurring during hazardous materials and CBRN emergency response.

3.3.29 Ensembles. Multiple ensemble elements that, when worn together, are designed to provide minimum full-body protection from some, but not all, risks occurring during hazardous materials emergencies and CBRN terrorism incidents. *(See also 3.3.28, Ensemble Elements).*

3.3.29.1 ***NFPA 1991-Certified Ensembles and Ensemble Elements.***

3.3.29.1.1* ***Vapor-Protective Ensemble.*** Multiple elements of compliant protective clothing and equipment that, when worn together, provide protection from some, but not all, risks in vapor, liquid splash-protective, and particulate environments during hazardous materials emergencies and CBRN terrorism incidents in vapor, gas, liquid, or particulate forms.

3.3.29.1.2 ***Vapor-Protective Ensemble with Optional Chemical Flash Fire Escape and Liquefied Gas Protection.*** A compliant vapor-protective ensemble that is also certified as compliant with the optional requirements for both limited protection against chemical flash fire for escape only and for protection against liquefied gases.

3.3.29.1.3* ***Vapor-Protective Ensemble with Optional Chemical Flash Fire Escape Protection.*** A compliant vapor-protective ensemble that is also certified as compliant with the optional requirements for limited protection against chemical flash fire for escape only.

3.3.29.1.4* ***Vapor-Protective Ensemble with Optional Liquefied Gas Protection.*** A compliant vapor-protective ensemble that is also certified as compliant with the optional requirements for protection against liquefied gases.

3.3.29.1.5* ***Vapor-Protective Footwear.*** The ensemble element of the protective ensemble that provides chemical protection and physical protection to the feet, ankles, and lower legs.

3.3.29.1.6 ***Vapor-Protective Gloves.*** The ensemble element of the protective ensemble that provides chemical protection to the hands and wrists.

3.3.29.2 ***NFPA 1992-Certified Ensembles and Ensemble Elements.***

3.3.29.2.1* ***Liquid Splash-Protective Ensemble.*** Multiple elements of compliant protective clothing and equipment products that, when worn together, provide protection from some, but not all, risks of hazardous materials emergencies involving liquids to the torso, legs, arms, head, hands, and feet.

3.3.29.2.2* ***Liquid Splash-Protective Footwear.*** The element of the protective ensemble or the item of protective clothing that provides liquid chemical protection and physical protection to the feet, ankles, and lower legs.

3.3.29.2.3* ***Liquid Splash-Protective Garment.*** The element of the protective ensemble or the item of protective clothing that provides liquid chemical protection to the upper and lower torso, arms, and legs, but excluding the head, hands, and feet.

3.3.29.2.4 ***Liquid Splash-Protective Glove.*** The element of the protective ensemble or the item of protective clothing that provides liquid chemical protection to the hands and wrists.

3.3.29.2.5* ***Liquid Splash-Protective Hood.*** The element of the protective ensemble or an item of protective clothing that provides liquid chemical protection and physical protection to the head and neck.

3.3.29.3 ***NFPA 1994-Certified Ensembles and Ensemble Elements.***

3.3.29.3.1 ***Class 1 Hazmat/CBRN Protective Ensemble.*** An ensemble comprising ensemble elements that, when worn together, are designed to protect emergency responders at hazardous materials emergencies and CBRN terrorism incidents involving vapor or liquid chemical hazards where concentrations are at or above immediately dangerous to life and health (IDLH) levels, thus requiring the use of self-contained breathing apparatus (SCBA).

3.3.29.3.2 ***Class 2 Hazmat/CBRN Protective Ensemble.*** An ensemble comprising ensemble elements that, when worn together, are designed to protect emergency responders at hazardous materials emergencies and CBRN terrorism incidents involving vapor or liquid chemical hazards where concentrations are at or above IDLH levels, thus requiring the use of self-contained breathing apparatus (SCBA).

3.3.29.3.3 ***Class 3 Hazmat/CBRN Protective Ensemble.*** An ensemble comprising ensemble elements that, when worn together, are designed to protect emergency responders at hazardous materials emergencies and CBRN terrorism incidents involving low levels of vapor or liquid chemical hazards where concentrations are below IDLH levels, thus permitting the use of CBRN air-purifying respirators (APR) or CBRN-powered air-purifying respirators (PAPR).

3.3.29.3.4 ***Class 4 Hazmat/CBRN Protective Ensemble.*** An ensemble comprising ensemble elements that, when worn together, are designed to protect emergency responders at hazardous materials emergencies and CBRN terrorism incidents involving biological or radiological particulate hazards where concentrations are below IDLH levels, thus permitting the use of APR or PAPR equipment.

3.3.29.3.5 ***Class 5 Hazmat/CBRN Protective Ensemble.*** An ensemble comprising ensemble elements that, when worn together, are designed to protect emergency responders at hazardous materials emergencies and CBRN terrorism incidents involving flammable gases not toxic to the skin where the potential exists for chemical flash fires, further requiring the use of SCBA equipment.

3.3.30* Exhaust Valve. One-way vent that releases exhaust to the outside environment and prevents entry of outside environment.

3.3.31* External Fittings. Any component that allows the passage of gases, liquids, or electrical current from the outside to the inside of the element or item as well as any fitting externally located on, and part of, the ensemble that is not part of the garment material, visor material, gloves, footwear, seams, or closure assembly.

3.3.32 Flammable or Explosive Atmospheres. Atmospheres containing solids, liquids, vapors, or gases at concentrations that will burn or explode if ignited.

3.3.33 Fluorescence. A process by which radiant flux of certain wavelengths is absorbed and reradiated nonthermally in other, usually longer, wavelengths.

3.3.34 Follow-Up Program. The sampling, inspections, tests, or other measures conducted by the certification organization on a periodic basis to determine the continued compliance of labeled and listed products that are being produced by the manufacturer to the requirements of this standard.

3.3.35 Footwear. The element of the protective ensemble that provides protection to the foot, ankle, and lower leg.

3.3.35.1 ***Standard Footwear.*** Footwear approved by the authority having jurisdiction for wear with protective garments as defined in 3.3.29 and, where required, worn with a footwear cover.

3.3.36* Footwear Cover. The element of the protective ensemble to be worn over standard footwear to provide barrier and physical protection to the wearer's feet.

3.3.37 Footwear Material. The primary material(s) used in the construction of the footwear.

3.3.38 Footwear Upper. That portion of the footwear element above the sole, heel, and insole.

3.3.39 Garment. The element of the protective ensemble that provides protection to the upper and lower torso, head, arms, and legs; excludes the hands and feet.

3.3.40 Garment Closure. The garment component designed and configured to allow the wearer to don (put on) and doff (take off) the garment.

3.3.41 Garment Material. The primary protective material(s) used in the construction of the garment.

3.3.42 Gas.

3.3.42.1 ***Cryogenic Gas.*** A refrigerated liquid gas having a boiling point below –130°F (–90°C) at atmospheric pressure.

3.3.42.2* ***Liquefied Gas.*** A gas that, under its charged pressure, is partially liquid at 21°C (70°F).

3.3.43 Glove. The element of the protective ensemble that provides protection to the wearer's hands and wrists.

3.3.43.1 ***Outer Glove.*** A glove worn over another glove component to provide additional protection to the wearer and meet the requirements of this standard.

3.3.44 Glove Body. The part of the glove that extends from the tip of the fingers to the wrist crease or to a specified distance beyond the wrist crease.

3.3.45 Glove Material. The primary material(s) used in the construction of gloves.

3.3.46* Gusset. The part of the protective footwear that is a relatively flexible material joining the footwear upper (quarter) and the tongue, which is intended to provide expansion of the footwear front to enable donning of the footwear while maintaining continuous moisture integrity of the footwear.

3.3.47 Hazard. A source of possible injury or damage to health.

3.3.48* Hazardous Materials. Matter (solid, liquid, or gas) or energy that, when released, is capable of creating harm to people, the environment, and property; includes weapons of mass destruction (WMD) as defined in 18 USC 2332a, "Use of Weapons of Mass Destruction," and all other criminal use of hazardous materials.

3.3.49* Hazardous Materials Emergencies. Incidents involving the release or potential release of hazardous materials.

3.3.50 Hood. The element of the protective ensemble that provides protection to the wearer's head and neck.

3.3.51 Insole. The inner part of the protective footwear upon which the foot rests and that conforms to the bottom of the foot.

3.3.52 Integrity Footwear Cover. A component of the protective footwear element designed and configured to be worn over an outer boot to provide footwear protection when integrated with the protective ensemble.

3.3.53 Interface Component(s). Any material, part, or subassembly used in the construction of the compliant product that provides limited protection to interface areas.

3.3.54* Ionizing Radiation. Radiation of sufficient energy to alter the atomic structure of materials or cells with which it interacts, including electromagnetic radiation such as x-rays, gamma rays, and microwaves and particulate radiation such as alpha and beta particles.

3.3.55 Ladder Shank. Reinforcement to the midsole area of protective footwear designed to provide additional support to the instep when standing on a ladder rung.

3.3.56 Liquefied Gas. See 3.3.42.2.

3.3.57 Lower Torso. The area of the body trunk below the waist, excluding the legs, ankles, and feet.

3.3.58 Maintenance. The inspection, service, and repair of protective clothing and equipment, including the determination for removal from service.

3.3.59 Manufacturer. The entity that assumes the liability for the compliant product.

3.3.60 Manufacturing Facility. The facility involved in the production, assembly, or final inspection or labeling of the compliant end product.

3.3.61 Material.

3.3.61.1 ***Protective Clothing Material.*** Any material or composite used in the construction of protective ensemble and ensemble elements.

3.3.62 Melt. A response to heat by a material resulting in evidence of flowing or dripping.

3.3.63 Model. The collective term used to identify a group of individual ensembles or elements made of the same basic design and components from a single manufacturer, produced by the same manufacturing and quality assurance procedures, and covered by the same certification.

3.3.64* Nonencapsulating Ensemble. A type of ensemble that does not fully cover the wearer's respirator and relies on the facepiece of the respirator to have an interface with the garment to complete the enclosure of the wearer.

3.3.65 Outer Boot. An item of footwear worn over the sock to provide physical protection and meet the requirements of this standard.

3.3.66* Outer Garment. A supplemental garment worn over the garment element to provide physical protection and meet the base or optional requirements of this standard.

3.3.67 Package. The wrapping or enclosure directly containing gloves, footwear, a hood, or a face protection device.

3.3.68 Package Product Label. The product label that is printed on or attached to a package containing one or more compliant products. *(See also 3.3.73, Product Label.)*

3.3.69* Particulates. Solid matter that is dispersed in air as a mixture.

3.3.70 Percent Inward Leakage. The ratio of vapor concentration inside the ensemble versus the vapor concentration outside the ensemble expressed as a percentage.

3.3.71 Pressure-Sensitive Adhesive Tape. A form of tape that is tacky and adheres at room temperature by pressure without any other form of adhesive activation such as light, heat, or chemical reaction.

3.3.72 Primary Materials. Element layers limited to the garment material, hood material, visor material, glove material, footwear material, and, if present, elastomeric interface material that provide protection from chemical and physical hazards.

3.3.73* Product Label. A label or marking affixed by the manufacturer to each compliant ensemble and ensemble element, containing compliance statements, certification statements, general information, care, and maintenance data. The product label is not the certification organization's label, symbol, or identifying mark; however, the certification organization's label, symbol, or identifying mark is attached to or a part of the product label.

3.3.74 Puncture-Resistant Device. A reinforcement to the bottom of protective footwear that is designed to provide puncture resistance.

3.3.75 Radiological and Nuclear Particulate Terrorism Agents. See 3.3.4.5, Radiological Particulate Terrorism Agents.

3.3.76 Recall System. The action taken by which a manufacturer identifies an element, provides notice to the users, withdraws an element from the marketplace and distribution sites, and returns the element to the manufacturer or other acceptable location for corrective action.

3.3.77* Respirator. A certified device that provides respiratory protection for the wearer and is worn as part of the ensemble.

3.3.78 Retroreflection. The reflection of light in which the reflected rays are preferentially returned in the direction close to the opposite of the direction of the incident rays, with this property being maintained over wide variations of the direction of the incident rays.

3.3.79 Ruggedized. A category of ensembles with increased physical durability.

3.3.80 Safety Alert. The action by which a manufacturer identifies a specific compliant product or a compliant product component, provides notice to users of the compliant product, and informs the marketplace and distributors of potential safety concerns regarding the product or component.

3.3.81 Sample. An amount of the material, product, or assembly to be tested that is representative of the item as a whole.

3.3.82 Seam. Any permanent attachment of two or more materials, excluding external fittings, gaskets, and garment closure assemblies, in a line formed by joining the separate material pieces.

3.3.83* Self-Contained Breathing Apparatus (SCBA). An atmosphere-supplying respirator that supplies a respirable air atmosphere to the user from a breathing air source that is independent of the ambient environment and designed to be carried by the user.

3.3.84* Single-Use Item. A designation applied to an ensemble or ensemble element indicating its one time use followed by disposal.

3.3.85* Sock. An extension of the garment leg or a separate item that covers the entire foot and is intended to be worn inside a protective outer boot.

3.3.86 Specimen. The conditioned element, item, component, or composite that is subjected to testing. Specimens are taken from samples. In some tests, the specimen and sample can also be the same element, item, component, or composite.

3.3.87 Storage Life. The date to remove from service an ensemble or element that has undergone proper care and maintenance in accordance with manufacturer's instructions but has not been used either in training or at actual incidents.

3.3.88 Suit. See 3.3.39, Garment.

3.3.89 Suit Material. See 3.3.41, Garment Material.

3.3.90* Tethered Applications. Applications in which a hose or line is attached to the garment or hood portion of an ensemble via an external fitting mounted on the garment material that is further connected to a fixed location external to the garment.

3.3.91* Tongue. The part of the protective footwear that is provided for protective footwear with a closure that extends from the vamp to the top line of the footwear between sides of the footwear upper and is exposed to the exterior environment when the footwear is correctly donned.

3.3.92 Trace Number. A code that can be used to retrieve the production history of a product (e.g., a lot or serial number).

3.3.93 Upper. That part of the protective footwear including, but not limited to, the toe, vamp, quarter, shaft, collar, and throat; but not including the sole with heel, puncture-resistant device, and insole.

3.3.94 Upper Torso. The area of the body trunk above the waist and extending to the shoulder; excludes the arms, wrists, and hands.

3.3.95* Visibility Materials. Fluorescent and retroreflective materials used in the construction of garments to provide conspicuity for the purpose of providing both daytime and nighttime visibility of the wearer.

3.3.96 Visor Material. The primary transparent material(s) that allows the wearer to see outside the protective ensemble or hood.

3.3.97 Weapon of Mass Destruction (WMD). (1) Any destructive device, such as any explosive, incendiary, or poison gas bomb, grenade, rocket having a propellant charge of more than 4 oz (113 grams), missile having an explosive or incendiary charge of more than 0.25 oz (7 grams), mine, or similar device; (2) any weapon involving toxic or poisonous chemicals; (3) any weapon involving a disease organism; or (4) any weapon that is designed to release radiation or radioactivity at a level dangerous to human life.

3.3.97.1 ***Radiological Weapons of Mass Destruction.***

3.3.97.1.1 ***Improvised Nuclear Device (IND).*** An illicit nuclear weapon that is bought, stolen, or otherwise obtained from a nuclear state (that is, a national government with nuclear weapons), or a weapon fabricated from fissile material that is capable of producing a nuclear explosion.

3.3.97.1.2 ***Radiation Exposure Device (RED).*** A device intended to cause harm by exposing people to radiation without spreading radioactive material.

3.3.97.1.3 ***Radiological Dispersal Device (RDD).*** A device designed to spread radioactive material through a detonation of conventional explosives or other means.

3.3.98 Wear Surface. A footwear term for the bottom of the sole, including the heel.

Chapter 4 Certification

4.1 General.

4.1.1 The process of certification of protective ensembles and ensemble elements as being compliant with NFPA 1991, NFPA 1992, and NFPA 1994, as incorporated within the 2022 edition of NFPA 1990, shall meet the requirements of 4.1 through 4.8.

4.1.2 All compliant ensembles and ensemble elements that are labeled as being compliant with this standard shall meet or exceed all the applicable requirements specified in this standard and shall be certified.

4.1.3 All certification shall be performed by a certification organization that meets at least the requirements specified in Section 4.2 and that is accredited for personal protective equipment in accordance with ISO/IEC 17065, *Conformity assessment — Requirements for bodies certifying products, processes, and services.* The accreditation shall be issued by an accreditation body operating in accordance with ISO/IEC 17011, *Conformity assessment — Requirements for accreditation bodies accrediting conformity assessment bodies.*

4.1.4* Manufacturers shall not claim compliance with portions or segments of the applicable requirements of this standard and shall not use the NFPA name or the name or identification of this standard in any statements about their respective product(s) unless the product(s) are certified as compliant with this standard.

4.1.4.1 In order to label products according to Chapter 5 of this standard, manufacturers shall demonstrate that their products meet all the applicable design requirements and performance requirements as outlined in Chapter 6 and Chapter 7, respectively.

4.1.5 All compliant protective ensembles and ensemble elements shall be labeled and listed.

4.1.5.1 The certification organization shall publicly list the following information for the certified ensembles or ensemble elements where applicable:

(1) Manufacturer's name
(2) Model number (which might include the SKU, minus the socks)
(3) Description of the item

(4) Glove manufacturer's name and model number
(5) Footwear manufacturer's name and model number
(6) Respirator manufacturer's name and model number
(7) Requirements to which the ensemble(s) or ensemble element(s) are certified
(8) Standard to which the ensemble(s) or ensemble element(s) are certified
(9) Hood manufacturer's name and model number

4.1.6 All compliant ensembles and ensemble elements shall have product labels that meet the applicable requirements specified in Chapter 5.

4.1.7* The certification organization's label, symbol, or identifying mark shall be attached to the product label, shall be part of the product label, or shall be immediately adjacent to the product label.

4.1.8 The certification organization shall not issue any new certifications based on the following standards on or after the NFPA effective date of the 2022 edition of NFPA 1990:

(1) 2016 edition of NFPA 1991
(2) 2018 edition of NFPA 1992
(3) 2018 edition of NFPA 1994

4.1.9 The certification organization shall not permit any manufacturer to continue to label any ensembles or ensemble elements that are certified as compliant with the 2016 edition of NFPA 1991, the 2018 edition of NFPA 1992, or the 2018 edition of NFPA 1994 on or after the NFPA effective date for the 2022 edition of NFPA 1990, plus 12 months.

4.1.10 The certification organization shall require manufacturers to remove all certification labels and product labels indicating compliance with the 2016 edition of NFPA 1991, the 2018 edition of NFPA 1992, or the 2018 edition of NFPA 1994 from all ensembles and ensemble elements that are under the control of the manufacturer on the effective date of the 2022 edition of NFPA 1990, plus 12 months, and the certification organization shall verify that this action is taken.

4.1.11 Scope.

4.1.11.1 This standard shall not be construed as addressing all of the safety concerns, if any, associated with its use for the designing, manufacturing, testing, or certifying of product to meet the requirements of this standard. It shall be the responsibility of the persons and organizations that use this standard to establish safety and health practices and determine the applicability of regulatory limitations prior to use of this standard.

4.1.11.2 Nothing herein shall restrict any jurisdiction or manufacturer from exceeding these minimum requirements.

4.1.12 Purpose.

4.1.12.1 The purpose of Chapters 4 through 8 shall be to establish a minimum level of protection for emergency response personnel against adverse vapor, liquid-splash, and particulate environments during hazardous materials incidents and against specified chemical and biological terrorism agents in vapor, liquid-splash, and particulate environments during CBRN terrorism incidents.

4.1.12.2 Controlled laboratory tests used to determine compliance with the performance requirements of this standard shall not be deemed as establishing performance levels for all situations to which personnel can be exposed.

4.1.12.3 This standard is not intended to be utilized as a detailed manufacturing or purchase specification but shall be permitted to be referenced in purchase specifications as minimum requirements.

4.2 Certification Program.

4.2.1* The certification organization shall not be owned or controlled by manufacturers or vendors of the product being certified.

4.2.2 The certification organization shall be primarily engaged in certification work and shall not have a monetary interest in the product's ultimate profitability.

4.2.3 The certification organization shall be accredited for personal protective equipment in accordance with ISO/IEC 17065. The accreditation shall be issued by an accreditation body operating in accordance with ISO/IEC 17011.

4.2.4 The certification organization shall refuse to certify products to this standard if the products do not comply with all the applicable requirements of this standard.

4.2.5* The contractual provisions between the certification organization and the manufacturer shall specify that certification is contingent on compliance with all the applicable requirements of this standard.

4.2.5.1 The certification organization shall not offer or confer any conditional, temporary, or partial certifications.

4.2.5.2 Manufacturers shall not be authorized to use any label or reference to the certification organization on products that are not compliant with all the applicable requirements of this standard.

4.2.6* The certification organization shall have access to laboratory facilities and equipment for conducting proper tests to determine product compliance.

4.2.6.1 The certification organization laboratory facilities shall have a program in place and functioning for the calibration of all instruments, and procedures shall be in place to ensure proper control of all testing.

4.2.6.2 The certification organization laboratory facilities shall follow good practice regarding the use of laboratory manuals, form data sheets, documented calibration and calibration routines, performance verification, proficiency testing, and staff qualification and training programs.

4.2.7 The certification organization shall require the manufacturer to establish and maintain a quality assurance program that meets the requirements of Section 4.5.

4.2.7.1* The certification organization shall require the manufacturer to have a safety alert and product recall system, as specified in Section 4.8, as part of the manufacturer's quality assurance program.

4.2.7.2 The certification organization shall audit the manufacturer's quality assurance program to ensure that the quality assurance program provides continued product compliance with this standard.

4.2.8 The certification organization and the manufacturer shall evaluate any changes affecting the form, fit, or function of compliant products to ensure their continued certification to this standard.

4.2.9* The certification organization shall have a follow-up inspection program for the manufacturing facility's compliant product with at least two random and unannounced visits per 12-month period to verify the product's continued compliance. Where portions of the production process are carried out by multiple facilities, the certification organization shall determine the appropriate follow-up program for the facilities that most closely meet the definition of a manufacturing facility *(See 3.3.60, Manufacturing Facility).*

4.2.9.1 As part of the follow-up inspection program, the certification organization shall select sample compliant product at random from the manufacturing facility's production line, from the manufacturer's or manufacturing facility's in-house stock, or from the open market.

4.2.9.2 Sample product shall be evaluated by the certification organization to verify the product's continued compliance and to ensure that the materials, components, and manufacturing quality assurance systems are consistent with the materials, components, and manufacturing quality assurance systems that were inspected and tested by the certification organization during initial certification and annual reverification.

4.2.9.3 The certification organization shall be permitted to conduct specific testing to verify a product's continued compliance.

4.2.9.4 For products, components, and materials where prior testing, judgment, and experience of the certification organization have shown results to be in jeopardy of not complying with this standard, the certification organization shall conduct more frequent testing of sample product, components, and materials against the applicable requirements of this standard in accordance with 4.8.1.

4.2.10 The certification organization shall have in place a series of procedures, as specified in Section 4.6, that address reports of situations in which a compliant product is subsequently found to be hazardous.

4.2.11 The certification organization's operating procedures shall include a mechanism for the manufacturer to appeal decisions. The procedures shall include the presentation of information from both sides of a controversy to a designated appeals panel.

4.2.12 The certification organization shall be in a position to use legal means to protect the integrity of its name and label. The name and label shall be registered and legally defended.

4.3 Inspection and Testing.

4.3.1 For both initial certification and recertification of protective ensembles and ensemble elements, the certification organization shall conduct both inspection and testing as specified in this section.

4.3.2 All inspections, evaluations, conditioning, and testing for certification or for annual verification shall be conducted by a certification organization's testing laboratory that is accredited in accordance with the requirements of ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories.*

4.3.2.1 The certification organization's testing laboratory's scope of accreditation to ISO/IEC 17025 shall encompass testing of personal protective equipment.

4.3.2.2 The accreditation of a certification organization's testing laboratory shall be issued by an accreditation body operating in accordance with ISO/IEC 17011.

4.3.3 A certification organization shall be permitted to utilize results from conditioning and testing conducted by a product or component manufacturer for certification or annual verification provided the manufacturer's testing laboratory meets the requirements specified in 4.3.3.1 through 4.3.3.5.

4.3.3.1 The manufacturer's testing laboratory shall be accredited in accordance with the requirements of ISO/IEC 17025.

4.3.3.2 The manufacturer's testing laboratory's scope of accreditation to ISO/IEC 17025 shall encompass testing of personal protective equipment.

4.3.3.3 The accreditation of a manufacturer's testing laboratory shall be issued by an accreditation body operating in accordance with ISO/IEC 17011.

4.3.3.4 The certification organization shall approve the manufacturer's testing laboratory.

4.3.3.5 The certification organization shall determine the level of supervision and witnessing of the conditioning and testing required for the certification or annual verification conducted at the manufacturer's testing laboratory.

4.3.4 Sampling levels for testing and inspection shall be established by the certification organization and the manufacturer to ensure reasonable and acceptable reliability at a reasonable and acceptable confidence level that products certified to this standard are compliant, unless such sampling levels are specified herein.

4.3.5 Inspection by the certification organization shall include a review of all product labels to ensure that all the required label attachments, compliance statements, certification statements, and other product information are at least as specified for the ensembles and ensemble elements per the applicable requirements of Chapter 5.

4.3.6 Inspection by the certification organization shall include an evaluation of any symbols or graphic representations used on product labels or in user information, as permitted by 5.1.1.5, to ensure that the symbols or graphic representations are clearly explained in the product's user information package.

4.3.7 Inspection by the certification organization shall include a review of the user information required by the applicable sections of Chapter 5 to ensure that the information has been developed and is available.

4.3.8 Inspection by the certification organization shall include a review of the Technical Data Package to determine compliance with the applicable requirements of Chapter 5.

4.3.9 Inspection and evaluation by the certification organization for determining compliance with the applicable design requirements specified in Chapter 6 shall be performed on whole or complete products.

4.3.10 Testing to determine product compliance with the applicable performance requirements specified in Chapter 7 shall be conducted by the certification organization in accordance with the specified testing requirements of Chapter 8.

4.3.10.1 Testing shall be performed on specimens representative of materials and components used in the actual construction of the protective ensembles and ensemble elements.

4.3.10.2 The certification organization shall also be permitted to use sample materials cut from a representative product.

4.3.11 The certification organization shall accept from the manufacturer, for evaluation and testing for certification, only product or product components that are the same in every respect as the actual final products or product components.

4.3.12 The certification organization shall not allow any modifications, pretreatment, conditioning, or other such special processes of the product or any product component prior to the product's submission for evaluation and testing by the certification organization.

4.3.13 The certification organization shall not allow the substitution, repair, or modification, other than as specifically permitted herein, of any product or any product component during testing.

4.3.14 The certification organization shall not allow test specimens that have been conditioned and tested for one method to be reconditioned and tested for another test method unless specifically permitted by the test method.

4.3.15 The certification organization shall test ensemble elements with the specific ensemble(s) with which they are to be certified.

4.3.16* Any change in the design, construction, or material of a compliant product shall necessitate new inspection and testing to verify its compliance with all the applicable requirements of this standard that the certification organization determines can be affected by such change. This recertification shall be conducted before labeling the modified product as being compliant with this standard.

4.3.17 The manufacturer shall maintain all the design and performance inspection and test data from the certification organization used in the certification of the manufacturer's compliant product. The manufacturer shall provide such data, upon request, to the purchaser or authority having jurisdiction.

4.3.18 The certification organization shall ensure that the manufacturer tests each vapor-protective ensemble for gastight integrity as specified in ASTM F1052, *Standard Test Method for Pressure Testing Vapor Protective Suits*. Each ensemble shall show an ending pressure of at least 797 Pa (3.2 in. water gauge) pressure. The date of the test shall be placed on the product label as specified in 5.1.1.7(9). The manufacturer shall provide the result for each ensemble.

4.4 Annual Verification.

4.4.1 General Annual Verification of Product Compliance.

4.4.1.1 All ensemble and ensemble element models that are labeled as being compliant with this standard shall, on an annual basis, undergo a verification evaluation that includes inspection, review of all design requirements, and testing to all performance requirements as required by this standard.

4.4.1.2 Any change that affects the ensemble or ensemble element performance requirements of this standard shall constitute a different model.

4.4.1.3 For the purposes of this standard, models shall include each unique pattern, style, or design of individual elements.

4.4.1.4 Samples of the ensembles, ensemble elements, and their components for verification shall be acquired from the manufacturer or component supplier during random and unannounced visits as part of the follow-up inspection program. The certification organization shall acquire a sufficient quantity of samples to be tested for verification as required by 4.4.2, 4.4.3, or 4.4.4, depending on the applicable certification standard.

4.4.1.5 Sample ensembles, ensemble elements, and their components shall be inspected, evaluated, and tested as required by 4.4.2, 4.4.3, or 4.4.4, depending on the applicable certification standard.

4.4.1.6 The manufacturer shall maintain all design, inspection, performance, and test data from the certification organization produced during the verification of the manufacturer's models and components. The manufacturer shall provide such data, upon request, to the purchaser or the authority having jurisdiction.

4.4.2 Annual Verification of Product Compliance Specific to NFPA 1991.

4.4.2.1 Each vapor-protective ensemble shall be inspected and evaluated based on all the applicable design requirements specified in Chapter 6.

4.4.2.2 A single specimen of each vapor-protective ensemble shall be tested for overall performance as specified in Chapter 7 using the following sequence of tests:

(1) The vapor-protective ensemble specimen shall be tested for liquidtight integrity as specified in 7.1.1.1.
(2) The vapor-protective ensemble specimen shall be tested for overall function and integrity as specified in 7.1.1.1.
(3) The vapor-protective ensemble specimen shall be tested for airflow capacity as specified in 7.1.1.1.5 and 7.1.1.1.5.1.
(4) A minimum of one new vapor-protective ensemble specimen shall be tested for overall inward leakage as specified in 7.1.1.1.1.
(5) If certified for optional chemical flash fire protection as specified in 7.1.8, a new vapor-protective ensemble specimen shall be tested for overall ensemble flash protection as specified in 7.1.8.1.

4.4.2.3 All base performance requirements, optional chemical flash fire performance requirements, and optional liquefied gas performance requirements shall be evaluated as specified in Chapter 7, except the requirements in 7.1.1.3.3 and 7.1.1.3.4, with the following modifications:

(1) Chemical permeation resistance testing shall be limited to the testing specified in 7.2.2 and limited to the following chemicals:
    (a) Acrylonitrile
    (b) Carbon disulfide
    (c) Dichloromethane
    (d) Diethylamine
    (e) Methanol
    (f) Tetrahydrofuran
(2) Chemical permeation resistance testing required for ensembles certified for optional liquefied gas protection, as specified in 7.2.4, shall be limited to ammonia.

(3) Chemical penetration resistance testing shall be limited to the testing specified in 7.2.3 and limited to the following chemicals:
   (a) Carbon disulfide
   (b) Dichloromethane
   (c) Diethylamine
   (d) Methanol
   (e) Tetrahydrofuran
(4) A total of two specimens shall be permitted for testing requirements. If testing is specified for both directions of a material, a total of two specimens per material direction shall be permitted for testing requirements.

4.4.3 Annual Verification of Product Compliance Specific to NFPA 1992.

4.4.3.1 Each liquid splash-protective ensemble and ensemble element shall be inspected and evaluated to all the applicable design requirements specified in Chapter 6.

4.4.3.2 Each liquid splash-protective ensemble specimen shall be tested for overall performance as specified in Chapter 7 using the following sequence of tests:

(1) The liquid splash-protective ensemble specimen shall then be tested for overall function and integrity as specified in 7.1.1.1.4.
(2) If certified for optional chemical flash fire protection as specified in 7.1.8, the liquid splash-protective ensemble shall be tested for overall ensemble flash protection as specified in 7.1.8.

4.4.3.3* All liquid splash-protective ensembles, ensemble elements, and components shall be evaluated as specified in Chapter 7, with the following modifications:

(1) Chemical penetration resistance testing shall be limited to the testing specified in 7.3.2, and shall be performed using the following chemicals:
   (a) Fuel H — surrogate gasoline [42.5 percent toluene, 42.5 percent isooctane, and 15 percent denatured ethanol, volume/volume (v/v)] as defined in ASTM D471, *Standard Test Method for Rubber Property — Effect of Liquids*.
   (b) Methyl isobutyl ketone, CAS No. 108-10-1, >95 percent, weight/weight (w/w)
   (c) Sulfuric acid, CAS No. 7664-93-9, 93.1 percent, w/w
(2) A total of two specimens shall be permitted for testing requirements. If the testing is specified for both directions of a material, a total of two specimens per material direction shall be permitted for testing requirements.

4.4.4 Annual Verification of Product Compliance Specific to NFPA 1994.

4.4.4.1 One sample of each compliant product shall be inspected and evaluated using all the applicable design requirements specified in Chapter 6.

4.4.4.2 A minimum of one specimen of each compliant ensemble shall be tested for overall ensemble performance as specified in Chapter 7 using the following sequence of tests:

(1) Where the ensemble is certified to Class 1, 2, 2R, 3, or 3R, the following sequence is permitted:
   (a) The ensemble specimen shall be tested for liquid integrity as specified in 7.1.1.1.2.
   (b) The ensemble specimen shall be tested for overall function and integrity as specified in 7.1.1.1.4.
   (c) A new ensemble specimen shall be tested for inward vapor leakage as specified in 7.1.1.1.1.
   (d) Where the ensemble is encapsulating and certified to Class 1, 2, or 2R, the ensemble specimen shall be tested for airflow capacity as specified in 7.1.1.1.5 and 7.1.1.1.5.2.
(2) Where the ensemble is certified to Class 4 or 4R, the following sequence is permitted:
   (a) The ensemble specimen shall be tested for liquid integrity as specified in 7.1.1.1.2.
   (b) The ensemble specimen shall be tested for overall function and integrity as specified in 7.1.1.1.4.
   (c) Inward particle leakage as specified in 7.1.1.1.3 shall not be performed.
(3) Where the ensemble is certified to Class 5, the following sequence is permitted:
   (a) The ensemble specimen shall be tested for overall flash fire performance.
(4) Where the ensemble is certified for optional chemical flash fire protection as specified in 7.1.8, a new ensemble shall be tested for overall ensemble flash protection as specified in 7.1.8.1.

4.4.4.3 Each ensemble, ensemble element, and component shall be tested as specified in Chapter 7, with the following modifications:

(1) Chemical permeation resistance testing for Class 1 ensembles shall be limited to the testing specified in 7.4.2 and the following chemicals:
   (a) Ammonia
   (b) Acrolein
   (c) Acrylonitrile
   (d) Chlorine
   (e) Dimethyl sulfate
(2) Chemical permeation resistance testing specified for Class 2, 2R, 3, and 3R ensembles shall be limited to the testing specified in 7.4.3 and the following chemicals:
   (a) Acrylonitrile
   (b) Ammonia
   (c) Dimethyl sulfate
(3) With the exception of chemical permeation testing, a total of two specimens shall be permitted for ensemble material and component testing requirements. If the testing is specified for both directions of a material, a total of two specimens per material direction shall be permitted for testing requirements.

4.5 Manufacturers' Quality Assurance Program.

4.5.1 The manufacturer shall provide and operate a quality assurance program that meets the requirements of this section and that includes a product recall system as specified in 4.2.7.1 and Section 4.8.

4.5.2 The operation of the quality assurance program shall evaluate and test compliant product production against this standard to ensure production remains in compliance.

4.5.3 All of the following entities shall be registered to ISO 9001, *Quality management systems — Requirements*, or shall be listed as covered locations under an ISO 9001-registered entity:

(1) Manufacturer

(2) Manufacturing facility
(3) Entity that directs and controls compliant product design
(4) Entity that directs and controls compliant product quality assurance
(5) Entity that provides the warranty for the compliant product
(6) Entity that puts their name on the product label and markets and sells the product as their own

4.5.3.1 Registration based on the requirements of ISO 9001 shall be conducted by a registrar that is accredited for personal protective equipment in accordance with ISO/IEC 17021, *Conformity assessment — Requirements for bodies providing audit and certification of management systems*. The registrar shall affix the accreditation mark on the ISO registration certificate.

4.5.4* Where the manufacturer uses subcontractors in the construction or assembly of the compliant product, the locations and names of all the subcontractor facilities shall be documented and the documentation shall be provided to the manufacturer's ISO registrar and the certification organization.

4.6 Hazards Involving Compliant Product.

4.6.1* The certification organization shall establish procedures to be followed where situation(s) are reported in which a compliant product is subsequently found to be hazardous. These procedures shall comply with the provisions of ISO Guide 27, *Guidelines for corrective action to be taken by a certification body in the event of misuse of its mark of conformity*, and as modified herein.

4.6.2* Where a report of a hazard related to a compliant product is received by the certification organization, the validity of the report shall be investigated.

4.6.3 With respect to a compliant product, a hazard shall be a condition, or shall create a situation, that results in exposing life, limb, or property to an imminently dangerous or dangerous condition.

4.6.4 Where a specific hazard is identified, the determination of the appropriate action for the certification organization and the manufacturer to undertake shall take into consideration the severity of the hazard and its consequences to the safety and health of users.

4.6.5 Where it is established that a hazard is related to a compliant product, the certification organization shall determine the scope of the hazard, including the products, model numbers, serial numbers, factory production facilities, production runs, and quantities involved.

4.6.6 The certification organization's investigation shall include, but not be limited to, the extent and scope of the problem as it might apply to other compliant products or compliant product components manufactured by other manufacturers or certified by other certification organizations.

4.6.7 The certification organization shall also investigate reports of a hazard where a compliant product is gaining widespread use in applications not foreseen when the standard was written; such applications, in turn, are ones for which the product was not certified, where there is no specific scope of application provided in the standard, and where there is no limiting scope of application provided by the manufacturer in written material accompanying the compliant product at the point of sale.

4.6.8 The certification organization shall require the manufacturer of the compliant product or product component, if applicable, to assist the certification organization in the investigation and to conduct its own investigation as specified in Section 4.7.

4.6.9 Where the facts indicating a need for corrective action are conclusive and the certification organization's appeal procedures referenced in 4.2.11 have been followed, the certification organization shall initiate corrective action immediately, provided there is a manufacturer to be held responsible for such action.

4.6.10 Where the facts are conclusive and corrective action is indicated but there is no manufacturer to be held responsible, such as when the manufacturer is out of business or the manufacturer is bankrupt, the certification organization shall immediately notify relevant governmental and regulatory agencies and issue a notice to the user community about the hazard.

4.6.11* Where the facts are conclusive and corrective action is indicated, the certification organization shall take one or more of the following corrective actions:

(1) Notification of parties authorized and responsible for issuing a safety alert when, in the opinion of the certification organization, such a notification is necessary to inform users
(2) Notification of parties authorized and responsible for issuing a product recall when, in the opinion of the certification organization, such a recall is necessary to protect users
(3) Removal of the mark of certification from the product
(4) Where a hazardous condition exists and it is not practical to implement 4.6.11(1), 4.6.11(2), or 4.6.11(3), or the responsible parties refuse to take corrective action, notification of relevant governmental and regulatory agencies and issuance of a notice to the user community about the hazard

4.6.12 The certification organization shall provide a report to the organization or individual identifying the reported hazardous condition and notify them of the corrective action taken or that no corrective action is indicated.

4.6.13* Where a change to an NFPA standard(s) is felt to be necessary, the certification organization shall also provide a copy of the report and corrective actions indicated to the NFPA, and it shall also submit either a Public Input for a proposed change to the next revision of the applicable standard or a proposed Temporary Interim Amendment (TIA) to the current edition of the applicable standard.

4.7 Manufacturers' Investigation of Complaints and Returns.

4.7.1 Manufacturers shall provide corrective action in accordance with ISO 9001 or an equivalent ISO quality management system for investigating written complaints and returned products.

4.7.2 Manufacturers' records of returns and complaints related to safety issues shall be retained for at least 5 years.

4.7.3 Where the manufacturer discovers, during the review of specific returns or complaints, that a compliant product or compliant product component might constitute a potential safety risk to end users that is possibly subject to a safety alert or product recall, the manufacturer shall immediately contact the certification organization and provide all the information

about their review to assist the certification organization with their investigation.

4.8 Manufacturers' Safety Alert and Product Recall Systems.

4.8.1 Manufacturers shall establish a written safety alert system and a written product recall system that describes the procedures to be used in the event that it decides, or is directed by the certification organization, to either issue a safety alert or conduct a product recall.

4.8.2 The manufacturers' safety alert and product recall system shall provide the following:

(1) The establishment of a coordinator and responsibilities by the manufacturer for the handling of safety alerts and product recalls
(2) A method of notifying all dealers, distributors, purchasers, users, and the NFPA about the safety alert or product recall that can be initiated within a 1-week period following the manufacturer's decision to issue a safety alert or conduct a product recall or after the manufacturer has been directed by the certification organization to issue a safety alert or conduct a product recall
(3) Techniques for communicating accurately and understandably the nature of a safety alert or product recall and, in particular, the specific hazard or safety issue found to exist
(4) Procedures for removing product that is recalled and documenting the effectiveness of the product recall
(5) A plan for either repairing, replacing, or compensating purchasers for returned product

Chapter 5 Labeling and Information

5.1 General Requirements.

5.1.1* General Product Label Requirements.

5.1.1.1 Each protective ensemble, ensemble element, clothing, or item shall have a product label permanently and conspicuously attached to or printed on the innermost surface when the ensemble, ensemble element, clothing, or item is properly assembled with all layers, components, and component parts in place.

5.1.1.2 As an alternative to the product label being attached to or printed on the protective ensemble(s), ensemble element(s), clothing, or item(s), the product label shall be permitted to be attached to, printed on, or inserted into each package containing the protective ensemble(s), ensemble element(s), clothing, or item(s).

5.1.1.2.1 Where package labels are required, the package product label shall be permanently and conspicuously located on the outside of the package or printed on the package and shall not be removed, obscured, or otherwise mutilated by the opening of the package when it is opened as intended.

5.1.1.3* For the purpose of ensuring all required statements and information appear on the product label, multiple label pieces shall be permitted if all label pieces comprising the entire product label are located adjacent to each other.

5.1.1.4 All worded portions of the required product label and package, where applicable, shall at least be in English.

5.1.1.5 Symbols and other graphic representations shall be permitted to be used to supplement worded statements on the product label(s) if they are clearly explained in the user information.

5.1.1.6 All letters and numbers on the product label(s) and product package label(s) shall meet the following requirements:

(1) The compliance statements in 5.2.1.1, 5.3.1.1, 5.3.1.2, 5.3.1.3, 5.3.1.4, 5.3.1.5, 5.3.1.6, 5.4.1.1, 5.4.1.2, and 5.4.1.3 shall be at least 2.5 mm (3⁄32 in.) high.
(2) The certification organization's symbol shall be at least 6 mm (1⁄4 in.) high.
(3) The certification organization's name shall be at least 2.5 mm (3⁄32 in.) high.
(4) All other labeling information shall be at least 1.6 mm (1⁄16 in.) high.

5.1.1.7 In addition to the compliance statements specified in 5.1.1.6(1), the following information at a minimum, shall also be printed legibly on the product label(s):

(1) Manufacturer's name, identification, or designation
(2) Manufacturer's address
(3) Country of manufacture
(4) Model, style, or serial number
(5) Size
(6) The word(s) "garment," "visor," "hood," "glove," or "ensemble element," as applicable
(7) For ensembles, the words "glove element component," "footwear element component," or "hood element component," as applicable
(8) Where the product is classified as breathable, the words "breathable (see manufacturer's technical data package)" as required by 7.1.3.6
(9) For NFPA 1991-compliant ensembles, the date and result (ending pressure) of compliance testing to ASTM F1052, *Standard Test Method for Pressure Testing Vapor Protective Suits*

5.1.2* General User Information Requirements.

5.1.2.1 The manufacturer shall provide user information including, at a minimum, warnings, information, and instructions with each ensemble and ensemble element.

5.1.2.2 The manufacturer shall attach the required user information, or packaging containing the user information, to the ensemble or ensemble element in such a manner that it is not possible to use the ensemble or ensemble element without being aware of the availability of the information.

5.1.2.2.1 The required user information, or packaging containing the user information, shall be attached to the ensemble or ensemble element in such a manner that a deliberate action is necessary to remove it. The manufacturer shall provide notice that the user information is to be removed only by the end user.

5.1.2.3 The manufacturer shall provide at least the following instructions and information with each ensemble and ensemble element:

(1) Pre-use information, as follows:
    (a) Safety considerations
    (b) Limitations of use
    (c) Ensemble or ensemble element marking recommendations and restrictions
    (d) A statement that most performance properties of the ensemble or ensemble element cannot be tested by the user in the field

(e) Closure lubricants, where applicable
(f) Visor antifog agents or procedures, where applicable
(g) Recommended undergarments
(h) Warranty information
(i) For NFPA 1992-certified ensembles and NFPA 1994-certified ensembles, the following:
i. A specific warning for nonencapsulated ensembles that the respirator has not been evaluated for chemical permeation resistance consistent with the other ensemble elements
ii. A specific warning not to use tape as a means for creating interfaces between ensemble elements
(j) A statement that the AHJ comply with the requirements of NFPA 1891 for the selection, care, and maintenance of protective ensemble and elements

(2) Storage information, as follows:
(a) Recommended practices
(b) Recommended conditions
(c) Storage life for all ensembles and ensemble elements

(3) Donning/doffing information, as follows:
(a) Donning and doffing procedures
(b) Sizing and adjustment procedures
(c) Ensemble interface attachment(s) and issues
(d) Respirator interface with ensemble
(e) Where applicable, procedures for ensuring that the interface of the respirator is maintained during use
(f)* Where applicable, procedures for completing interfaces with detachable components
(g) Where applicable, instructions for removal of hands from gloves and reinsertion of hands into gloves
(h) Specific instructions for doffing when contaminated

(4) Proper use information, as follows:
(a) A statement requiring users to comply with NFPA 1500
(b) For users in the United States, a statement requiring users to comply with 29 CFR 1910.132, "Personal Protective Equipment: General Requirements"
(c) For users in other countries, a statement requiring users to comply with national or other applicable personal protective equipment regulations
(d) If applicable, a statement indicating that the ensembles or ensemble elements are for single use only
(e) Instructions for removal and replacement of gloves and other user-replaceable components

(5) Cleaning and maintenance information, as follows:
(a) Cleaning instructions and precautions with a statement instructing users not to use ensembles or ensemble elements that are not thoroughly cleaned and dried
(b) Inspection frequency details
(c) Where applicable, maintenance criteria and methods of repair
(d) Decontamination procedures for both chemical and biological contamination
(e) Instructions for removal and replacement of gloves and other user-replaceable components

(6) Retirement and disposal criteria and consideration
(7) For nonencapsulating ensembles where a respirator is required, the make and model of the respirator used to achieve compliance
(8)* For NFPA 1991-certified ensembles, the words "The closure has not been tested for permeation resistance"

5.1.2.4* The manufacturer shall state the storage life in years following the date of manufacture and the rationale for this determination.

5.1.2.5* For protective ensembles, the following additional instructions and information shall be provided:

(1) The specific sequence and requirements for donning each item of the ensemble
(2) Specific recommended methods for cleaning each element of the ensemble where elements are combined or attached
(3)* Specific considerations for decontamination to be employed during the doffing of ensemble elements
(4)* The specific sequence, precautions, and requirements for doffing each item of the ensemble, when contaminated, for the avoidance of cross-contamination of the individual wearer, other ensemble items, and the outside environment

5.1.3 General Technical Data Package Requirements.

5.1.3.1* The manufacturer shall designate if the ensemble or ensemble elements are for single use only and provide guidance on what constitutes a single use, if indicated.

5.2 NFPA 1991–Specific Requirements.

5.2.1 NFPA 1991–Specific Labeling Requirements.

5.2.1.1 Each vapor-protective ensemble shall have at least the following compliance statement and information on the product label:

THIS VAPOR-PROTECTIVE ENSEMBLE MEETS THE REQUIREMENTS OF NFPA 1991, INCORPORATED IN THE 2022 EDITION OF NFPA 1990, AND THE ADDITIONAL REQUIREMENTS INDICATED BELOW.

THE TECHNICAL DATA PACKAGE CONTAINS INFORMATION ON CHEMICALS AND SPECIFIC CHEMICAL MIXTURES FOR WHICH THIS ENSEMBLE IS CERTIFIED. CONSULT TECHNICAL DATA PACKAGE AND MANUFACTURER'S INSTRUCTIONS BEFORE USE.
DO NOT REMOVE THIS LABEL.

ADDITIONAL REQUIREMENTS	YES	NO
LIMITED FLASH FIRE PROTECTION FOR ESCAPE ONLY IN THE EVENT OF A FLASH FIRE		
LIQUEFIED GAS PROTECTION		

5.2.1.1.1 Where the ensemble provides the optional additional protection, the YES box shall be marked for the additional requirement.

5.2.1.1.2 Where the ensemble does not provide the optional additional protection, the NO box shall be marked for the additional requirement.

5.2.1.2 Each vapor-protective ensemble element shall have at least the following compliance statement and information on the product label, with the appropriate element name inserted where indicated:

THIS [insert the element name GLOVE or FOOTWEAR here] ELEMENT MEETS THE REQUIREMENTS OF NFPA 1991, INCORPORATED IN THE 2022 EDITION OF NFPA 1990, AND THE ADDITIONAL REQUIREMENTS AS INDICATED BELOW.

THE TECHNICAL DATA PACKAGE CONTAINS INFORMATION ON CHEMICALS AND SPECIFIC CHEMICAL MIXTURES FOR WHICH THIS [insert the element name GLOVE or FOOTWEAR here] IS CERTIFIED. CONSULT THE TECHNICAL DATA PACKAGE AND MANUFACTURER'S INSTRUCTIONS BEFORE USE.
DO NOT REMOVE THIS LABEL.

ADDITIONAL REQUIREMENTS	YES	NO
LIMITED FLASH FIRE PROTECTION FOR ESCAPE ONLY IN THE EVENT OF A FLASH FIRE		
LIQUEFIED GAS PROTECTION		

5.2.1.2.1 Where the ensemble element provides the optional additional protection, the YES box shall be marked for the additional requirement.

5.2.1.2.2 Where the ensemble element does not provide the optional additional protection, the NO box shall be marked for the additional requirement.

5.2.1.3* Where detachable components of an ensemble or ensemble element must be worn with the ensemble or ensemble element in order to be compliant with this standard or any optional requirements of this standard, at least the following statement and information shall also be printed legibly on the product label of the ensemble element that requires an additional component with all letters at least 1.6 mm ($\frac{1}{16}$ in.) high and following the product compliance statement on the label, the appropriate term inserted where indicated, and the detachable component(s) listed by type, identification and how properly worn:

FOR COMPLIANCE WITH NFPA 1991, AND [insert OPTIONAL LIMITED FLASH FIRE PROTECTION FOR ESCAPE ONLY IN THE EVENT OF A FLASH FIRE or LIQUEFIED GAS PROTECTION or both here], THE FOLLOWING ADDITIONAL COMPONENTS MUST BE WORN IN CONJUNCTION WITH THIS VAPOR-PROTECTIVE [insert the term ENSEMBLE or ENSEMBLE ELEMENT here]:
[list detachable components here]

5.2.1.3.1 The manufacturer shall be permitted to list the detachable components in the technical data package by providing an additional statement on the label specified in 5.2.1.3 as follows:

SEE TECHNICAL DATA PACKAGE FOR A LIST OF DETACHABLE COMPONENTS.

5.2.1.3.2 Detachable components specified in 5.2.1.3 shall meet the label requirements specified in ASTM F1301, *Standard Practice for Labeling Chemical Protective Clothing*, and the requirements of 5.1.1.1 through 5.1.1.5.

5.2.2 NFPA 1991–Specific User Information Requirements.

5.2.2.1* Vapor-protective ensemble and ensemble element manufacturers shall furnish a log book with each ensemble and ensemble element along with instructions on the log book's proper completion and maintenance.

5.2.2.2* For vapor-protective ensembles, the manufacturer shall state the model(s) and cylinder(s) size of the NFPA 1981– or NFPA 1986–compliant open-circuit SCBA worn during certification of the garment.

5.2.3 NFPA 1991–Specific Technical Data Package Requirements.

5.2.3.1 General.

5.2.3.1.1* The manufacturer shall furnish a technical data package with each vapor-protective ensemble and each ensemble element.

5.2.3.1.2* The technical data package shall contain all documentation required by this standard and the values obtained from the initial certification showing compliance with the requirements of Chapter 7 in the current edition of this standard using the reporting formats provided in Table 5.2.3.1.2(a) and Table 5.2.3.1.2(b) and by indicating "Pass" for those requirements that have no reported quantitative values and "Not applicable" for specific requirements that do not apply to the vapor-protective ensemble.

5.2.3.1.3 In the technical data package, the manufacturer shall describe the vapor-protective ensemble or ensemble elements in terms of manufacturer trade name, model number, manufacturer replaceable components and component parts, and available options such as accessories, testing devices, and sizes.

5.2.3.1.4* In the technical data package, the manufacturer shall describe the available sizes of the vapor-protective ensemble and include in that description the range in height and weight for persons fitting each particular size and information to the wearer as to whether these sizes apply to persons wearing SCBA, hard hats, communications devices, structural firefighting protective clothing, and other similar clothing or equipment.

5.2.3.2 Material and Component Descriptions.

5.2.3.2.1 Where specific clothing items, equipment, or component parts are required for certifying the vapor-protective ensemble or ensemble element as compliant with this standard, the manufacturer shall list these clothing items, equipment, or component parts in the technical data package.

5.2.3.2.2 The manufacturer shall provide, in the technical data package, the list and descriptions of the following ensemble or individual ensemble element materials and component parts, where applicable:

(1) Garment material
(2) Visor material
(3) Glove material and type of attachment
(4) Footwear material and type of attachment
(5) Zipper/closure type and materials
(6) Material seam types and composition
(7) Exhaust valve type(s) and material(s)
(8) External fitting type(s) and material(s)
(9) External gasket type(s) and material(s)
(10) Outer garment, glove, or boot material(s)
(11) Type or style of head protection accommodated within the garment

Table 5.2.3.1.2(a) Format for Reporting NFPA 1991-Specific Certification Test Data in Technical Data Package

Ensemble or Ensemble Element	Performance Requirement	Test Method	Requirement	Result
Base Requirements				
Ensemble	Overall inward leakage	Section 8.2.2.2	$PPDF_{sys}$ ≥488 $PPDF_i$ (local) ≥1071	Indicate lowest average value and its location
	Liquidtight integrity	ASTM F1359/F1359M (Section 8.2.3)	No liquid penetration No liquid accumulation in outer gloves No liquid accumulation in outer boots No liquid inside ensemble next to exhaust valves	
	Overall ensemble function and integrity	ASTM F1154/ASTM F1052 (Section 8.6.1)	Ending garment pressure ≥80 mm (3 5/32 in.) water gauge Test subject completes tasks within 30 minutes Accommodates head protection devices meeting ANSI/ISEA Z89.1 (Type 1, Class G) Test subject has visual acuity of 20/35 or better through facepiece lens and visor Test subject identifies three of four letters on test sign Time to remove hands from and reinsert hands into gloves five times ≤2.5 minutes Garment closures remain engaged Protective flap stays remain closed	
	Airflow capacity	Section 8.6.2	Internal garment pressure ≤150 mm (6 in.) water gauge Ending garment pressure ≥80 mm (3 5/32 in.) water gauge	
Exhaust valve	Inward leakage	Section 8.6.3	Leakage rate ≤30 mL/min (1.83 in^3/min)	
	Mounting strength	Section 8.5.4	Strength >135 N (30 lbf)	
External fitting	Installation effect on integrity	ASTM F1052 (Section 8.2.1)	Ending garment pressure ≥80 mm (3 5/32 in.) water gauge	
	Pull-out strength (tethered applications)	Section 8.5.5	Strength >1000 N (225 lbf)	
	Pull-out strength (non-tethered applications)	Section 8.5.5	Strength >1000 N (225 lbf)	
Garment material	Chemical permeation resistance	ASTM F739 (Section 8.3.1.1)	Cumulative permeation ≤6.0 μg/m^2 (1 hour); ≤2.0 μg/m^2 (first 15 minutes)	See Table 5.2.3.1.2(b)
	Sulfur mustard (HD) permeation resistance	Section 8.3.1.2	Cumulative permeation ≤4.0 μg/m^2 (1 hour); ≤1.33 μg/m^2 (first 15 minutes)	See Table 5.2.3.1.2(b)
	Soman (GD) permeation resistance	Section 8.3.1.2	Cumulative permeation ≤1.25 μg/m^2 (1 hour); ≤0.43 μg/m^2 (first 15 minutes)	See Table 5.2.3.1.2(b)
	Flame resistance	ASTM F1358 (Section 8.4.1)	Afterflame time ≤2 seconds No melting and dripping	
	Burst strength	ASTM D751 (Section 8.5.1)	Strength >200 N (45 lbf)	

(continues)

Table 5.2.3.1.2(a) *Continued*

Ensemble or Ensemble Element	Performance Requirement	Test Method	Requirement	Result
	Puncture propagation tear resistance	ASTM D2582 (Section 8.5.2)	Tear resistance ≥49 N (11 lbf)	
	Cold temperature bending	ASTM D747 (Section 8.5.11.1)	Bend moment ≤0.057 N·m (0.5 in.-lb)	
Garment seam	Chemical permeation resistance	ASTM F739 (Section 8.3.1.1)	Cumulative permeation ≤6.0 $\mu g/m^2$ (1 hour); ≤2.0 $\mu g/m^2$ (first 15 minutes)	See Table 5.2.3.1.2(b)
	Sulfur mustard (HD) permeation resistance	Section 8.3.1.2	Cumulative permeation ≤4.0 $\mu g/m^2$ (1 hour); ≤1.33 $\mu g/m^2$ (first 15 minutes)	See Table 5.2.3.1.2(b)
	Soman (GD) permeation resistance	Section 8.3.1.2	Cumulative permeation ≤1.25 $\mu g/m^2$ (1 hour); ≤0.43 $\mu g/m^2$ (first 15 minutes)	See Table 5.2.3.1.2(b)
	Seam strength	ASTM D751 (Section 8.5.3)	Strength >67 N/25 mm (15 in.·lbf)	
Garment closure	Chemical penetration resistance	ASTM F903 (Section 8.3.3)	No penetration of 15 liquid chemicals	
	Closure strength	ASTM D751 (Section 8.5.3)	Strength >67 N/25 mm (15 in.·lbf)	
Visor material	Chemical permeation resistance	ASTM F739 (Section 8.3.1.1)	Cumulative permeation ≤6.0 $\mu g/m^2$ (1 hour); ≤2.0 $\mu g/m^2$ (first 15 minutes)	See Table 5.2.3.1.2(b)
	Sulfur mustard (HD) permeation resistance	Section 8.3.1.2	Cumulative permeation ≤4.0 $\mu g/m^2$ (1 hour); ≤1.33 $\mu g/m^2$ (first 15 minutes)	See Table 5.2.3.1.2(b)
	Soman (GD) permeation resistance	Section 8.3.1.2	Cumulative permeation ≤1.25 $\mu g/m^2$ (1 hour); ≤0.43 $\mu g/m^2$ (first 15 minutes)	See Table 5.2.3.1.2(b)
	Flame resistance	ASTM F1358 (Section 8.4.1)	Afterflame time ≤2 seconds No melting and dripping	
	Visor high-mass impact resistance	Section 8.5.10	No full-thickness cracks, holes, or fractures	
	Cold temperature bending	Section 8.5.11.2	No cracking or evidence of visual damage	
Visor seam	Chemical permeation resistance	ASTM F739 (Section 8.3.1.1)	Cumulative permeation ≤6.0 $\mu g/m^2$ (1 hour); ≤2.0 $\mu g/m^2$ (first 15 minutes)	See Table 5.2.3.1.2(b)
	Sulfur mustard (HD) permeation resistance	Section 8.3.1.2	Cumulative permeation ≤4.0 $\mu g/m^2$ (1 hour); ≤1.33 $\mu g/m^2$ (first 15 minutes)	See Table 5.2.3.1.2(b)
	Soman (GD) permeation resistance	Section 8.3.1.2	Cumulative permeation ≤1.25 $\mu g/m^2$ (1 hour); ≤0.43 $\mu g/m^2$ (first 15 minutes)	See Table 5.2.3.1.2(b)
	Seam strength	ASTM D751 (Section 8.5.3)	Strength >67 N/25 mm (15 in.·lbf)	
Elastomeric interface material	Chemical permeation resistance	ASTM F739 (Section 8.3.1.1)	Cumulative permeation ≤6.0 $\mu g/m^2$ (1 hour); ≤2.0 $\mu g/m^2$ (first 15 minutes)	See Table 5.2.3.1.2(b)
	Sulfur mustard (HD) permeation resistance	Section 8.3.1.2	Cumulative permeation ≤4.0 $\mu g/m^2$ (1 hour); ≤1.33 $\mu g/m^2$ (first 15 minutes)	See Table 5.2.3.1.2(b)
	Soman (GD) permeation resistance	Section 8.3.1.2	Cumulative permeation ≤1.25 $\mu g/m^2$ (1 hour); ≤0.43 $\mu g/m^2$ (first 15 minutes)	See Table 5.2.3.1.2(b)
	Elongation	Method A of ASTM D412 (Section 8.5.6)	Elongation at rupture ≥125 percent	

(continues)

Table 5.2.3.1.2(a) *Continued*

Ensemble or Ensemble Element	Performance Requirement	Test Method	Requirement	Result
	Cut resistance	ASTM F1790 (Section 8.5.7)	Blade travel distance ≥20 mm at 50 grams (0.8 in. at 1.76 oz)	
	Puncture resistance	Method A of ASTM F1342/F1342M (Section 8.5.8.1)	Puncture force ≥22 N (5 lbf)	
	Ultimate tensile strength	Method A of ASTM D412 (Section 8.5.6)	Strength ≥4 MPa	
	Cold temperature bending	ASTM D747 (Section 8.5.11.1)	Bend moment ≤0.057 N·m (0.5 in.-lb)	
Gloves	Dexterity	ASTM F2010/F2010M (Section 8.6.5)	Percent increase in bare-handed control <600 percent	
Glove material	Chemical permeation resistance	ASTM F739 (Section 8.3.1.1)	Cumulative permeation ≤6.0 $\mu g/m^2$ (1 hour); ≤2.0 $\mu g/m^2$ (first 15 minutes)	See Table 5.2.3.1.2(b)
	Sulfur mustard (HD) permeation resistance	Section 8.3.1.2	Cumulative permeation ≤4.0 $\mu g/m^2$ (1 hour); ≤1.33 $\mu g/m^2$ (first 15 minutes)	See Table 5.2.3.1.2(b)
	Soman (GD) permeation resistance	Section 8.3.1.2	Cumulative permeation ≤1.25 $\mu g/m^2$ (1 hour); ≤0.43 $\mu g/m^2$ (first 15 minutes)	See Table 5.2.3.1.2(b)
	Flame resistance	ASTM F1358 (Section 8.4.1)	Afterflame time ≤2 seconds No melting	
	Cut resistance	ASTM F1790 (Section 8.5.7)	Blade travel distance ≥20 mm at 150 grams (0.8 in. at 5.29 oz)	
	Puncture resistance	Method A of ASTM F1342/F1342M (Section 8.5.8.1)	Puncture force ≥22 N (5 lbf)	
	Cold temperature bending	ASTM D747	Bend moment ≤0.057 N·m (0.5 in.-lb)	
Footwear	Impact, compression, and sole puncture resistance	ASTM F2412	Footwear meets ASTM F2413 criteria	
Footwear upper material	Chemical permeation resistance	ASTM F739 (Section 8.3.1.1)	Cumulative permeation ≤6.0 $\mu g/m^2$ (1 hour); ≤2.0 $\mu g/m^2$ (first 15 minutes)	See Table 5.2.3.1.2(b)
	Sulfur mustard (HD) permeation resistance	Section 8.3.1.2	Cumulative permeation ≤4.0 $\mu g/m^2$ (1 hour); ≤1.33 $\mu g/m^2$ (first 15 minutes)	See Table 5.2.3.1.2(b)
	Soman (GD) permeation resistance	Section 8.3.1.2	Cumulative permeation ≤1.25 $\mu g/m^2$ (1 hour); ≤0.43 $\mu g/m^2$ (first 15 minutes)	See Table 5.2.3.1.2(b)
	Flame resistance	ASTM F1358 (Section 8.4.1)	Afterflame time ≤2 seconds No melting and dripping	
	Cut resistance	ASTM F1790 (Section 8.5.7)	Blade travel distance ≥20 mm at 350 grams (0.8 in. at 12.35 oz)	
	Puncture resistance	Method A of ASTM F1342/F1342M (Section 8.5.8.1)	Puncture force ≥36 N (8.0 lbf)	
Footwear soles and heels	Abrasion resistance	Method A of ISO 4649 (Section 8.5.9.2)	Relative volume loss ≤250 mm^3	
	Slip resistance	ASTM F2913 (Section 8.6.7)	Coefficient ≥0.40	
Optional Flash Fire Protection Requirements				
Ensemble	Overall flash fire protection	ASTM F1930 (Section 8.4.4)	Afterflame time ≤5 seconds Test subject has visual acuity of 20/100 or better through facepiece lens and visor Break-open of material or seam ≤51 mm (2.0 in.) No evidence of dripping	

(continues)

Table 5.2.3.1.2(a) *Continued*

Ensemble or Ensemble Element	Performance Requirement	Test Method	Requirement	Result
			Percent second-degree and third-degree body burn area (optional reporting)	
Garment material	Heat transfer performance	ASTM F2700 (Section 8.4.2)	HTP rating ≥8 cal/cm^2	
	Flame resistance	ASTM F1358 (Section 8.4.1)	Afterflame time ≤2 seconds Burn distance ≤100 mm (4.0 in.) No melting and dripping	
Visor material	Heat transfer performance	ASTM F2700 (Section 8.4.2)	HTP rating ≥8 cal/cm^2	
	Flame resistance	ASTM F1358 (Section 8.4.1)	Afterflame time ≤2 seconds Burn distance ≤100 mm (4.0 in.) No melting and dripping	
Glove material	Heat transfer performance	ASTM F2700 (Section 8.4.2)	HTP rating ≥8 cal/cm^2	
	Flame resistance	ASTM F1358 (Section 8.4.1)	Afterflame time ≤2 seconds Burn distance ≤100 mm (4.0 in.) No melting and dripping	
Footwear material	Heat transfer performance	ASTM F2700 (Section 8.4.2)	HTP rating ≥12 cal/cm^2	
	Flame resistance	ASTM F1358 (Section 8.4.1)	Afterflame time ≤2 seconds Burn distance ≤100 mm (4.0 in.)	
Elastomeric interface material	Flame resistance	ASTM F1358 (Section 8.4.1)	Afterflame time ≤2 seconds Burn distance ≤100 mm (4.0 in.)	
Optional Liquefied Gas Protection Requirements				
Garment material	Liquefied gas permeation resistance	ASTM F739 (Section 8.3.1.1)		See Table 5.2.3.1.2(b)
Visor material	Liquefied gas permeation resistance	ASTM F739 (Section 8.3.1.1)		See Table 5.2.3.1.2(b)
Glove material	Liquefied gas permeation resistance	ASTM F739 (Section 8.3.1.1)		See Table 5.2.3.1.2(b)
Footwear material	Liquefied gas permeation resistance	ASTM F739 (Section 8.3.1.1)		See Table 5.2.3.1.2(b)
Optional Stealth Performance				
Ensemble	Acoustic signature	Section 8.7.2	Report only (dBA)	
Each ensemble material	Color/visibility	Section 8.7.1	Y Brightness <25 L* value <55	

Table 5.2.3.1.2(b) Format for Reporting NFPA 1991-Specific Certification Permeation Test Data in Technical Data Package

Material or Seam Tested	[insert material or seam description][a]	
	Cumulative Permeation ($\mu g/cm^2$) Over Test Period Interval	
Test Period Interval	0–15 min	0–1 hour
Base Chemicals	≤2.0	≤6.0
Acetone		
Acetonitrile		
Acrolein		
Acrylonitrile		
Anhydrous ammonia (gas)		
1,3-Butadiene (gas)		
Carbon disulfide		
Chlorine (gas)		
Dichloromethane		
Diethylamine		
Dimethylformamide		
Dimethyl sulfate		
Ethyl acetate		
Ethylene oxide (gas)		
Hexane		
Hydrogen chloride (gas)		
Methanol		
Methyl chloride (gas)		
Nitrobenzene		
Sodium hydroxide, 50% w/w		
Sulfuric acid, 96.1% w/w		
Tetrachloroethylene		
Tetrahydrofuran		
Blister Agent Requirements	≤1.33	≤4.00
Distilled Mustard		
Nerve Agent Requirements	≤0.40	≤1.25
Soman		
Optional Liquefied Gases[b]	≤6.0	
Ammonia (liquefied)		
Chlorine (liquefied)		
Ethylene oxide (liquefied)		

[a]Repeat the Result column for each material and seam tested.
[b]Liquefied chemical gases are only evaluated over a 15-minute exposure period.

5.2.3.2.3 All descriptions of material composition shall specify either the generic material names or, if the composition of the material is proprietary, the trade names.

5.2.3.2.4 Where applicable, the descriptions of respective vapor-protective ensemble materials, ensemble element materials, and component part materials shall include the following information:

(1) Visor material information (e.g., the availability of any permanent detachable covers and films)
(2) Glove information, as follows:
    (a) Type of linings or surface treatments
    (b) Available glove sizes and sizing information
(3) Footwear information, as follows:
    (a) Type of linings or surface treatments
    (b) Type of soles or special toe reinforcements
    (c) Available footwear sizes
(4) Garment zipper or closure information, as follows:
    (a) Material(s) of construction for the closure (including chain, slide, pull, and tape for zippers)
    (b) Location and the length of the completed closure assembly
    (c) Description of any protective covers for flaps
(5) Garment exhaust valves or ports information, as follows:
    (a) Type (e.g., flapper) pressure demand
    (b) Number and method of attachment to the garment
    (c) Description of any protective covers or pockets
(6) Other clothing items (e.g., outer garments) information (e.g., the type and how used with protective garment)

5.2.3.2.5 The manufacturer shall describe, in the technical data package, the type of seams or methods of attachment for the following ensemble material and component combinations:

(1) Garment material–garment material
(2) Garment material–visor
(3) Garment material–glove
(4) Garment material–footwear
(5) Garment material–garment closure
(6) Outer cover–outer cover

5.3 NFPA 1992-Specific Requirements.

5.3.1 NFPA 1992-Specific Labeling Requirements.

5.3.1.1 NFPA 1992-Specific Ensembles and Clothing Compliance Statements.

5.3.1.1.1 Each liquid splash-protective garment element shall have at least the following compliance statements and information on the product label:

THIS LIQUID SPLASH-PROTECTIVE GARMENT MEETS THE BASIC REQUIREMENTS OF NFPA 1992, INCORPORATED IN THE 2022 EDITION OF NFPA 1990, AND THE ADDITIONAL REQUIREMENTS INDICATED BELOW.

THE TECHNICAL DATA PACKAGE CONTAINS INFORMATION ON CHEMICALS AND SPECIFIC CHEMICAL MIXTURES FOR WHICH THIS GARMENT IS CERTIFIED. CONSULT THE TECHNICAL DATA PACKAGE AND MANUFACTURER'S INSTRUCTIONS BEFORE USE.
DO NOT REMOVE THIS LABEL.

ADDITIONAL REQUIREMENTS	YES	NO
LIMITED FLASH FIRE PROTECTION FOR ESCAPE ONLY IN THE EVENT OF A FLASH FIRE		
CLAIM OF OPTIONAL BREATHABILITY FOR GARMENT MATERIALS		

5.3.1.1.1.1 Where the garment provides the optional limited flash fire protection above the basic requirements of this standard, the YES box shall be marked.

5.3.1.1.1.2 Where the garment does not provide the optional limited flash fire protection above the basic requirements of this standard, the NO box shall be marked.

5.3.1.1.1.3 Where the garment is represented as providing the optional breathability above the basic requirements of this standard, the YES box shall be marked.

5.3.1.1.1.4 Where the garment is not represented as providing the optional breathability above the basic requirements of this standard, the NO box shall be marked.

5.3.1.1.2 For garments where the integrity of the interfaces between the respirator and hood or garment, between the gloves and garment sleeves, and between the footwear and garment legs has not been evaluated as specified in 7.1.1.1.2, the following warning shall be provided on the product label:

WARNING — THE INTEGRITY OF THE FOLLOWING INTERFACES OF THIS GARMENT WITH THE RESPIRATOR, GLOVES, AND FOOTWEAR HAS NOT BEEN EVALUATED ACCORDING TO THE REQUIREMENTS OF NFPA 1992. USE OF THIS GARMENT IN A LIQUID EXPOSURE ENVIRONMENT MIGHT RESULT IN LIQUID PENETRATION THROUGH THESE INTERFACES.

5.3.1.2 NFPA 1992-Specific Glove Element Compliance Statements.

5.3.1.2.1 Each liquid splash-protective glove element shall have at least the following compliance statements and information on the product label:

THIS LIQUID SPLASH-PROTECTIVE GLOVE MEETS THE BASIC REQUIREMENTS OF NFPA 1992, INCORPORATED IN THE 2022 EDITION OF NFPA 1990, AND THE ADDITIONAL REQUIREMENT INDICATED BELOW.

THE TECHNICAL DATA PACKAGE CONTAINS INFORMATION ON CHEMICALS AND SPECIFIC CHEMICAL MIXTURES FOR WHICH THIS GLOVE IS CERTIFIED. CONSULT THE TECHNICAL DATA PACKAGE AND MANUFACTURER'S INSTRUCTIONS BEFORE USE. DO NOT REMOVE THIS LABEL.

ADDITIONAL REQUIREMENT	YES	NO
LIMITED FLASH FIRE PROTECTION FOR ESCAPE ONLY IN THE EVENT OF A FLASH FIRE		

5.3.1.2.1.1 Where the glove provides the optional limited flash fire protection above the basic requirements of this standard, the YES box shall be marked.

5.3.1.2.1.2 Where the glove does not provide the optional limited flash fire protection above the basic requirements of this standard, the NO box shall be marked.

5.3.1.2.2 Each liquid splash-protective glove shall be permitted to have the labeling information specified in 5.3.1.2.1 placed on the package label. If applicable, the statement in either 5.3.1.2.2.1 or 5.3.1.2.2.2 shall be directly printed, embossed, or attached to each glove in lettering at least 1.6 mm ($\frac{1}{16}$ in.) high.

5.3.1.2.2.1 Where the glove is not compliant with the optional limited flash fire protection above the basic requirements of this standard, the following statement shall be used:

MEETS NFPA 1992 (INCORPORATED IN THE 2022 EDITION OF NFPA 1990)

5.3.1.2.2.2 Where the glove is compliant with the optional limited flash fire protection above the basic requirements of this standard, the following statement shall be used:

MEETS FLASH FIRE ESCAPE PROTECTION REQUIREMENTS OF NFPA 1992 (INCORPORATED IN THE 2022 EDITION OF NFPA 1990)

5.3.1.3 NFPA 1992-Specific Footwear Element Compliance Statements.

5.3.1.3.1 Each liquid splash-protective footwear piece shall have at least the following compliance statements and information on the product label:

THIS LIQUID SPLASH-PROTECTIVE FOOTWEAR MEETS THE BASIC REQUIREMENTS OF NFPA 1992, INCORPORATED IN THE 2022 EDITION OF NFPA 1990, AND THE ADDITIONAL REQUIREMENT INDICATED BELOW.

THE TECHNICAL DATA PACKAGE CONTAINS INFORMATION ON CHEMICALS AND SPECIFIC CHEMICAL MIXTURES FOR WHICH THIS FOOTWEAR IS CERTIFIED. CONSULT TECHNICAL DATA PACKAGE AND MANUFACTURER'S INSTRUCTIONS BEFORE USE. DO NOT REMOVE THIS LABEL.

ADDITIONAL REQUIREMENT	YES	NO
LIMITED FLASH FIRE PROTECTION FOR ESCAPE ONLY IN THE EVENT OF A FLASH FIRE		

5.3.1.3.1.1 Where the footwear provides the optional limited flash fire protection above the basic requirements of this standard, the YES box shall be marked.

5.3.1.3.1.2 Where the footwear does not provide the optional limited flash fire protection above the basic requirements of this standard, the NO box shall be marked.

5.3.1.4 NFPA 1992-Specific Hood Element Compliance Statements.

5.3.1.4.1 Each liquid splash-protective hood shall have at least the following compliance statements and information on the product label:

THIS LIQUID SPLASH-PROTECTIVE HOOD MEETS THE BASIC REQUIREMENTS OF NFPA 1992, INCORPORATED IN THE 2022 EDITION OF NFPA 1990, AND THE ADDITIONAL REQUIREMENTS INDICATED BELOW.

THE TECHNICAL DATA PACKAGE CONTAINS INFORMATION ON CHEMICALS AND SPECIFIC CHEMICAL MIXTURES FOR WHICH THIS HOOD IS CERTIFIED. CONSULT THE TECHNICAL DATA PACKAGE AND MANUFACTURER'S INSTRUCTIONS BEFORE USE. DO NOT REMOVE THIS LABEL.

ADDITIONAL REQUIREMENTS	YES	NO
LIMITED FLASH FIRE PROTECTION FOR ESCAPE ONLY IN THE EVENT OF A FLASH FIRE		
CLAIM OF OPTIONAL BREATHABILITY FOR GARMENT MATERIALS		

5.3.1.4.1.1 Where the hood provides the optional limited flash fire protection above the basic requirements of this standard, the YES box shall be marked.

5.3.1.4.1.2 Where the hood does not provide the optional limited flash fire protection above the basic requirements of this standard, the NO box shall be marked.

5.3.1.4.1.3 Where the hood is represented as providing the optional breathability above the basic requirements of this standard, the YES box shall be marked.

5.3.1.4.1.4 Where the hood is not represented as providing the optional breathability above the basic requirements of this standard, the NO box shall be marked.

5.3.1.5 NFPA 1992-Specific Nonencapsulating Ensemble Compliance Statements.

5.3.1.5.1 Each nonencapsulating liquid splash-protective ensemble shall have at least the following compliance statements and information on the product label:

THIS NONENCAPSULATING LIQUID SPLASH-PROTECTIVE ENSEMBLE MEETS THE BASIC REQUIREMENTS OF NFPA 1992, INCORPORATED IN THE 2022 EDITION OF NFPA 1990, AND THE ADDITIONAL REQUIREMENTS INDICATED BELOW.

THE TECHNICAL DATA PACKAGE CONTAINS INFORMATION ON CHEMICALS AND SPECIFIC CHEMICAL MIXTURES FOR WHICH THIS NONENCAPSULATING ENSEMBLE IS CERTIFIED. CONSULT THE TECHNICAL DATA PACKAGE AND MANUFACTURER'S INSTRUCTIONS BEFORE USE.
DO NOT REMOVE THIS LABEL.

ADDITIONAL REQUIREMENTS	YES	NO
LIMITED FLASH FIRE PROTECTION FOR ESCAPE ONLY IN THE EVENT OF A FLASH FIRE		
CLAIM OF OPTIONAL BREATHABILITY FOR GARMENT MATERIALS		

5.3.1.5.1.1 Where the nonencapsulating ensemble provides the optional limited flash fire protection above the basic requirements of this standard, the YES box shall be marked.

5.3.1.5.1.2 Where the nonencapsulating ensemble does not provide the optional limited flash fire protection above the basic requirements of this standard, the NO box shall be marked.

5.3.1.5.1.3 Where the garment element of the ensemble is represented as providing optional breathability above the basic requirements of this standard, the YES box shall be marked.

5.3.1.5.1.4 Where the garment element of the ensemble is not represented as providing optional breathability above the basic requirements of this standard, the NO box shall be marked.

5.3.1.5.1.5 Where the manufacturer specifies outer boot footwear element options as permitted in 7.3.5, the following additional language shall be provided as part of the product label:

OUTER BOOT FOOTWEAR OPTIONS WORN WITH THIS ENSEMBLE MUST MEASURE AT LEAST 140 mm (5.5 in.) HIGH AND BE CERTIFIED TO NFPA 1951, NFPA 1971, NFPA 1991, NFPA 1992, NFPA 1994, OR NFPA 1999.

5.3.1.6 NFPA 1992-Specific Encapsulating Ensemble Compliance Statements.

5.3.1.6.1 Each encapsulating liquid splash-protective ensemble shall have at least the following compliance statements and information on the product label:

THIS ENCAPSULATING LIQUID SPLASH-PROTECTIVE ENSEMBLE MEETS THE BASIC REQUIREMENTS OF NFPA 1992, INCORPORATED IN THE 2022 EDITION OF NFPA 1990, AND THE ADDITIONAL REQUIREMENTS INDICATED BELOW.

THE TECHNICAL DATA PACKAGE CONTAINS INFORMATION ON CHEMICALS AND SPECIFIC CHEMICAL MIXTURES FOR WHICH THIS ENCAPSULATING ENSEMBLE IS CERTIFIED. CONSULT THE TECHNICAL DATA PACKAGE AND MANUFACTURER'S INSTRUCTIONS BEFORE USE.
DO NOT REMOVE THIS LABEL.

ADDITIONAL REQUIREMENTS	YES	NO
LIMITED FLASH FIRE PROTECTION FOR ESCAPE ONLY IN THE EVENT OF A FLASH FIRE		
CLAIM OF OPTIONAL BREATHABILITY FOR GARMENT MATERIALS		

5.3.1.6.1.1 Where the encapsulating ensemble provides the optional limited flash fire protection above the basic requirements of this standard, the YES box shall be marked.

5.3.1.6.1.2 Where the encapsulating ensemble does not provide the optional limited flash fire protection above the basic requirements of this standard, the NO box shall be marked.

5.3.1.6.1.3 Where the garment ensemble is represented as providing the optional breathability above the basic requirements of this standard, the YES box shall be marked.

5.3.1.6.1.4 Where the garment ensemble is not represented as providing the optional breathability above the basic requirements of this standard, the NO box shall be marked.

5.3.1.6.1.5 Where the manufacturer specifies outer boot footwear element options as permitted in 7.3.5, the following additional language shall be provided as part of the product label:

OUTER BOOT FOOTWEAR OPTIONS WORN WITH THIS ENSEMBLE MUST MEASURE AT LEAST 140 mm (5.5 in.) HIGH AND BE CERTIFIED TO NFPA 1951, NFPA 1971, NFPA 1991, NFPA 1992, NFPA 1994, OR NFPA 1999.

5.3.1.6.2* Where detachable components of an ensemble or ensemble element must be worn with the ensemble or ensemble element in order to be compliant with this standard or any optional requirements of this standard, at least the following statement and information shall also be printed legibly on the product label of the ensemble element that requires an additional component with all letters at least 1.6 mm (1/16 in.) high and following the product compliance statement on the label, the appropriate term inserted where indicated, and the detachable component(s) listed by type, identification and how properly worn:

"FOR COMPLIANCE WITH NFPA 1992, THE FOLLOWING ADDITIONAL COMPONENTS MUST BE WORN IN CONJUNCTION WITH THIS LIQUID SPLASH PROTECTIVE [insert the term GARMENT, GLOVE, FOOTWEAR, HOOD or ENSEMBLE here]: [list detachable components here]"

5.3.1.6.2.1 The manufacturer shall be permitted to list the detachable components in the technical data package by providing an additional statement on the label specified in 5.3.1.6.2 as follows:

SEE TECHNICAL DATA PACKAGE FOR A LIST OF DETACHABLE COMPONENTS.

5.3.1.6.2.2 Detachable components specified in 5.3.1.6.2 shall meet the label requirements specified in ASTM F1301, *Standard Practice for Labeling Chemical Protective Clothing*, and the requirements of 5.1.1.1 through 5.1.1.5.

5.3.2 NFPA 1992-Specific User Information Requirements. (Reserved)

5.3.3 NFPA 1992-Specific Technical Data Package Requirements.

5.3.3.1* The manufacturer shall furnish a technical data package for the protective ensemble, ensemble element, or clothing item upon the request of the purchaser.

5.3.3.2* The technical data package shall contain all documentation required by this standard and the values obtained from the initial certification showing compliance with the requirements of Chapter 12 in the current edition of this standard using the reporting formats provided in Table 5.3.3.2(a) and Table 5.3.3.2(b) for each ensemble, ensemble element, material, or component, as applicable.

5.3.3.2.1 The technical data package information shall indicate "Pass" for those requirements where there is no quantitative value reported and "Not applicable" for specific requirements that do not apply to the liquid splash-protective ensemble.

5.3.3.2.2 The manufacturer shall be permitted to make modifications in the tabular format to accommodate specific product features or additional materials as applicable to the certified product.

5.3.3.3 In the technical data package, the manufacturer shall describe the clothing item, ensemble element, or ensemble in terms of manufacturer trade name, model number, manufacturer replaceable components, available options, and sizes.

5.3.3.4* Descriptions of sizes shall include the range in height and weight for persons fitting each particular size (for garments), or specific sizes in accordance with Chapter 6 (for gloves and footwear), and shall provide information to the wearer as to whether these sizes apply to persons wearing SCBA, hard hats, communications devices, firefighting protective clothing, and other similar gear.

5.3.3.5 Garment Material and Component Descriptions.

5.3.3.5.1 Where specific clothing items or equipment are required for certifying the ensemble, ensemble element, or clothing item as compliant to this standard, the manufacturer shall list these clothing items or equipment in the technical data package.

5.3.3.5.2 The manufacturer shall provide, in the technical data package, the list and descriptions of the following ensemble materials and components, where applicable:

(1) Garment material
(2) Visor material
(3) Glove material and type of attachment
(4) Footwear material and type of attachment
(5) Hood material
(6) Zipper/closure type and materials
(7) Material seam types and composition
(8) Exhaust valve type(s) and material(s)
(9) External fitting type(s) and material(s)
(10) External gasket type(s) and material(s)
(11) Outer garment, glove, or boot material(s)
(12) Type or style of head protection accommodated within the garment
(13) Interface materials

5.3.3.5.3 All descriptions of material composition shall specify either the generic material names or, if the composition of the material is proprietary, trade names.

5.3.3.5.4 Where applicable, the descriptions of respective garment materials and components shall include the following information:

(1) Visor material (e.g., the availability of any permanent detachable covers and films)
(2) Glove information, as follows:
    (a) Type of linings or surface treatments
    (b) Available glove sizes
(3) Footwear information, as follows:
    (a) Type of linings or surface treatments
    (b) Type of soles or special toe reinforcements
    (c) Available footwear sizes
(4) Garment zipper or closure information, as follows:
    (a) Material(s) of construction for the closure (including chain, slide, pull, and tape for zippers)
    (b) Location and the length of the completed closure assembly
    (c) Description of any protective covers for flaps
(5) Other clothing items (e.g., outer garments) information (e.g., the type and how used with protective garment)

Table 5.3.3.2(a) Format for Reporting NFPA 1992-Specific Certification Test Data in Technical Data Package

Ensemble or Ensemble Element	Performance Requirement	Test Method	Requirement	Result
Base Requirements				
Ensemble	Liquidtight integrity	ASTM F1359/F1359M with modifications (Section 8.2.3)	No liquid penetration after 20 minutes No liquid accumulation in outer gloves No liquid accumulation in outer boots No liquid inside ensemble next to exhaust valves	
	Overall function and integrity	ASTM F1154 (Section 8.6.1)	No liquid penetration after 20 minutes Complete all tasks within 15 minutes Accommodates head protection devices meeting ANSI/ISEA Z89.1 (Type 1, Class G) Test subject has visual acuity of 20/35 or better through visor and facepiece lens Test subject properly identifies three out of four numbers on NFPA 704 placard at each angle Time to remove hands from and reinsert hands in gloves 5 times ≤2.5 minutes Garment closures remain engaged Protective flap stays remain closed	
	Airflow capacity	Section 8.6.2	Internal garment pressure ≤150 mm (6 in.) water gauge Ending garment pressure ≥80 mm (3 5/32 in.) water gauge	
Exhaust valve	Mounting strength	Section 8.5.4	Strength >135 N (30 lbf)	
External fitting	Installation effect on integrity	ASTM F1052 (Section 8.2.1)	No liquid penetration in 20 minutes in liquid integrity test	
	Pull-out strength (tethered applications)	Section 8.5.5	Strength >1000 N (225 lbf)	
	Pull-out strength (non-tethered applications)	Section 8.5.5	Strength >1000 N (225 lbf)	
Garment (or hood or sock) material	Chemical penetration resistance	ASTM F903 (Section 8.3.2)	No penetration for at least 1 hour for each of the specified chemicals	See Table 5.3.3.2(b)
	Burst strength	ASTM D751 (Section 8.5.1)	Strength ≥135 N (30 lbf)	
	Puncture propagation tear resistance	ASTM D2582 (Section 8.5.2)	Tear resistance ≥25 N (5.6 lbf)	
	Cold temperature bending	ASTM D747 (Section 8.5.11.1)	Bending moment ≤0.057 N·m (0.5 in.-lb)	
Garment (or hood) visor	Chemical penetration resistance	ASTM F903 (Section 8.3.2)	No penetration for at least 1 hour for each of the specified chemicals	See Table 5.3.3.2(b)
	Visor high-mass impact resistance	Section 8.5.10	No full-thickness cracks, holes, or fractures	

(continues)

Table 5.3.3.2(a) *Continued*

Ensemble or Ensemble Element	Performance Requirement	Test Method	Requirement	Result
Garment (or hood) seam	Cold temperature bending	Section 8.5.11.2	No cracking or evidence of visual damage	
	Chemical penetration resistance test	ASTM F903 (Section 8.3.2)	No penetration for at least 1 hour for each of the specified chemicals	See Table 5.3.3.2(b)
	Seam strength	ASTM D751 (Section 8.5.3)	Strength ≥33 N/25 mm (7.6 in.·lbf)	
Garment (or hood) closure	Closure strength	ASTM D751 (Section 9.5.3)	Strength ≥33 N/25 mm (7.5 in.·lbf)	
Elastomeric interface material	Chemical penetration resistance	ASTM F903 (Section 8.3.2)	No penetration for at least 1 hour for each of the specified chemicals	See Table 5.3.3.2(b)
	Elongation	Method A of ASTM D412 (Section 8.5.6)	Elongation at rupture ≥125 percent	
	Cut resistance	ASTM F1790 (Section 8.5.7)	Blade travel distance ≥20 mm at 50 g (0.8 in. at 1.76 oz)	
	Puncture resistance	Method A of ASTM F1342/F1342M (Section 8.5.8.1)	Puncture force ≥7 N (1.6 lbf)	
	Ultimate tensile strength	ASTM D412 (Section 8.5.6)	Strength ≥4 MPa (580 psi)	
Gloves	Liquidtight integrity	ASTM D5151 with modifications (Section 8.2.3.2)	No leakage	
	Dexterity	ASTM F2010/F2010M (Section 8.6.5)	Percent increase over barehanded control ≤200 percent	
Glove material	Chemical penetration resistance	ASTM F903 (Section 8.3.2)	No penetration for at least 1 hour for each of the specified chemicals	See Table 5.3.3.2(b)
	Cut resistance	ASTM F1790 (Section 8.5.7)	Blade travel distance ≥20 mm at 50 g (0.8 in. at 1.76 oz)	
	Puncture resistance	Method A of ASTM F1342/F1342M (Section 8.5.8.1)	Puncture force ≥9 N (2 lbf)	
	Cold temperature bending	ASTM D747 (Section 8.5.11.1)	Bending moment ≤0.057 N·m (0.5 in.-lb)	
Glove material seams	Chemical penetration resistance	ASTM F903 (Section 8.3.2)	No penetration for at least 1 hour for each of the specified chemicals	See Table 5.3.3.2(b)
Full footwear	Liquidtight integrity	Section 8.2.3.3	No leakage	
	Toe impact and compression resistance; sole puncture resistance	ASTM F2412	Footwear meets ASTM F2413 criteria	
Full footwear upper materials	Chemical penetration resistance	ASTM F903 (Section 8.3.2)	No penetration for at least 1 hour for each of the specified chemicals	See Table 5.3.3.2(b)
	Cut resistance	ASTM F1790 (Section 8.5.7)	Blade travel distance ≥20 mm at 350 g (0.8 in. at 12.35 oz)	
	Puncture resistance	Method A of ASTM F1342/F1342M	Puncture force ≥36 N (8.0 lbf)	
Full footwear upper material seams	Chemical penetration resistance	ASTM F903 (Section 8.3.2)	No penetration for at least 1 hour for each of the specified chemicals	See Table 5.3.3.2(b)

(continues)

Table 5.3.3.2(a) *Continued*

Ensemble or Ensemble Element	Performance Requirement	Test Method	Requirement	Result
Full footwear sole and heels	Abrasion resistance	Method A of ISO 4649 (Section 8.14)	Relative volume loss ≤250 mm^3	
	Slip resistance	ASTM F2913 (Section 8.6.7)	Coefficient ≥0.40	
Outer boot	Liquidtight integrity	Section 8.2.3.3	No leakage	
	Toe impact and compression resistance; sole puncture resistance	ASTM F2412	Footwear meets ASTM F2413 criteria	
Outer boot upper material	Cut resistance	ASTM F1790 (Section 8.5.7)	Blade travel distance ≥20 mm at 350 g (0.8 in. at 12.35 oz)	
	Puncture resistance	Method A of ASTM F1342/ F1342M	Puncture force ≥36 N (8.0 lbf)	
Outer boot sole and heels	Abrasion resistance	Method A of ISO 4649 (Section 8.14)	Relative volume loss ≤250 mm^3	
	Slip resistance	ASTM F2913 (Section 8.6.7)	Coefficient ≥0.40	
Footwear cover	Liquid integrity	ASTM D5151 with modifications (Section 8.2.3.2)	No leakage	
Footwear cover upper material	Cut resistance	ASTM F1790 (Section 8.5.7)	Blade travel distance ≥20 mm at 150 g (0.8 in. at 5.29 oz)	
	Puncture resistance	Method A of ASTM F1342/ F1342M	Puncture force ≥15 N (3.8 lbf)	
	Cold temperature bending	ASTM D747 (Section 8.5.11.1)	Bending moment ≤0.057 N·m (0.5 in.-lb)	
Footwear cover wear surface	Abrasion resistance	ASTM D3884 (Section 8.5.9.2)	Wear-through ≥3000 cycles	
	Slip resistance	ASTM F2913 (Section 8.6.7)	Coefficient ≥0.40	
Optional Flash Fire Protection Requirements				
Ensemble	Overall flash protection	ASTM F1930 (Section 8.4.4)	Afterflame times ≤2 seconds Test subject has visual acuity of 20/35 or better through visor and facepiece lens Break-open of material or seam ≤51 mm (2.0 in.) No evidence of dripping Percent second-degree and third-degree body burn area (optional reporting)	
Garment material	Heat transfer performance	ASTM F2700 (Section 8.4.2)	HTP rating ≥8 cal/ cm^2(29.5 Btu/ft^2)	
	Flame resistance	ASTM F1358 (Section 8.4.1)	Afterflame time ≤2 seconds Burn distance ≤100 mm (4.0 in.) No melting or dripping	
Visor material	Heat transfer performance	ASTM F2700 (Section 8.4.2)	Average HTP rating ≥8 cal/cm^2 (29.5 Btu/ft^2)	
	Flame resistance	ASTM F1358 (Section 8.4.1)	Afterflame time ≤2 seconds Burn distance ≤100 mm (4.0 in.) No melting or dripping	
Glove material	Heat transfer performance	ASTM F2700 (Section 8.4.2)	Average HTP rating ≥8 cal/cm^2 (29.5 Btu/ft^2)	

(continues)

Table 5.3.3.2(a) *Continued*

Ensemble or Ensemble Element	Performance Requirement	Test Method	Requirement	Result
	Flame resistance	ASTM F1358 (Section 8.4.1)	Afterflame time ≤2 seconds Burn distance ≤100 mm (4.0 in.) No melting or dripping	
Footwear material	Heat transfer performance	ASTM F2700 (Section 8.4.2)	Average HTP rating ≥8 cal/cm^2 (29.5 Btu/ft^2)	
	Flame resistance	ASTM F1358 (Section 8.4.1)	Afterflame time ≤2 seconds Burn distance ≤100 mm (4.0 in.) No melting or dripping	
Elastomeric Interface Materials	Flame resistance	ASTM F1358 (Section 8.4.1)	Afterflame time ≤2 seconds Burn distance ≤100 mm (4.0 in.) No melting or dripping	
Optional Stealth Performance				
Ensemble	Acoustic signature	Section 8.7.2	Report only (dBA)	
Each ensemble material	Color/visibility	Section 8.7.1	Y Brightness <25 L* value <55	
Optional Breathability Claim				
Garment (or hood) material	Total heat loss	Method C of ASTM F1868 (Section 8.6.4.1)	Total heat loss ≥200 W/m^2 (if breathability is claimed) Apparent intrinsic evaporative resistance (report only) Intrinsic thermal resistance (report only)	
	Evaporative resistance	Method B of ASTM F1868 (Section 8.6.4.2)	Evaporative resistance ≤30 Pa·m^2/W (if breathability is claimed)	

5.3.3.5.5 The manufacturer shall describe, in the technical data package, the type of seams or methods of attachment for the following garment material and component combinations, if applicable:

(1) Garment material–garment material
(2) Garment material–visor
(3) Garment material–glove
(4) Garment material–footwear
(5) Garment material–garment closure
(6) Outer cover–outer cover
(7) Hood material–visor material
(8) Hood material–hood material
(9) Hood material–garment materials
(10) Sock material–garment material (if the sock material is different from the garment material)

5.4 NFPA 1994-Specific Requirements.

5.4.1 NFPA 1994-Specific Labeling Requirements.

5.4.1.1 NFPA 1994-Specific Ensemble Compliance Statements.

5.4.1.1.1 Each protective ensemble shall have at least the following compliance statement on the product label and the appropriate number for the class of the ensemble, and the appropriate term for the type of ensemble inserted where indicated:

THIS CLASS [insert 1, 2, 2R, 3, 3R, 4, 4R, or 5 here] [insert ENCAPSULATING or NONENCAPSULATING here] HAZARDOUS MATERIALS AND CBRN PROTECTIVE ENSEMBLE MEETS THE REQUIREMENTS OF NFPA 1994, INCORPORATED IN THE 2022 EDITION OF NFPA 1990, FOR THE ABOVE NOTED CLASS.

THE TECHNICAL DATA PACKAGE CONTAINS INFORMATION ON HAZARDOUS MATERIALS AND CBRN AGENTS FOR WHICH THIS ENSEMBLE IS CERTIFIED. CONSULT THE TECHNICAL DATA PACKAGE AND MANUFACTURER'S INSTRUCTIONS BEFORE USE.
DO NOT REMOVE THIS LABEL.

5.4.1.1.2 Where the manufacturer specifies outer footwear element options as permitted in 7.4.10, the following additional language shall be provided as part of the product label:

OUTER BOOT FOOTWEAR OPTIONS WORN WITH THIS ENSEMBLE MUST MEASURE AT LEAST 140 mm (5.5 in.) HIGH AND BE CERTIFIED TO NFPA 1951, NFPA 1971, NFPA 1991, NFPA 1992, NFPA 1994, or NFPA 1999.

Table 5.3.3.2(b) Format for Reporting NFPA 1992-Specific Certification Penetration Test Data in Technical Data Package

Chemical (concentration)	Minimum Requirement*	Garment Material	Garment Visor	Garment Seam	Interface Material	Glove Material	Footwear Upper Material	Hood Material
Butyl acetate, CAS No. 123-86-4, >95%	Pass			NR				
Dimethylformamide, CAS No. 68-12-2, >95%	Pass			NR				
Fuel H (42.5% toluene, 42.5% isooctane, 15% ethanol mixture, v/v)	Pass							
Isopropyl alcohol, CAS No. 67-63-0, >91%	Pass			NR				
Methyl isobutyl ketone, CAS No. 108-10-1, >95%	Pass							
Nitrobenzene, CAS No. 98-95-3, >95%	Pass			NR				
Sodium hydroxide, CAS No. 1310-73-2, 50%	Pass			NR				
Sodium hypochlorite, 10%	Pass			NR				
Sulfuric acid, CAS No. 7664-93-9, 93.1%	Pass							
Tetrachloroethylene, CAS No. 127-18-4, >95%	Pass			NR				

NR: Indicates no requirement for testing.
*A pass result indicates no liquid penetration through the tested specimens after a 1-hour exposure with 1 minute of the exposure at 7.8 kPa (2.0 psi) hydrostatic pressure.

5.4.1.1.3 Class 5 garments shall include the following language as part of the product label:

NOT FOR STRUCTURAL FIREFIGHTING.

5.4.1.1.4 Class 5 garments with detachable liners shall include the following language as part of the product label of the outer shell:

THIS PRODUCT IS NOT COMPLIANT WITH THE NFPA 1994 CLASS 5 REQUIREMENTS UNLESS THE LINER IS PROPERLY DEPLOYED.

5.4.1.2 NFPA 1994-Specific Glove, Footwear, and Hood Element Compliance Statements.

5.4.1.2.1 Each glove, footwear, and hood element shall have at least the following compliance statement on the product label and the appropriate number for the class of the ensemble and the appropriate term for the type of element inserted where indicated:

THIS CLASS [insert 1, 2, 2R, 3, 3R, 4, 4R, or 5 here] HAZARDOUS MATERIALS AND CBRN PROTECTIVE [insert the element name GLOVE, FOOTWEAR, or HOOD here] ELEMENT MEETS THE REQUIREMENTS OF NFPA 1994, INCORPORATED IN THE 2022 EDITION OF NFPA 1990, FOR THE ABOVE NOTED CLASS.

THE TECHNICAL DATA PACKAGE CONTAINS INFORMATION ON HAZARDOUS MATERIALS AND CBRN AGENTS FOR WHICH THIS [insert the element name GLOVE, FOOTWEAR, or HOOD here] ELEMENT IS CERTIFIED. CONSULT THE TECHNICAL DATA PACKAGE AND MANUFACTURER'S INSTRUCTIONS BEFORE USE.
DO NOT REMOVE THIS LABEL.

5.4.1.2.2 Where footwear is designed and configured in accordance with 6.1.5.3, the sock, the outer boot, and the integrity cover shall have at least the following compliance statement on each component, and all letters shall be at least 2.5 mm (3/32 in.) high:

THIS [insert component name SOCK, OUTER BOOT, or INTEGRITY COVER], WHEN WORN WITH [insert other two components], MEETS THE HAZARDOUS MATERIALS AND CBRN FOOTWEAR REQUIREMENTS OF CLASS [insert 1, 2, 2R, 3, 3R, 4, 4R, or 5 here] of NFPA 1994, INCORPORATED IN THE 2022 EDITION OF NFPA 1990, FOR THE ABOVE NOTED CLASS.
DO NOT REMOVE THIS LABEL.

5.4.1.3 NFPA 1994-Specific Ensemble Optional Compliance Statements.

5.4.1.3.1 Where a protective ensemble meets the additional optional requirements for flash fire protection, the protective ensemble shall have the following additional compliance statement as part of the product label, and all letters shall be at least 2.5 mm (3⁄32 in.) high:

THIS ENSEMBLE HAS BEEN CERTIFIED FOR LIMITED FLASH FIRE PROTECTION ESCAPE ONLY IN THE EVENT OF A FLASH FIRE.
DO NOT REMOVE THIS LABEL.

5.4.1.3.2 Where the protective ensemble has also been evaluated to the optional stealth requirements, the protective ensemble shall have the following additional statement as part of the product label, and all letters shall be at least 2.5 mm (3⁄32 in.) high:

THIS ENSEMBLE HAS BEEN EVALUATED TO THE OPTIONAL STEALTH REQUIREMENTS OF THIS STANDARD. REFER TO THE TECHNICAL DATA PACKAGE FOR SPECIFIC INFORMATION.
DO NOT REMOVE THIS LABEL.

5.4.1.4* Where detachable components of an ensemble or ensemble element must be worn with the ensemble or ensemble element in order to be compliant with this standard or any optional requirements of this standard, at least the following statement and information shall also be printed legibly on the product label of the ensemble element that requires an additional component with all letters at least 1.6 mm (1⁄16 in.) high and following the product compliance statement on the label, the appropriate term inserted where indicated, and the detachable component(s) listed by type, identification, and how properly worn:

FOR COMPLIANCE WITH NFPA 1994, THE FOLLOWING ADDITIONAL COMPONENTS MUST BE WORN IN CONJUNCTION WITH THIS HAZARDOUS MATERIALS AND CBRN PROTECTIVE [insert the term ENSEMBLE or ENSEMBLE ELEMENT here]:

[list detachable components here]

5.4.1.4.1 The manufacturer shall be permitted to list the detachable components in the technical data package by providing an additional statement on the label specified in 5.4.1.4 as follows:

SEE TECHNICAL DATA PACKAGE FOR A LIST OF DETACHABLE COMPONENTS.

5.4.1.4.2 Detachable components specified in 5.4.1.4 shall meet the label requirements specified in ASTM F1301, *Standard Practice for Labeling Chemical Protective Clothing*, and the requirements of 5.1.1.1 through 5.1.1.5.

5.4.2 NFPA 1994-Specific User Information Requirements. (Reserved)

5.4.3 NFPA 1994-Specific Technical Data Package Requirements.

5.4.3.1* The manufacturer shall furnish a technical data package for the hazardous materials and CBRN protective ensemble and ensemble elements upon the request of the purchaser.

5.4.3.2* The technical data package shall contain all documentation required by this standard and the values obtained from the initial certification showing compliance with the requirements of Chapter 7 in the current edition of this standard using the reporting formats provided in Table 5.4.3.2(a) and Table 5.4.3.2(b) for each ensemble, ensemble element, material, or component, as applicable.

5.4.3.2.1 The technical data package information shall indicate "Pass" for those requirements where there is no quantitative value reported and "NR (No Requirement)" for specific requirements that do not apply to the protective ensemble.

5.4.3.2.2 The manufacturer shall be permitted to make modifications in the tabular format in order to accommodate specific product features or additional materials as applicable to the certified product.

5.4.3.3* In the technical data package, the manufacturer shall describe the hazardous materials and CBRN protective ensemble and ensemble elements in terms of manufacturer trade name, model number, manufacturer replaceable components, available options, accessories, testing devices, and sizes.

5.4.3.3.1 Descriptions of size shall include the range in height and weight for persons fitting each particular size (for ensembles) or sizes in accordance with Chapter 6 (for glove, hood, and footwear elements).

5.4.3.3.2 Descriptions also shall provide information to the wearer as to whether these sizes apply to persons wearing SCBA or other respirators, hard hats, communications devices, and other similar equipment.

5.4.3.4 NFPA 1994-Specific Garment Material and Component Descriptions.

5.4.3.4.1 Where specific clothing items and equipment are required for certifying hazardous materials and CBRN protective ensembles and ensemble elements as compliant to this standard, the manufacturer shall list these clothing items and equipment in the technical data package.

5.4.3.4.2 The manufacturer shall provide, in the technical data package, the list and descriptions of the following hazardous materials and CBRN protective ensemble materials and ensemble elements, where applicable:

(1) Garment material
(2) Visor material
(3) Glove material and type of attachment
(4) Footwear material and type of attachment
(5) Hood material and type of attachment
(6) Zipper/closure type and materials
(7) Material seam types and composition
(8) Exhaust valve type(s) and material(s)
(9) External fitting type(s) and material(s)
(10) External interface type(s) and material(s)
(11) Outer garment, glove, or footwear material(s)
(12) Manufacturer and specific model of respirator(s) tested with the ensemble
(13) Type or style of head protection accommodated within the garment

5.4.3.4.3 All descriptions of material composition shall specify either the generic material names or, if the composition of the material is proprietary, trade names. For separate items or detachable components, the description shall also include the manufacturer and style or model number.

Table 5.4.3.2(a) Format for Reporting NFPA 1994-Specific Certification Test Data in Technical Data Package

Ensemble or Ensemble Element	Performance Requirement	Test Method	Class 1	Class 2/2R	Class 3/3R	Class 4/4R	Class 5	Result
Ensemble	Overall inward leakage	Section 8.2.2.2	$PPDF_{sys}$ ≥441	$PPDF_{sys}$ ≥328	$PPDF_{sys}$ ≥35			
			$PPDF_i$ (local) ≥871	$PPDF_i$ (local) ≥481	$PPDF_i$ (local) ≥80			Indicate lowest average value and its location.
	Liquidtight integrity	ASTM F1359/ F1359M (Section 8.2.3)						
F1359M (Section 8.2.3)	No liquid penetration in 20 minutes	No liquid penetration in 20 minutes	No liquid penetration in 8 minutes	No liquid penetration in 4 minutes				
			No liquid accumulation in outer gloves	No liquid accumulation in outer gloves	No liquid accumulation in outer gloves	No liquid accumulation in outer gloves		
			No liquid accumulation in outer boots	No liquid accumulation in outer boots	No liquid accumulation in outer boots	No liquid accumulation in outer boots		
			No liquid inside ensemble next to exhaust valves	No liquid inside ensemble next to exhaust valves	No liquid inside ensemble next to exhaust valves	No liquid inside ensemble next to exhaust valves		
	Particle inward leakage	Section 8.2.4				No visible particulate on test subject; OR no sample area with particulate ≥6.0 μg/cm^2		
	Overall ensemble function and integrity	ASTM F1154/ASTM F1359/F1359M (Section 8.6.1)	No liquid penetration in 20 minutes	No liquid penetration in 20 minutes	No liquid penetration in 8 minutes	No liquid penetration in 4 minutes		
			Test subject completes tasks within 20 minutes	Test subject completes tasks within 20 minutes	Test subject completes tasks within 15 minutes	Test subject completes tasks within 15 minutes		
			Accommodates head protection devices meeting ANSI/ISEA Z89.1 (Type 1, Class G)	Accommodates head protection devices meeting ANSI/ISEA Z89.1 (Type 1, Class G)	Accommodates head protection devices meeting ANSI/ISEA Z89.1 (Type 1, Class G)	Accommodates head protection devices meeting ANSI/ISEA Z89.1 (Type 1, Class G)		
			Test subject has visual acuity of 20/35 or better through facepiece lens and visor	Test subject has visual acuity of 20/35 or better through facepiece lens and visor	Test subject has visual acuity of 20/35 or better through facepiece lens and visor	Test subject has visual acuity of 20/35 or better through facepiece lens and visor		
			Test subject identifies three of four letters on test sign	Test subject identifies three of four letters on test sign	Test subject identifies three of four letters on test sign	Test subject identifies three of four letters on test sign		
			Time to remove hands from and reinsert hands in gloves 5 times ≤2.5 minutes	Time to remove hands from and reinsert hands in gloves 5 times ≤2.5 minutes	Time to remove hands from and reinsert hands in gloves 5 times ≤2.5 minutes	Time to remove hands from and reinsert hands in gloves 5 times ≤2.5 minutes		
			Garment closures remain engaged	Garment closures remain engaged	Garment closures remain engaged	Garment closures remain engaged		
			Protective flap stays remain closed	Protective flap stays remain closed	Protective flap stays remain closed	Protective flap stays remain closed		

(continues)

Table 5.4.3.2(a) *Continued*

Ensemble or Ensemble Element	Performance Requirement	Test Method	Class 1	Class 2/2R	Class 3/3R	Class 4/4R	Class 5	Result
	Airflow capacity	Section 8.6.2	Internal garment pressure ≤150 mm (6 in.) water gauge No liquid penetration in 20 minutes					
Exhaust valve	Inward leakage	Section 8.6.3	Leakage rate ≤30 mL/min (1.83 in.3/min)	Leakage rate ≤30 mL/min (1.83 in.3/min)	Leakage rate ≤30 mL/min (1.83 in.3/min)	Leakage rate ≤30 mL/min (1.83 in.3/min)		
	Mounting strength	Section 8.5.4	Strength >135 N (30 lbf)	Strength >135 N (30 lbf)	Strength >135 N (30 lbf)	Strength >135 N (30 lbf)		
External fitting	Installation effect on integrity	ASTM F1052 (Section 8.2.1)	Ending garment pressure ≥80 mm (3 5/32 in.) water gauge	No liquid penetration in 20 minutes	No liquid penetration in 8 minutes	No liquid penetration in 4 minutes		
	Pull-out strength (tethered applications)	Section 8.5.5	Strength >1000 N (225 lbf)	Strength >1000 N (225 lbf)	Strength >1000 N (225 lbf)	Strength >1000 N (225 lbf)		
	Pull-out strength (non-tethered applications)	Section 8.5.5	Strength >1000 N (225 lbf)	Strength >1000 N (225 lbf)	Strength >1000 N (225 lbf)	Strength >1000 N (225 lbf)		
Garment material	Toxic industrial chemical permeation resistance	Section 8.3.1.2	Cumulative permeation ≤6.0 $\mu g/m^2$ (1 hour); ≤2.0 $\mu g/m^2$ (first 15 minutes)	Cumulative permeation ≤6.0 $\mu g/m^2$ (1 hour); ≤2.0 $\mu g/m^2$ (first 15 minutes)	Cumulative permeation ≤6.0 $\mu g/m^2$ (1 hour); ≤2.0 $\mu g/m^2$ (first 15 minutes)			See Table 5.4.3.2(b)
	Sulfur mustard (HD) permeation resistance	Section 8.3.1.2	Cumulative permeation ≤4.0 $\mu g/m^2$ (1 hour); ≤1.33 $\mu g/m^2$ (first 15 minutes)	Cumulative permeation ≤4.0 $\mu g/m^2$ (1 hour); ≤1.33 $\mu g/m^2$ (first 15 minutes)	Cumulative permeation ≤4.0 $\mu g/m^2$ (1 hour); ≤1.33 $\mu g/m^2$ (first 15 minutes)			See Table 5.4.3.2(b)
	Soman (GD) permeation resistance	Section 8.3.1.2	Cumulative permeation ≤1.25 $\mu g/m^2$ (1 hour); ≤0.43 $\mu g/m^2$ (first 15 minutes)	Cumulative permeation ≤1.25 $\mu g/m^2$ (1 hour); ≤0.43 $\mu g/m^2$ (first 15 minutes)	Cumulative permeation ≤1.25 $\mu g/m^2$ (1 hour); ≤0.43 $\mu g/m^2$ (first 15 minutes)			See Table 5.4.3.2(b)
	Low vapor pressure chemical permeation resistance	Section 8.3.1.3	Cumulative permeation ≤6.0 $\mu g/m^2$ (1 hour)					
	Viral penetration resistance	ASTM F1671 (Section 8.3.4)		No penetration in 1 hour	No penetration in 1 hour	No penetration in 1 hour		
	Liquid repellency	ISO 6530 (Section 8.3.5)					Index of repellency ≥80 percent	
	Flame resistance	ASTM F1358 (Section 8.4.1)	Afterflame time ≤2 seconds No melting and dripping					
	Burst strength	ASTM D751 (Section 8.5.1)	Strength >200 N (45 lbf)	Strength >156 N (35 lbf) 2R: Strength >200 N (45 lbf)	Strength >145 N (25 lbf) 3R: Strength >156 N (35 lbf)	Strength >145 N (25 lbf) 4R: Strength >156 N (35 lbf)		
	Puncture propagation tear resistance	ASTM D2582 (Section 8.5.2)	Tear resistance ≥49 N (11 lbf)	Tear resistance ≥31 N (7 lbf) 2R: Tear resistance ≥49 N (11 lbf)	Tear resistance ≥25 N (5.6 lbf) 3R: Tear resistance ≥31 N (7 lbf)	Tear resistance ≥25 N (5.6 lbf) 4R: Tear resistance ≥31 N (7 lbf)		

(continues)

Table 5.4.3.2(a) *Continued*

Ensemble or Ensemble Element	Performance Requirement	Test Method	Class 1	Class 2/2R	Class 3/3R	Class 4/4R	Class 5	Result
	Cold temperature bending	ASTM D747 (Section 8.5.11.1)	Bend moment ≤0.057 N·m (0.5 in.-lb)	Bend moment ≤0.057 N·m (0.5 in.-lb)	Bend moment ≤0.057 N·m (0.5 in.-lb)	Bend moment ≤0.057 N·m (0.5 in.-lb)		
	Total heat loss	Method C of ASTM F1868 (Section 8.6.4.1)		Total heat loss ≥200 W/m^2 (if breathability is claimed)	Total heat loss ≥200 W/m^2	Total heat loss ≥450 W/m^2	Total heat loss ≥325 W/m^2	
	Evaporative resistance	Method B of ASTM F1868 (Section 8.6.4.2)		Evaporative resistance ≤30 Pa·m^2/W (if breathability is claimed)	Evaporative resistance ≤30 Pa·m^2/W	Evaporative resistance ≤30 Pa·m^2/W	Evaporative resistance ≤30 Pa·m^2/W	
Garment seam	Toxic industrial chemical permeation resistance	Section 8.3.1.2	Cumulative permeation ≤6.0 μg/m^2 (1 hour); ≤2.0 μg/m^2 (first 15 minutes)	Cumulative permeation ≤6.0 μg/m^2 (1 hour); ≤2.0 μg/m^2 (first 15 minutes)	Cumulative permeation ≤6.0 μg/m^2 (1 hour); ≤2.0 μg/m^2 (first 15 minutes)			See Table 5.4.3.2(b)
	Sulfur mustard (HD) permeation resistance	Section 8.3.1.2	Cumulative permeation ≤4.0 μg/m^2 (1 hour); ≤1.33 μg/m^2 (first 15 minutes)	Cumulative permeation ≤4.0 μg/m^2 (1 hour); ≤1.33 μg/m^2 (first 15 minutes)	Cumulative permeation ≤4.0 μg/m^2 (1 hour); ≤1.33 μg/m^2 (first 15 minutes)			See Table 5.4.3.2(b)
	Soman (GD) permeation resistance	Section 8.3.1.2	Cumulative permeation ≤1.25 μg/m^2 (1 hour); ≤0.43 μg/m^2 (first 15 minutes)	Cumulative permeation ≤1.25 μg/m^2 (1 hour); ≤0.43 μg/m^2 (first 15 minutes)	Cumulative permeation ≤1.25 μg/m^2 (1 hour); ≤0.43 μg/m^2 (first 15 minutes)			See Table 5.4.3.2(b)
	Low vapor pressure chemical permeation resistance	Section 8.3.1.3	Cumulative permeation ≤6.0 μg/m^2 (1 hour)					
	Viral penetration resistance	ASTM F1671 (Section 8.3.4)		No penetration in 1 hour	No penetration in 1 hour	No penetration in 1 hour		
	Seam strength	ASTM D751 (Section 8.5.3)	Strength >67 N/25 mm (15 in.·lbf)	Strength >34 N/25 mm (7.6 in.·lbf)	Strength >34 N/25 mm (7.6 in.·lbf)	Strength >34 N/25 mm (7.6 in.·lbf)		
Garment closure	Closure strength	ASTM D751 (Section 8.5.3)	Strength >67 N/25 mm (15 in.·lbf)	Strength >34 N/25 mm (7.6 in.·lbf)	Strength >34 N/25 mm (7.6 in.·lbf)	Strength >34 N/25 mm (7.6 in.·lbf)		
Visor material	Toxic industrial chemical permeation resistance	Section 8.3.1.2	Cumulative permeation ≤6.0 μg/m^2 (1 hour); ≤2.0 μg/m^2 (first 15 minutes)	Cumulative permeation ≤6.0 μg/m^2 (1 hour); ≤2.0 μg/m^2 (first 15 minutes)	Cumulative permeation ≤6.0 μg/m^2 (1 hour); ≤2.0 μg/m^2 (first 15 minutes)			See Table 5.4.3.2(b)
	Sulfur mustard (HD) permeation resistance	Section 8.3.1.2	Cumulative permeation ≤4.0 μg/m^2 (1 hour); ≤1.33 μg/m^2 (first 15 minutes)	Cumulative permeation ≤4.0 μg/m^2 (1 hour); ≤1.33 μg/m^2 (first 15 minutes)	Cumulative permeation ≤4.0 μg/m^2 (1 hour); ≤1.33 μg/m^2 (first 15 minutes)			See Table 5.4.3.2(b)
	Soman (GD) permeation resistance	Section 8.3.1.2	Cumulative permeation ≤1.25 μg/m^2 (1 hour); ≤0.43 μg/m^2 (first 15 minutes)	Cumulative permeation ≤1.25 μg/m^2 (1 hour); ≤0.43 μg/m^2 (first 15 minutes)	Cumulative permeation ≤1.25 μg/m^2 (1 hour); ≤0.43 μg/m^2 (first 15 minutes)			See Table 5.4.3.2(b)

(continues)

Table 5.4.3.2(a) ***Continued***

Ensemble or Ensemble Element	Performance Requirement	Test Method	Class 1	Class 2/2R	Class 3/3R	Class 4/4R	Class 5	Result
	Low vapor pressure chemical permeation resistance	Section 8.3.1.3	Cumulative permeation ≤6.0 $\mu g/m^2$ (1 hour)					
	Viral penetration resistance	ASTM F1671 (Section 8.3.4)		No penetration in 1 hour	No penetration in 1 hour	No penetration in 1 hour		
	Flame resistance	ASTM F1358 (Section 8.4.1)	Afterflame time ≤2 seconds No melting and dripping					
	Visor high-mass impact resistance	Section 8.5.10	No full-thickness cracks, holes, or fractures	No full-thickness cracks, holes, or fractures	No full-thickness cracks, holes, or fractures	No full-thickness cracks, holes, or fractures		
	Cold temperature bending	Section 8.5.11.2	No cracking or evidence of visual damage	No cracking or evidence of visual damage	No cracking or evidence of visual damage	No cracking or evidence of visual damage		
Visor seam	Toxic industrial chemical permeation resistance	Section 8.3.1.2	Cumulative permeation ≤6.0 $\mu g/m^2$ (1 hour); ≤2.0 $\mu g/m^2$ (first 15 minutes)	Cumulative permeation ≤6.0 $\mu g/m^2$ (1 hour); ≤2.0 $\mu g/m^2$ (first 15 minutes)	Cumulative permeation ≤6.0 $\mu g/m^2$ (1 hour); ≤2.0 $\mu g/m^2$ (first 15 minutes)			See Table 5.4.3.2(b)
	Sulfur mustard (HD) permeation resistance	Section 8.3.1.2	Cumulative permeation ≤4.0 $\mu g/m^2$ (1 hour); ≤1.33 $\mu g/m^2$ (first 15 minutes)	Cumulative permeation ≤4.0 $\mu g/m^2$ (1 hour); ≤1.33 $\mu g/m^2$ (first 15 minutes)	Cumulative permeation ≤4.0 $\mu g/m^2$ (1 hour); ≤1.33 $\mu g/m^2$ (first 15 minutes)			See Table 5.4.3.2(b)
	Soman (GD) permeation resistance	Section 8.3.1.2	Cumulative permeation ≤1.25 $\mu g/m^2$ (1 hour); ≤0.43 $\mu g/m^2$ (first 15 minutes)	Cumulative permeation ≤1.25 $\mu g/m^2$ (1 hour); ≤0.43 $\mu g/m^2$ (first 15 minutes)	Cumulative permeation ≤1.25 $\mu g/m^2$ (1 hour); ≤0.43 $\mu g/m^2$ (first 15 minutes)			See Table 5.4.3.2(b)
	Low vapor pressure chemical permeation resistance	Section 8.3.1.3	Cumulative permeation ≤6.0 $\mu g/m^2$ (1 hour)					
	Viral penetration resistance	ASTM F1671 (Section 8.3.4)		No penetration in 1 hour	No penetration in 1 hour	No penetration in 1 hour		
	Seam strength	ASTM D751 (Section 8.5.3)	Strength >67 N/25 mm (15 in.·lbf)	Strength >34 N/25 mm (7.6 in.·lbf)	Strength >34 N/25 mm (7.6 in.·lbf)	Strength >34 N/25 mm (7.6 in.·lbf)		
Elastomeric interface material	Toxic industrial chemical permeation resistance	Section 8.3.1.2	Cumulative permeation ≤6.0 $\mu g/m^2$ (1 hour); ≤2.0 $\mu g/m^2$ (first 15 minutes)	Cumulative permeation ≤6.0 $\mu g/m^2$ (1 hour); ≤2.0 $\mu g/m^2$ (first 15 minutes)	Cumulative permeation ≤6.0 $\mu g/m^2$ (1 hour); ≤2.0 $\mu g/m^2$ (first 15 minutes)			See Table 5.4.3.2(b)
	Sulfur mustard (HD) permeation resistance	Section 8.3.1.2	Cumulative permeation ≤4.0 $\mu g/m^2$ (1 hour); ≤1.33 $\mu g/m^2$ (first 15 minutes)	Cumulative permeation ≤4.0 $\mu g/m^2$ (1 hour); ≤1.33 $\mu g/m^2$ (first 15 minutes)	Cumulative permeation ≤4.0 $\mu g/m^2$ (1 hour); ≤1.33 $\mu g/m^2$ (first 15 minutes)			See Table 5.4.3.2(b)
	Soman (GD) permeation resistance	Section 8.3.1.2	Cumulative permeation ≤1.25 $\mu g/m^2$ (1 hour); ≤0.43 $\mu g/m^2$ (first 15 minutes)	Cumulative permeation ≤1.25 $\mu g/m^2$ (1 hour); ≤0.43 $\mu g/m^2$ (first 15 minutes)	Cumulative permeation ≤1.25 $\mu g/m^2$ (1 hour); ≤0.43 $\mu g/m^2$ (first 15 minutes)			See Table 5.4.3.2(b)

(continues)

Table 5.4.3.2(a) *Continued*

Ensemble or Ensemble Element	Performance Requirement	Test Method	Class 1	Class 2/2R	Class 3/3R	Class 4/4R	Class 5	Result
	Low vapor pressure chemical permeation resistance	Section 8.3.1.3	Cumulative permeation ≤6.0 μg/m^2 (1 hour)					
	Viral penetration resistance	ASTM F1671 (Section 8.3.4)		No penetration in 1 hour	No penetration in 1 hour	No penetration in 1 hour		
	Elongation	Method A of ASTM D412 (Section 8.5.6)	Elongation at rupture ≥125 percent	Elongation at rupture ≥125 percent	Elongation at rupture ≥125 percent	Elongation at rupture ≥125 percent		
	Cut resistance	ASTM F1790 (Section 8.5.7)	Blade travel distance ≥20 mm at 50 g (0.8 in. at 1.76 oz)	Blade travel distance ≥20 mm at 50 g (0.8 in. at 1.76 oz)	Blade travel distance ≥20 mm at 50 g (0.8 in. at 1.76 oz)	Blade travel distance ≥20 mm at 50 g (0.8 in. at 1.76 oz)		
	Puncture resistance	Method A of ASTM F1342/F1342M (Section 8.5.8.1)	Puncture force ≥22 N (5 lbf)	Puncture force ≥22 N (5 lbf)	Puncture force ≥22 N (5 lbf)	Puncture force ≥22 N (5 lbf)		
	Ultimate tensile strength	Method A of ASTM D412 (Section 8.5.6)	Strength ≥4 MPa (580 psi)	Strength ≥4 MPa (580 psi)	Strength ≥4 MPa (580 psi)	Strength ≥4 MPa (580 psi)		
	Cold temperature bending	ASTM D747 (Section 8.5.11.1)	Bend moment ≤0.057 N·m (0.5 in.-lb)	Bend moment ≤0.057 N·m (0.5 in.-lb)	Bend moment ≤0.057 N·m (0.5 in.-lb)	Bend moment ≤0.057 N·m (0.5 in.-lb)		
Gloves	Liquidtight integrity	ASTM D5151 with modifications (Section 8.2.3.2)	No leakage	No leakage	No leakage	No leakage	No leakage	
	Dexterity	ASTM F2010/ F2010M (Section 8.6.5)	Percent increase in bare-handed control ≤300 percent	Percent increase in bare-handed control ≤300 percent	Percent increase in bare-handed control ≤200 percent	Percent increase in bare-handed control ≤200 percent	Percent increase in bare-handed control ≤300 percent	
Glove material	Toxic industrial chemical permeation resistance	Section 8.3.1.2	Cumulative permeation ≤6.0 μg/m^2 (1 hour); ≤2.0 μg/m^2 (first 15 minutes)	Cumulative permeation ≤6.0 μg/m^2 (1 hour); ≤2.0 μg/m^2 (first 15 minutes)	Cumulative permeation ≤6.0 μg/m^2 (1 hour); ≤2.0 μg/m^2 (first 15 minutes)			See Table 5.4.3.2(b)
	Sulfur mustard (HD) permeation resistance	Section 8.3.1.2	Cumulative permeation ≤4.0 μg/m^2 (1 hour); ≤1.33 μg/m^2 (first 15 minutes)	Cumulative permeation ≤4.0 μg/m^2 (1 hour); ≤1.33 μg/m^2 (first 15 minutes)	Cumulative permeation ≤4.0 μg/m^2 (1 hour); ≤1.33 μg/m^2 (first 15 minutes)			See Table 5.4.3.2(b)
	Soman (GD) permeation resistance	Section 8.3.1.2	Cumulative permeation ≤1.25 μg/m^2 (1 hour); ≤0.43 μg/m^2 (first 15 minutes)	Cumulative permeation ≤1.25 μg/m^2 (1 hour); ≤0.43 μg/m^2 (first 15 minutes)	Cumulative permeation ≤1.25 μg/m^2 (1 hour); ≤0.43 μg/m^2 (first 15 minutes)			See Table 5.4.3.2(b)
	Low vapor pressure chemical permeation resistance	Section 8.3.1.3	Cumulative permeation ≤6.0 μg/m^2 (1 hour)					
	Viral penetration resistance	ASTM F1671 (Section 8.3.4)		No penetration in 1 hour	No penetration in 1 hour	No penetration in 1 hour		
	Flame resistance	ASTM F1358 (Section 8.4.1)	Afterflame time ≤2 seconds No melting					
	Cut resistance	ASTM F1790 (Section 8.5.7)	Blade travel distance ≥20 mm at 75 g (0.8 in. at 2.64 oz)	Blade travel distance ≥20 mm at 75 g (0.8 in. at 2.64 oz)	Blade travel distance ≥20 mm at 50 g (0.8 in. at 1.76 oz)	Blade travel distance ≥20 mm at 50 g (0.8 in. at 1.76 oz)	Blade travel distance ≥20 mm at 150 g (0.8 in. at 5.29 oz)	
	Puncture resistance	Method A of ASTM F1342/F1342M (Section 8.5.8.1)	Puncture force ≥15 N (3.8 lbf)	Puncture force ≥15 N (3.8 lbf)	Puncture force ≥9 N (2 lbf)	Puncture force ≥9 N (2 lbf)	Puncture force ≥22 N (5 lbf)	

(continues)

Table 5.4.3.2(a) *Continued*

Ensemble or Ensemble Element	Performance Requirement	Test Method	Class 1	Class 2/2R	Class 3/3R	Class 4/4R	Class 5	Result
	Cold temperature bending	ASTM D747	Bend moment ≤0.057 N·m (0.5 in.-lb)	Bend moment ≤0.057 N·m (0.5 in.-lb)	Bend moment ≤0.057 N·m (0.5 in.-lb)	Bend moment ≤0.057 N·m (0.5 in.-lb)	Bend moment ≤0.057 N·m (0.5 in.-lb)	
Full footwear	Liquidtight integrity	Section 8.2.3.3	No leakage	No leakage	No leakage	No leakage	No leakage	
	Impact, compression, and sole puncture resistance	ASTM F2412	Footwear meets ASTM F2413 criteria	Footwear meets ASTM F2413 criteria			Footwear meets ASTM F2413 criteria	
Full footwear upper material	Toxic industrial chemical permeation resistance	Section 8.3.1.2	Cumulative permeation ≤6.0 μg/m^2 (1 hour); ≤2.0 μg/m^2 (first 15 minutes)	Cumulative permeation ≤6.0 μg/m^2 (1 hour); ≤2.0 μg/m^2 (first 15 minutes)	Cumulative permeation ≤6.0 μg/m^2 (1 hour); ≤2.0 μg/m^2 (first 15 minutes)			See Table 5.4.3.2(b)
	Sulfur mustard (HD) permeation resistance	Section 8.3.1.2	Cumulative permeation ≤4.0 μg/m^2 (1 hour); ≤1.33 μg/m^2 (first 15 minutes)	Cumulative permeation ≤4.0 μg/m^2 (1 hour); ≤1.33 μg/m^2 (first 15 minutes)	Cumulative permeation ≤4.0 μg/m^2 (1 hour); ≤1.33 μg/m^2 (first 15 minutes)			See Table 5.4.3.2(b)
	Soman (GD) permeation resistance	Section 8.3.1.2	Cumulative permeation ≤1.25 μg/m^2 (1 hour); ≤0.43 μg/m^2 (first 15 minutes)	Cumulative permeation ≤1.25 μg/m^2 (1 hour); ≤0.43 μg/m^2 (first 15 minutes)	Cumulative permeation ≤1.25 μg/m^2 (1 hour); ≤0.43 μg/m^2 (first 15 minutes)			See Table 5.4.3.2(b)
	Low vapor pressure chemical permeation resistance	Section 8.3.1.3	Cumulative permeation ≤6.0 μg/m^2 (1 hour)					
	Viral penetration resistance	ASTM F1671 (Section 8.3.4)		No penetration in 1 hour	No penetration in 1 hour	No penetration in 1 hour		
	Flame resistance	ASTM F1358 (Section 8.4.1)	Afterflame time ≤2 seconds No melting and dripping					
	Cut resistance	ASTM F1790 (Section 8.5.7)	Blade travel distance ≥20 mm at 350 g (0.8 in. at 12.35 oz)	Blade travel distance ≥20 mm at 350 g (0.8 in. at 12.35 oz)	Blade travel distance ≥20 mm at 350 g (0.8 in. at 12.35 oz)	Blade travel distance ≥20 mm at 350 g (0.8 in. at 12.35 oz)	Blade travel distance ≥20 mm at 350 g (0.8 in. at 12.35 oz)	
	Puncture resistance	Method A of ASTM F1342/F1342M (Section 8.5.8.1)	Puncture force ≥36 N (8.0 lbf)	Puncture force ≥36 N (8.0 lbf)	Puncture force ≥36 N (8.0 lbf)	Puncture force ≥36 N (8.0 lbf)	Puncture force ≥36 N (8.0 lbf)	
Full footwear soles and heels	Abrasion resistance	Method A of ISO 4649 (Section 8.5.9.2)	Relative volume loss ≤250 mm^3	Relative volume loss ≤250 mm^3	Relative volume loss ≤250 mm^3	Relative volume loss ≤250 mm^3	Relative volume loss ≤250 mm^3	
	Slip resistance	ASTM F2913 (Section 8.6.7)	Coefficient ≥0.40	Coefficient ≥0.40	Coefficient ≥0.40	Coefficient ≥0.40	Coefficient ≥0.40	
Sock	Toxic industrial chemical permeation resistance	Section 8.3.1.2	Cumulative permeation ≤6.0 μg/m^2 (1 hour); ≤2.0 μg/m^2 (first 15 minutes)	Cumulative permeation ≤6.0 μg/m^2 (1 hour); ≤2.0 μg/m^2 (first 15 minutes)	Cumulative permeation ≤6.0 μg/m^2 (1 hour); ≤2.0 μg/m^2 (first 15 minutes)			See Table 5.4.3.2(b)
	Sulfur mustard (HD) permeation resistance	Section 8.3.1.2	Cumulative permeation ≤4.0 μg/m^2 (1 hour); ≤1.33 μg/m^2 (first 15 minutes)	Cumulative permeation ≤4.0 μg/m^2 (1 hour); ≤1.33 μg/m^2 (first 15 minutes)	Cumulative permeation ≤4.0 μg/m^2 (1 hour); ≤1.33 μg/m^2 (first 15 minutes)			See Table 5.4.3.2(b)

(continues)

Table 5.4.3.2(a) *Continued*

Ensemble or Ensemble Element	Performance Requirement	Test Method	Class 1	Class 2/2R	Class 3/3R	Class 4/4R	Class 5	Result
	Soman (GD) permeation resistance	Section 8.3.1.2	Cumulative permeation ≤1.25 μg/m^2 (1 hour); ≤0.43 μg/m^2 (first 15 minutes)	Cumulative permeation ≤1.25 μg/m^2 (1 hour); ≤0.43 μg/m^2 (first 15 minutes)	Cumulative permeation ≤1.25 μg/m^2 (1 hour); ≤0.43 μg/m^2 (first 15 minutes)			See Table 5.4.3.2(b)
	Low vapor pressure chemical permeation resistance	Section 8.3.1.3	Cumulative permeation ≤6.0 μg/m^2 (1 hour)					
	Viral penetration resistance	ASTM F1671 (Section 8.3.4)		No penetration in 1 hour	No penetration in 1 hour	No penetration in 1 hour		
	Burst strength	ASTM D751 (Section 8.5.1)	Strength >156 N (35 lbf)	Strength >156 N (35 lbf)	Strength >145 N (25 lbf)	Strength >145 N (25 lbf)		
	Puncture propagation tear resistance	ASTM D2582 (Section 8.5.2)	Tear resistance ≥31 N (7 lbf)	Tear resistance ≥31 N (7 lbf)	Tear resistance ≥25 N (5.6 lbf)	Tear resistance ≥25 N (5.6 lbf)		
	Cold temperature bending	ASTM D747 (Section 8.5.11.1)	Bend moment ≤0.057 N·m (0.5 in.-lb)	Bend moment ≤0.057 N·m (0.5 in.-lb)	Bend moment ≤0.057 N·m (0.5 in.-lb)	Bend moment ≤0.057 N·m (0.5 in.-lb)		
Outer boot	Liquidtight integrity	Section 8.2.3.3	No leakage	No leakage	No leakage	No leakage	No leakage	
	Toe impact and compression resistance; sole puncture resistance	ASTM F2412	Footwear meets ASTM F2413 criteria	Footwear meets ASTM F2413 criteria			Footwear meets ASTM F2413 criteria	
Outer boot upper material	Cut resistance	ASTM F1790 (Section 8.5.7)	Blade travel distance ≥20 mm at 350 g (0.8 in. at 12.35 oz)	Blade travel distance ≥20 mm at 350 g (0.8 in. at 12.35 oz)	Blade travel distance ≥20 mm at 350 g (0.8 in. at 12.35 oz)	Blade travel distance ≥20 mm at 350 g (0.8 in. at 12.35 oz)	Blade travel distance ≥20 mm at 350 g (0.8 in. at 12.35 oz)	
	Puncture resistance	Method A of ASTM F1342/F1342M	Puncture force ≥36 N (8.0 lbf)	Puncture force ≥36 N (8.0 lbf)	Puncture force ≥36 N (8.0 lbf)	Puncture force ≥36 N (8.0 lbf)	Puncture force ≥36 N (8.0 lbf)	
Outer boot sole and heels	Abrasion resistance	Method A of ISO 4649 (Section 8.14)	Relative volume loss ≤250 mm^3	Relative volume loss ≤250 mm^3	Relative volume loss ≤250 mm^3	Relative volume loss ≤250 mm^3	Relative volume loss ≤250 mm^3	
	Slip resistance	ASTM F2913 (Section 8.6.7)	Coefficient ≥0.40	Coefficient ≥0.40	Coefficient ≥0.40	Coefficient ≥0.40	Coefficient ≥0.40	
Footwear cover	Liquid integrity	ASTM D5151 with modifications (Section 8.2.3.2)	No leakage	No leakage	No leakage	No leakage	No leakage	
Footwear cover upper material	Cut resistance	ASTM F1790 (Section 8.5.7)	Blade travel distance ≥20 mm at 150 g (0.8 in. at 5.29 oz)	Blade travel distance ≥20 mm at 150 g (0.8 in. at 5.29 oz)	Blade travel distance ≥20 mm at 150 g (0.8 in. at 5.29 oz)	Blade travel distance ≥20 mm at 150 g (0.8 in. at 5.29 oz)	Blade travel distance ≥20 mm at 150 g (0.8 in. at 5.29 oz)	
	Puncture resistance	Method A of ASTM F1342/F1342M	Puncture force ≥15 N (3.8 lbf)	Puncture force ≥15 N (3.8 lbf)	Puncture force ≥15 N (3.8 lbf)	Puncture force ≥15 N (3.8 lbf)	Puncture force ≥15 N (3.8 lbf)	
	Cold temperature bending	ASTM D747 (Section 8.5.11.1)	Bending moment ≤0.057 N·m (0.5 in.-lb)	Bending moment ≤0.057 N·m (0.5 in.-lb)	Bending moment ≤0.057 N·m (0.5 in.-lb)	Bending moment ≤0.057 N·m (0.5 in.-lb)	Bending moment ≤0.057 N·m (0.5 in.-lb)	
Footwear cover wear surface	Abrasion resistance	ASTM D3884 (Section 8.5.9.2)	Wear-through ≥3000 cycles	Wear-through ≥3000 cycles	Wear-through ≥3000 cycles	Wear-through ≥3000 cycles	Wear-through ≥3000 cycles	
	Slip resistance	ASTM F2913 (Section 8.6.7)	Coefficient ≥0.40	Coefficient ≥0.40	Coefficient ≥0.40	Coefficient ≥0.40	Coefficient ≥0.40	
Ensemble	Overall flash fire protection	ASTM F1930 (Section 8.4.4)	Afterflame time ≤5 seconds Test subject has visual acuity of 20/100 or better through facepiece lens and visor	Afterflame time ≤5 seconds Test subject has visual acuity of 20/100 or better through facepiece lens and visor	Afterflame time ≤5 seconds Test subject has visual acuity of 20/100 or better through facepiece lens and visor	Afterflame time ≤5 seconds Test subject has visual acuity of 20/100 or better through facepiece lens and visor	Afterflame time ≤5 seconds Test subject has visual acuity of 20/100 or better through facepiece lens and visor	

(continues)

Table 5.4.3.2(a) ***Continued***

Ensemble or Ensemble Element	Performance Requirement	Test Method	Class 1	Class 2/2R	Class 3/3R	Class 4/4R	Class 5	Result
			Break-open of material or seam ≤51 mm (2.0 in.) No evidence of dripping Percent second-degree and third-degree body burn area (optional reporting)	Break-open of material or seam ≤51 mm (2.0 in.) No evidence of dripping Percent second-degree and third-degree body burn area (optional reporting)	Break-open of material or seam ≤51 mm (2.0 in.) No evidence of dripping Percent second-degree and third-degree body burn area (optional reporting)	Break-open of material or seam ≤51 mm (2.0 in.) No evidence of dripping Percent second-degree and third-degree body burn area (optional reporting)	Break-open of material or seam ≤51 mm (2.0 in.) No evidence of dripping Percent second-degree and third-degree body burn area (optional reporting)	
Garment material	Heat transfer performance	ASTM F2700 (Section 8.4.2)	HTP rating ≥8 cal/cm^2 (29.5 Btu/ft^2)	HTP rating ≥8 cal/cm^2 (29.5 Btu/ft^2)	HTP rating ≥8 cal/cm^2 (29.5 Btu/ft^2)	HTP rating ≥8 cal/cm^2 (29.5 Btu/ft^2)	HTP rating ≥20 cal/cm^2	
	Flame resistance	ASTM F1358 (Section 8.4.1)	Afterflame time ≤2 seconds Burn distance ≤100 mm (4.0 in.) No melting and dripping	Afterflame time ≤2 seconds Burn distance ≤100 mm (4.0 in.) No melting and dripping	Afterflame time ≤2 seconds Burn distance ≤100 mm (4.0 in.) No melting and dripping	Afterflame time ≤2 seconds Burn distance ≤100 mm (4.0 in.) No melting and dripping	Afterflame time ≤2 seconds Burn distance ≤100 mm (4.0 in.) No melting and dripping	
Visor material	Heat transfer performance	ASTM F2700 (Section 8.4.2)	HTP rating ≥8 cal/cm^2 (29.5 Btu/ft^2)	HTP rating ≥8 cal/cm^2 (29.5 Btu/ft^2)	HTP rating ≥8 cal/cm^2 (29.5 Btu/ft^2)	HTP rating ≥8 cal/cm^2 (29.5 Btu/ft^2)	HTP rating ≥20 cal/cm^2	
	Flame resistance	ASTM F1358 (Section 8.4.1)	Afterflame time ≤2 seconds Burn distance ≤100 mm (4.0 in.) No melting and dripping	Afterflame time ≤2 seconds Burn distance ≤100 mm (4.0 in.) No melting and dripping	Afterflame time ≤2 seconds Burn distance ≤100 mm (4.0 in.) No melting and dripping	Afterflame time ≤2 seconds Burn distance ≤100 mm (4.0 in.) No melting and dripping	Afterflame time ≤2 seconds Burn distance ≤100 mm (4.0 in.) No melting and dripping	
Glove material	Heat transfer performance	ASTM F2700 (Section 8.4.2)	HTP rating ≥8 cal/cm^2 (29.5 Btu/ft^2)	HTP rating ≥8 cal/cm^2 (29.5 Btu/ft^2)	HTP rating ≥8 cal/cm^2 (29.5 Btu/ft^2)	HTP rating ≥8 cal/cm^2 (29.5 Btu/ft^2)	HTP rating ≥20 cal/cm^2	
	Flame resistance	ASTM F1358 (Section 8.4.1)	Afterflame time ≤2 seconds Burn distance ≤100 mm (4.0 in.) No melting and dripping	Afterflame time ≤2 seconds Burn distance ≤100 mm (4.0 in.) No melting and dripping	Afterflame time ≤2 seconds Burn distance ≤100 mm (4.0 in.) No melting and dripping	Afterflame time ≤2 seconds Burn distance ≤100 mm (4.0 in.) No melting and dripping	Afterflame time ≤2 seconds Burn distance ≤100 mm (4.0 in.) No melting and dripping	
Footwear material	Heat transfer performance	ASTM F2700 (Section 8.4.2)	HTP rating ≥12 cal/cm^2	HTP rating ≥8 cal/cm^2 (29.5 Btu/ft^2)	HTP rating ≥8 cal/cm^2 (29.5 Btu/ft^2)	HTP rating ≥8 cal/cm^2 (29.5 Btu/ft^2)	HTP rating ≥20 cal/cm^2	
	Flame resistance	ASTM F1358 (Section 8.4.1)	Afterflame time ≤2 seconds Burn distance ≤100 mm (4.0 in.) No melting and dripping	Afterflame time ≤2 seconds Burn distance ≤100 mm (4.0 in.) No melting and dripping	Afterflame time ≤2 seconds Burn distance ≤100 mm (4.0 in.) No melting and dripping	Afterflame time ≤2 seconds Burn distance ≤100 mm (4.0 in.) No melting and dripping	Afterflame time ≤2 seconds Burn distance ≤100 mm (4.0 in.) No melting and dripping	
Elastomeric interface material	Flame resistance	ASTM F1358 (Section 8.4.1)	Afterflame time ≤2 seconds Burn distance ≤100 mm (4.0 in.) No melting and dripping	Afterflame time ≤2 seconds Burn distance ≤100 mm (4.0 in.) No melting and dripping	Afterflame time ≤2 seconds Burn distance ≤100 mm (4.0 in.) No melting and dripping	Afterflame time ≤2 seconds Burn distance ≤100 mm (4.0 in.) No melting and dripping	Afterflame time ≤2 seconds Burn distance ≤100 mm (4.0 in.) No melting and dripping	
Ensemble	Acoustic signature	Section 8.7.2	Report only (dBA)	Report only (dBA)	Report only (dBA)	Report only (dBA)	Report only (dBA)	
Each ensemble material	Color/visibility	Section 8.7.1	Y Brightness <25 L* value <55	Y Brightness <25 L* value <55	Y Brightness <25 L* value <55	Y Brightness <25 L* value <55	Y Brightness <25 L* value <55	

Table 5.4.3.2(b) Format for Reporting NFPA 1994-Specific Certification Permeation Test Data in Technical Data Package

Chemical	Test Concentration[a]	Time Interval (min)	Minimum Requirement[b]	Garment Material	Garment Seam	Visor Material	Visor Seam	Glove Material	Footwear Upper Material	Hood Material
Acrolein (vapor)		15	≤2.0							
		60	≤6.0							
Acrylonitrile (vapor)		15	≤2.0							
		60	≤6.0							
Anhydrous ammonia (gas)		15	≤2.0							
		60	≤6.0							
Chlorine (gas)		15	≤2.0							
		60	≤6.0							
Diethylamine (vapor)[c]		15	≤2.0							
		60	≤6.0							
Dimethyl sulfate (liquid)		15	≤2.0							
		60	≤6.0							
Ethyl acetate (vapor)[c]		15	≤2.0							
		60	≤6.0							
Sulfuric acid, 96.1% w/w[c]		60	≤6.0							
Tetrachloroethylene (liquid)[c]		15	≤2.0							
		60	≤6.0							
Toluene (liquid)[c]		15	≤2.0							
		60	≤6.0							
Distilled mustard (liquid)		15	≤1.33							
		60	≤4.0							
Soman (liquid)		15	≤0.43							
		60	≤1.25							

[a]Indicate either liquid challenge level [Class 1 — 20 g/m^2 or Class 2/3 — 10 g/m^2] or gas concentration (Class 1 — 1 percent, Class 2 — 350 ppm, Class 3 — 40 ppm).
[b]All values are cumulative permeation mass reported values in μg/cm^2.
[c]Chemicals for Class 1 only.

5.4.3.4.4 Where applicable, the descriptions of respective materials and components shall include the following information:

(1) Visor material (e.g., the availability of any permanent detachable covers and films)
(2) Glove information, as follows:
    (a) Type of linings or surface treatments
    (b)* Available glove sizes and dimensional data for size determination
(3) Footwear information, as follows:
    (a) Type of linings or surface treatments
    (b) Type of soles or special toe reinforcements
    (c) Available footwear sizes
(4) Garment closure information, as follows:
    (a) Material(s) of construction for the closure (including chain, slide, pull, and tape for zippers)
    (b) Location and length of the completed closure assembly
    (c) Description of any protective covers for flaps
    (d) Other clothing items (e.g., outer garments) information (e.g., the type and how used with ensemble)

5.4.3.4.5 The manufacturer shall describe, in the technical data package, the type of seams or methods of attachment for the following garment material and component combinations, if applicable:

(1) Garment material–garment material
(2) Garment material–visor
(3) Garment material–glove
(4) Garment material–footwear
(5) Garment material–garment closure
(6) Outer cover–outer cover
(7) Hood material–visor material
(8) Hood material–hood material
(9) Hood material–garment materials
(10) Sock material–garment material (if the sock material is different from the garment material)
(11) Hood–respirator

Chapter 6 Design Requirements

6.1 General Design Requirements (NFPA 1991, NFPA 1992, and NFPA 1994).

6.1.1 Encapsulating Ensemble Design Requirements.

6.1.1.1* Encapsulating ensembles shall be designed and configured to protect and completely enclose the wearer's torso, head, arms, legs, hands, feet, and SCBA.

6.1.1.2 Encapsulating ensembles shall include the following:

(1) A garment with an integral hood and visor
(2) Attached gloves or glove system consisting of an attached inner glove and a separate outer glove
(3) Attached footwear or footwear consisting of an attached sock and separate outer boot

6.1.1.2.1 Garment elements of encapsulating ensembles shall meet the design requirements specified in 6.1.3.

6.1.1.2.2 Glove elements of encapsulating ensembles shall meet the design requirements specified in 6.1.4.

6.1.1.2.3 Footwear elements of encapsulating ensembles shall meet the design requirements specified in 6.1.5.

6.1.1.2.3.1 Where footwear consists of an attached sock and separate outer boot, the manufacturer shall specify outer boots that, in combination with the attached sock, meet all footwear design and performance requirements of the respective standard.

6.1.1.2.3.2 Where footwear consists of an attached sock and separate outer boot, the garment portion of the encapsulating ensemble shall be designed so that the top of the outer boot is covered by the garment.

6.1.1.2.4 Hood elements of encapsulating ensembles shall meet the design requirements specified in 6.1.6.

6.1.1.2.5* Only open-circuit SCBA that is certified to either NFPA 1981 or NFPA 1986 shall be specified to be worn with encapsulating ensembles.

6.1.1.2.5.1* The interface and integration of the selected respirator with the protective ensemble shall not invalidate the NIOSH certification.

6.1.1.3 Other than outer gloves and outer boots, encapsulating ensembles shall be designed so that all separate components are securely attached and the ensembles are provided as single integrated units.

6.1.1.4* The application of separate pressure-sensitive adhesive tape shall not be permitted in the design of ensemble interfaces with the exception of tape that is permanently applied in the creation of the ensemble.

6.1.1.5 Encapsulating ensembles shall be offered in at least four unique and different sizes.

6.1.1.6* Encapsulating ensembles shall be equipped with a means to release exhaust air from inside the ensemble to the outside environment.

6.1.1.6.1 Protective covers constructed using materials meeting the requirements of 6.1.5 shall be provided to protect from direct chemical splashes to the seat of the exhaust port(s). The covers shall allow access to the ports for removal and inspection.

6.1.1.6.2 Exhaust valves shall be one-way valves.

6.1.1.6.3 The mounting mechanism of exhaust valves shall be designed to allow their removal and reinstallation or replacement for inspection for vapor-protective ensembles.

6.1.1.7 All external hardware and fittings shall be free of rough spots, burrs, or sharp edges that could tear materials.

6.1.2 Nonencapsulating Ensemble Design Requirements.

6.1.2.1 Nonencapsulating ensembles shall be designed and configured as follows:

(1) The wearer's torso, head, arms, legs, hands, and feet shall be completely enclosed and protected.
(2) The wearer's respirator shall not be completely enclosed.

6.1.2.1.1 Nonencapsulating ensembles shall be designed to accommodate the respirator(s) specified by the manufacturer.

6.1.2.1.2 All respirators specified by the ensemble manufacturer shall be certified by NIOSH as compliant with the *Statement of Standard for NIOSH CBRN SCBA Testing,* the *Statement of Standard for NIOSH CBRN APR Testing,* or the *Statement of Standard for NIOSH CBRN PAPR Testing.*

6.1.2.1.3 Where SCBAs are used as the respirators, the SCBA specified by the manufacturer shall meet the requirements of either NFPA 1981 or NFPA 1986.

6.1.2.1.4* The interface and integration of the selected respirator with the protective ensemble shall not invalidate the NIOSH certification of the respirator.

6.1.2.2 Nonencapsulating ensembles shall include garments, gloves, footwear, and hoods in combination with the specified respirator.

6.1.2.2.1 Garment elements of nonencapsulating ensembles shall meet the design requirements specified in 6.1.3.

6.1.2.2.2 Glove elements of nonencapsulating ensembles shall meet the design requirements specified in 6.1.4.

6.1.2.2.2.1 Gloves shall be permitted to be attached to the garment sleeves.

6.1.2.2.2.2 Attached gloves shall be permitted to be inner gloves that meet the barrier performance requirements of the respective standard.

6.1.2.2.2.3 Where inner gloves are used as part of the nonencapsulating ensemble, the manufacturer shall provide outer gloves that, in combination with the inner gloves, meet all glove design and performance requirements of the respective standard.

6.1.2.2.3 Footwear elements of nonencapsulating ensembles shall meet the design requirements specified in 6.1.5.

6.1.2.2.3.1 Where footwear consists of an attached sock and separate outer boot, the manufacturer shall specify outer boots that, in combination with the attached sock, meet all footwear design and performance requirements of the respective standard.

6.1.2.2.3.2 Where footwear consists of an attached sock and separate outer boot, the garment portion of the nonencapsulating ensemble shall be designed so that the top of the outer boot is covered by the garment.

6.1.2.2.4 Hoods of nonencapsulating ensembles shall meet the design requirements specified in 6.1.6.

6.1.2.3 The application of pressure-sensitive adhesive tape shall not be permitted in the design of ensemble interfaces with the exception of tape that is permanently applied in the creation of the ensemble. *(See A.6.1.1.4.)*

6.1.2.4 Nonencapsulating ensembles shall be offered in at least four unique and different sizes.

6.1.3 Garment Design Requirements.

6.1.3.1 Garment elements shall be designed and configured to protect the wearer's upper and lower torso, arms, and legs.

6.1.3.2 Garment elements shall be permitted to include an attached hood.

6.1.3.2.1 Where used, the attached hood shall be designed and configured to protect the wearer's head and neck but shall be permitted to exclude the face.

6.1.3.2.1.1 The attached hood shall be permitted to be constructed of a material different than the rest of the garment.

6.1.3.2.1.2 No detachable visor materials shall be permitted to be used to achieve base certification requirements.

6.1.3.3 Garment elements shall be permitted to have attached gloves.

6.1.3.3.1 Attached gloves shall be permitted to be inner gloves that meet the barrier performance requirements of the respective standard.

6.1.3.3.2 Where inner gloves are used as part of the ensemble, the manufacturer shall provide outer gloves that, in combination with the inner gloves, meet all glove design and performance requirements of the respective standard.

6.1.3.4 Where garments incorporate socks, the socks shall be designed as an extension of the garment leg and shall cover the entire foot and ankle.

6.1.3.4.1 Socks shall be permitted to be constructed of a different material than the base material used in the garment.

6.1.3.5 Garments shall be offered in at least four unique and different sizes.

6.1.3.6 All external fittings shall be free of rough spots, burrs, or sharp edges that could tear materials.

6.1.4 Glove Design Requirements.

6.1.4.1 Glove elements shall be designed and configured to protect the wearer's hands and wrists.

6.1.4.2 Glove elements shall provide protection to at least 16.5 cm (6.5 in.) from the tip of the longest finger of the glove.

6.1.4.3 Gloves shall be permitted to be single gloves, gloves with multiple layers, or multiple gloves used in combination to meet the performance requirements of the respective standard.

6.1.4.3.1 Where the gloves provided include multiple layers or are multiple gloves, it shall be permitted that individual layers or gloves are indicated as providing the barrier protection for the purposes of performance testing.

6.1.4.4 All external hardware and fittings shall be free of rough spots, burrs, or sharp edges that could tear materials.

6.1.4.5 Gloves shall be provided in at least four unique and different sizes.

6.1.5 Footwear Design Requirements.

6.1.5.1 Footwear elements shall be designed and configured to provide protection to the feet and ankles.

6.1.5.2 Footwear elements shall be permitted to be as follows:

(1) The footwear configuration shall be one of the following:
   (a) Full footwear that meets all requirements of the respective standard.
   (b) A combination of socks attached to the garment worn with an outer boot where the socks provide the principal protection barrier and the outer boots provide the primary physical protection.
(2) Footwear covers shall further be permitted as part of the configurations in 6.1.5.2(1)(a) and 6.1.5.2(1)(b) to allow for reducing contamination to either the full boot or outer boot.

6.1.5.3 Where multiple footwear items are used as part of the footwear element, the combination of all footwear elements shall be specified by the manufacturer and meet all of the applicable criteria in this section and the requirements of the respective standard.

6.1.5.3.1 Where used as part of the footwear element, the sock shall cover the entire foot and ankle and provide protection when worn in conjunction with an outer boot.

6.1.5.3.2 If a footwear cover is used as part of the footwear element, the footwear cover, in combination with other footwear components, shall be specified by manufacturer as part of the overall footwear for compliance with the respective standard.

6.1.5.4 Footwear height shall be a minimum of 150 mm (6 in.).

6.1.5.4.1 Footwear height shall be determined by measuring inside the footwear from the center of the insole at the heel up to a perpendicular reference line extending across the width of the footwear at the lowest point of the topline, excluding the tongue and gusset.

6.1.5.4.2 Removable insole inserts shall not be removed prior to measurement.

6.1.5.4.3 The chemical protection layer shall be continuous circumferentially to within 50 mm (2 in.) of the footwear topline in all areas with the exception of the area inside of and within 13 mm (0.5 in.) around the pull-up holes that fully penetrate the footwear from the outside to the inside. The height of the chemical protection layer in all parts of the boot shall be no less than 150 mm (6 in.) when measured as described in 6.1.5.4.1.

6.1.5.4.4 Physical protection shall be continuous circumferentially to within 50 mm (2 in.) of the footwear topline in all areas with the exception of the tongue and gusset, and the area inside of and within 13 mm (0.5 in.) around pull-up holes that fully penetrate the footwear from the outside to the inside. The height of physical protection in all parts of the boot with the exception of the tongue and gusset shall be no less than 150 mm (6 in.) when measured as described in 6.1.5.4.1.

6.1.5.5 Footwear shall have the following physical features:

(1) All external hardware and fittings shall be free of rough spots, burrs, or sharp edges that could tear materials.
(2) Metal parts shall not penetrate from the outside into the lining or insole at any point.
(3)* No metal parts shall be present or utilized in the construction or attachment of the sole (with heel) to the puncture-resistant device, if present; insole; or upper.
(4) If required by the respective standard, the heel breast shall not be less than 13 mm (½ in.) nor more than 25 mm (1 in.).
(5) If required by the respective standard, toe impact–resistant, compression-resistant, and sole puncture–resistant components shall be integral and nonremovable parts of the footwear.

6.1.5.6 Footwear elements shall be offered in at least four unique and different sizes.

6.1.5.6.1 Where applicable, footwear covers shall accommodate the range of footwear sizes offered.

6.1.6 Hood Design Requirements.

6.1.6.1 Hoods shall be designed and configured to protect the wearer's head and neck.

6.1.6.1.1 Hoods shall be permitted to include a visor.

6.1.6.1.2 Hoods shall be permitted to have a face opening that provides an interface with a specific respirator facepiece.

6.1.6.1.2.1 Hoods that include a respirator interface shall be designed to accommodate the respirator(s) specified by the manufacturer.

6.1.6.1.2.2 All respirators specified by the hood manufacturer shall be certified by NIOSH as compliant with the *Statement of Standard for NIOSH CBRN SCBA Testing*, the *Statement of Standard for NIOSH CBRN APR Testing*, or the *Statement of Standard for NIOSH CBRN PAPR Testing*.

6.1.6.1.2.3 All respirators shall cover the eyes, nose, and mouth at a minimum.

6.1.6.1.3 The interface and integration of the selected respirator with the protective hood shall not invalidate the NIOSH certification of the respirator.

6.1.6.2* Where loose-fitting facepiece powered air-purifying respirators (PAPR) are used as part of a nonencapsulating ensemble as specified by the manufacturer, the hood portion of the PAPR shall be considered a hood under this standard.

6.1.6.2.1 The hood portion of the PAPR shall be subject to the performance criteria specified for garments in the respective standard.

6.1.6.2.2 The PAPR shall be certified by NIOSH as compliant with the *Statement of Standard for NIOSH CBRN PAPR Testing*.

6.1.6.3 All external fittings shall be free of rough spots, burrs, or sharp edges that could tear primary materials.

6.1.7 Optional Flash Fire Requirements. Where liquid splash-protective ensembles or elements rely on external clothing items or multiple layers to meet the performance requirements in 7.1.8, the ensemble or ensemble elements shall be designed so that all layers or separate parts are securely attached and provided as a single and integrated unit.

6.1.8 Optional Stealth Requirements. Where protective ensembles or ensemble elements are designed to meet the performance requirements in 7.1.9, the complete ensemble and all elements shall be subject to the applicable requirements.

6.2 Design Requirements Specific to NFPA 1991 Ensembles and Elements.

6.2.1 NFPA 1991-certified ensembles shall only be encapsulating ensembles and shall meet the respective requirements of Section 6.1 and the specific ensemble requirements of 6.2.1.1 through 6.2.1.5.

6.2.1.1 NFPA 1991-certified ensembles shall not be permitted to be constructed using an outer garment designed to be worn over the ensemble element to meet the base or optional requirements of this standard.

6.2.1.2 The vapor-protective ensemble garment with hood and visor, gloves, and footwear shall be constructed using primary material that shall provide protection from chemical and physical hazards. The primary material shall include chemical-protective layers that can be configured as separate layers or as a composite.

6.2.1.3 The chemical-protective layer shall be designed to provide permeation resistance to chemicals and gastight integrity for the vapor-protective ensemble.

6.2.1.3.1 The chemical-protective layer shall be considered a primary material and shall be permitted to be configured as a separate layer or as a composite with other primary materials.

6.2.1.3.2 The chemical-protective layer shall be permitted to depend on another primary material to provide physical protection.

6.2.1.4* A protective cover(s) constructed with material that meets all applicable performance criteria in Section 7.2 shall be provided to protect the garment closure assembly from direct chemical splashes. The cover(s) shall allow access to the closure(s) for donning, doffing, and inspection.

6.2.1.5* Only open-circuit SCBAs that are certified to NFPA 1981 or NFPA 1986 shall be specified to be worn with vapor-protective ensembles.

6.2.2 Vapor-protective ensemble gloves and glove elements shall meet the respective requirements of 6.1.4 and the specific ensemble requirement of 6.2.2.1.

6.2.2.1 Where gloves are designed for removal, the interface of glove element to vapor-protective garment sleeve shall permit removal and replacement of the gloves attached to each garment sleeve within 30 minutes.

6.2.3 Vapor-protective ensemble footwear and footwear elements shall meet the respective requirements of 6.1.5 and the specific ensemble requirements of 6.2.3.1 and 6.2.3.2.

6.2.3.1 Socks, where provided, shall be designed as an extension of the chemical protective garment leg, shall cover the entire foot and ankle, and shall provide protection to the feet when worn in conjunction with an outer boot.

6.2.3.2 Footwear elements shall be constructed using primary material that provides protection from chemical and physical hazards. The primary material shall include chemical-protective layers that can be configured as separate layers or as a composite.

6.2.3.3 The footwear chemical-protective layer shall be designed to provide permeation resistance to chemicals and gastight integrity for the vapor-protective footwear.

6.2.3.3.1 The footwear chemical-protective layer shall be considered a primary material and shall be permitted to be configured as a separate layer or as a composite with other primary materials.

6.2.3.3.2 The footwear chemical-protective layer shall be permitted to depend on another primary material to provide physical protection.

6.3 Design Requirements Specific to NFPA 1992 Ensembles and Ensemble Elements.

6.3.1 NFPA 1992-certified ensembles or garments shall be permitted to be either encapsulating or nonencapsulating and shall meet the respective requirements of Section 6.1.

6.3.2 NFPA 1992-certified garment elements shall meet the requirements of 6.1.3.

6.3.3 Ensembles shall be designed to accommodate the respirators specified by the manufacturer.

6.3.3.1 All respirators specified for use with encapsulated ensembles shall be open-circuit SCBA certified as compliant with NFPA 1981 or NFPA 1986.

6.3.3.2 All respirators specified for use with nonencapsulated ensembles shall be certified by NIOSH as compliant with the *Statement of Standard for NIOSH CBRN SCBA Testing*, the *Statement of Standard for NIOSH CBRN APR Testing*, or the *Statement of Standard for NIOSH CBRN PAPR Testing*.

6.3.3.2.1 Where SCBAs are used as respirators, the SCBA specified by the manufacturer shall meet the requirements of either NFPA 1981 or NFPA 1986.

6.3.4 NFPA 1992-certified ensemble gloves and glove elements shall meet the requirements of 6.1.4.

6.3.4.1 Where the glove is not attached to the sleeve, the glove elements shall provide protection to at least 27.94 cm (11 in.) from the tip of the longest finger of the glove.

6.3.4.2 Where NFPA 1992-certified ensemble gloves are designed for removal, the interface of the glove to the liquid splash-protective garment sleeve shall be designed to permit removal and replacement of the gloves attached to each sleeve within a 30-minute period.

6.3.5 NFPA 1992–certified ensemble footwear and footwear elements shall meet the requirements of 6.1.5.

6.3.5.1 Protective footwear shall be permitted to be constructed using an outer boot designed to be worn over a sock where such additional footwear components are necessary to meet the footwear requirements of this standard.

6.3.5.2 Where socks are used as part of an encapsulating or nonencapsulating NFPA 1992-certified ensemble, the use of any NFPA 1992-certified footwear element or any outer boot of the footwear element that is certified to NFPA 1951, NFPA 1971, NFPA 1991, NFPA 1994, or NFPA 1999 that also meets the minimum height requirement specified in 6.1.5.4 shall be permitted.

6.3.5.3 If the manufacturer chooses to allow choices of footwear as permitted in 6.3.5.2, then the product label shall have an additional warning as stipulated in Chapter 5.

6.3.6 Liquid splash-protective ensemble hoods and hood elements shall meet the requirements of 6.1.6.

6.4 Design Requirements Specific to NFPA 1994 Ensembles.

6.4.1 Hazardous materials and CBRN protective ensembles shall meet the requirements in either 6.1.1 or 6.1.2 as applicable to the design and configuration of the ensemble.

6.4.1.1 Class 1, Class 2, and Class 2R ensembles shall be permitted to be designed and configured as either encapsulating or nonencapsulating ensembles and shall be so designated on the product label as specified in Chapter 5.

6.4.1.2 Class 3, Class 3R, Class 4, and Class 4R ensembles shall be nonencapsulating ensembles.

6.4.1.3 Ensembles shall be designed to accommodate the respirators specified by the manufacturer.

6.4.1.3.1 All respirators specified for use with Class 1, Class 2, Class 2R, and Class 5 ensembles shall be open-circuit SCBA certified as compliant with NFPA 1981 or NFPA 1986.

6.4.1.3.2 All respirators specified for use with Class 3, Class 3R, Class 4, or Class 4R ensembles shall be certified by NIOSH as compliant with the *Statement of Standard for NIOSH CBRN SCBA Testing*, the *Statement of Standard for NIOSH CBRN APR Testing*, or the *Statement of Standard for NIOSH CBRN PAPR Testing*.

6.4.1.3.2.1 Where SCBAs are used as respirators, the SCBA specified by the manufacturer shall meet the requirements of either NFPA 1981 or NFPA 1986.

6.4.1.4 Hazardous materials and CBRN protective ensemble gloves shall meet the requirements of 6.1.4.

6.4.1.5 Hazardous materials and CBRN protective ensemble footwear and footwear elements shall meet the requirements of 6.1.5.

6.4.1.5.1 Where socks are used as part of the protective ensemble, the manufacturer shall permit the use of any NFPA 1994-certified footwear element or any outer boot of the footwear element that is certified to NFPA 1951, NFPA 1971, NFPA 1991, NFPA 1992, or NFPA 1999 that also meets the minimum height requirement specified in 6.1.5.4.

6.4.1.6 Hazardous materials and CBRN protective ensemble hoods and hood elements shall meet the requirements of 6.1.6.

6.4.1.6.1 Separate hood elements shall be permitted for Class 3, Class 3R, Class 4, Class 4R, and Class 5 ensembles only.

6.4.2 Additional Design Requirements Specific to NFPA 1994 Class 5 Ensembles and Ensemble Elements.

6.4.2.1 Class 5 ensembles shall be nonencapsulating.

6.4.2.2 Class 5 garments shall meet the design requirements for technical rescue protective ensemble garments in Section 6.1 of NFPA 1951 with the following exceptions:

(1) Garments shall be permitted to be either a set of coat and pants or coveralls.
(2) Upper torso garments and coveralls shall be permitted to have an attached hood in lieu of a collar.
(3) Garments shall be permitted to have an attached or detachable liner.
(4) Garments shall be permitted to meet the optional requirements for blood-borne pathogen protective technical rescue garment ensemble elements in 6.1.1.15 of NFPA 1951.
(5) If a garment has a detachable liner that is necessary to meet the performance requirements for Class 5 garments in Chapter 7, the product label shall include a warning on the garment outer shell that indicates that the liner must be properly attached for compliance with the NFPA 1994 Class 5 requirements.
(6) Garments shall be permitted to have visibility markings.

6.4.2.3 Class 5 ensembles shall consist of the following additional elements:

(1) If a garment does not include an attached hood, the ensemble shall include a hood that is certified to the hood interface component requirements of NFPA 1971 or a hood that is certified to NFPA 1994 Class 3, Class 3R, Class 4, or Class 4R requirements, as well as the optional flash fire protection requirements of this standard.
(2) The ensemble shall include a helmet that is certified to NFPA 1951, NFPA 1977, or NFPA 1971.
(3) The ensemble shall include gloves that are certified to NFPA 1951, NFPA 1977 (work gloves only), or NFPA 1971, or gloves that are certified to NFPA 1994 Class 3, Class 3R, Class 4, or Class 4R requirements, as well as the optional flash fire protection requirements of this standard.
(4) The ensemble shall include footwear that is certified to NFPA 1951, NFPA 1971, or NFPA 1977, or footwear that is certified to this standard, as well as the optional flash fire protection requirements.

Chapter 7 Performance Requirements

7.1 General Performance Requirements (Applies to NFPA 1991, NFPA 1992, and NFPA 1994).

7.1.1 Ensemble Performance Requirements.

7.1.1.1 Ensemble Integrity Performance Requirements.

7.1.1.1.1* Ensembles providing protection from gases or vapors shall be tested for inward vapor leakage in accordance with 8.2.2 and shall have both a geometric mean local physiological protective dosage factor ($PPDF_i$) value at each passive adsorbent dosimeter (PAD) location for the four ensembles tested and a geometric mean systemic physiological protective dosage factor ($PPDF_{sys}$) value as specified in Table 7.1.1.1.1.

7.1.1.1.2 Ensembles providing protection from liquids shall be tested for liquid integrity in accordance with 8.2.3.1 using the test durations specified in Table 7.1.1.1.2, shall show no evidence of liquid penetration, and shall meet the following additional criteria as applicable in the design of the ensemble:

(1)* Where outer gloves are designed to be worn in conjunction with gloves attached to the ensemble, the outer gloves shall not collect liquid.
(2) Where outer boots are designed to be worn in conjunction with socks, the outer boots shall not collect liquid.
(3) Where ensembles include exhaust valves, no liquid shall collect inside the ensembles next to the exhaust valves.

Table 7.1.1.1.1 Performance Requirements for Inward Vapor leakage

Level	$PPDF_i$ at each PAD location*	$PPDF_{sys}$*
Ultrahigh	≥1071	≥488
High	≥871	≥441
Moderate	≥481	≥328
Low	≥80	≥35

*Geometric means for all ensembles tested.

Table 7.1.1.1.2 Test Duration for Liquid Integrity Testing

Level	Test Duration (min)
Ultrahigh	60
High	20
Moderate	8
Low	4

7.1.1.1.3 Ensembles intended primarily for protection from particulates shall be tested for overall particulate inward leakage as specified in 8.2.4 and shall either show no visual particulate inward leakage on black indicator garments or, where fluorescence is observed, shall have no individual sampling area with an average surface concentration of particulates over 6.0 $\mu g/cm^2$.

7.1.1.1.4 Ensembles shall be tested for overall function and integrity as specified 8.6.1 and shall meet the following criteria and additional criteria specified in Table 7.1.1.1.4.

(1) Ensembles shall not restrict test subjects from performing any tasks.
(2) Where hoods are provided as part of ensembles, ensembles shall accommodate head protection devices meeting the dimensional requirements for Type I, Class G helmets of ANSI/ISEA Z89.1, *American National Standard for Industrial Head Protection.*
(3) Ensembles shall permit test subjects to see through the combination of respiratory protective device and ensemble visor, if present, with a visual acuity of 20/35 or better.
(4) Where ensembles include a hood with a visor that covers the respirator facepiece, test subjects shall be able to properly identify 3 out of 4 letters on the test sign at each of the following angles with respect to the test subjects:
    (a) Upwards, 36 degrees
    (b) Downwards, 30 degrees
    (c) Right, 60 degrees
    (d) Left, 60 degrees
(5) Where ensembles are encapsulating, ensembles shall permit the test subjects to remove their hands from and reinsert their hands into the glove system 5 times sequentially within a period of 2.5 minutes or less.
(6) Garment closures shall remain engaged during the entire garment function testing.
(7) Where protective flaps cover the garment closures, protective flaps shall remain closed for the duration of the overall garment function test.

7.1.1.1.4.1 Where ensembles are tested for liquid integrity as part of the overall function and integrity test, the test results for liquid integrity shall be permitted to demonstrate compliance with 7.1.1.1.2.

7.1.1.1.5 Where ensembles have installed exhaust valves or exhaust ports, encapsulating ensembles shall be tested for airflow capacity as specified in 8.6.2, exhibit no internal pressures greater than 150 mm (6 in.) water gauge pressure, and meet the post-test integrity requirement specified in either 7.1.1.1.5.1 or 7.1.1.1.5.2, as appropriate.

Table 7.1.1.1.4 Performance Requirements for Overall Function and Integrity

Level	Task Completion Time	Post-Task Ensemble Integrity
Ultrahigh	All tasks completed within 30 min	Ensembles have an ending pressure of at least 80 mm (3 5/32 in.) water gauge pressure
High	All tasks completed within 20 min	Ensembles meet high level requirements as specified in 7.1.1.1.2
Moderate	All tasks completed within 15 min	Ensembles meet moderate level requirements as specified in 7.1.1.1.2
Low	All tasks completed within 15 min	Ensembles meet low level requirements as specified in 7.1.1.1.2
Very Low	All tasks completed within 15 min	None

7.1.1.1.5.1 Encapsulating ensembles meeting the ultrahigh performance level for inward vapor leakage shall show an ending pressure of at least 80 mm (3 5/32 in.) water gauge pressure after subsequent testing for gastight integrity as specified in 8.2.1.

7.1.1.1.5.2 All other encapsulating ensembles shall show no evidence of liquid penetration when tested as specified in 8.2.3.1.

7.1.1.2 Exhaust Valve Performance Requirements.

7.1.1.2.1* Where present in ensembles providing vapor protection, exhaust valves installed in ensembles shall be tested for inward leakage as specified in 8.6.3 and shall not exhibit a leakage rating exceeding 30 mL/min (1.83 $in.^3$/min).

7.1.1.2.2* Where present, exhaust valves installed in ensembles shall be tested for mounting strength as specified in 8.5.4 and shall have a failure force greater than 135 N (30 lbf).

7.1.1.3 External Fitting Performance Requirements.

7.1.1.3.1 Vapor-protective ensembles on which external fittings are installed that penetrate any garment, visor, glove, footwear, or elastomeric interface materials shall be tested for gastight integrity as specified in 8.2.1 and show an ending pressure of at least 80 mm (3 5/32 in.) water gauge. *(See A.7.1.1.2.1.)*

7.1.1.3.2 Liquid splash-protective ensembles on which external fittings are installed that penetrate any visor, glove, footwear, or elastomeric interface materials shall meet the respective liquidtight integrity requirements in 7.1.1.1.2.

7.1.1.3.3 Where present, external fittings installed in ensembles that are intended for tethered applications shall be tested for pull-out strength as specified in 8.5.5 and shall not have a failure force of less than 1000 N (225 lbf).

7.1.1.3.4 Where present, external fittings installed in ensembles that are not intended for tethered applications shall be tested for pull-out strength as specified in 8.5.5 and shall not have a failure force of less than 135 N (30 lbf).

7.1.2 Material and Seam Barrier Performance Requirements.

7.1.2.1 Ultrahigh Permeation Resistance for Industrial Chemicals. Where specified for ultrahigh permeation resistance against industrial chemicals, the garment, visor, glove, footwear, hood, and elastomeric interface materials and seams in and between these elements and components shall be tested for permeation resistance as specified in 8.3.1.1, shall have an average cumulative permeation that does not exceed 6.0 $\mu g/cm^2$ for the 1-hour test period, and shall not exceed an average cumulative permeation for the first 15-minute interval of 2.0 $\mu g/cm^2$ for each of the specified chemicals and for each additional chemical or specific chemical mixture for which the manufacturer is certifying the ensemble or ensemble element.

7.1.2.2 Permeation Resistance for Toxic Industrial Chemicals. Where specified for permeation resistance against toxic industrial chemicals, the garment, visor, glove, footwear, hood, and elastomeric interface materials and seams in and between these elements and components shall be tested for permeation resistance as specified in 8.3.1.2, shall have an average cumulative permeation that does not exceed 6.0 $\mu g/cm^2$ for the 1-hour test period, and shall not exceed an average cumulative permeation for the first 15-minute interval of 2.0 $\mu g/cm^2$ for each of the specified chemicals and for each additional chemical or specific chemical mixture for which the manufacturer is certifying the ensemble or ensemble element.

7.1.2.3 Permeation Resistance for Chemical Warfare Agents.

7.1.2.3.1 Where specified for permeation resistance against the liquid chemical warfare agent sulfur mustard, distilled [HD, or bis (2-chloroethyl) sulfide, CAS No. 505-60-2], the garment, visor, glove, footwear, hood, and elastomeric interface materials and seams in and between these elements and components shall be tested for permeation resistance as specified in 8.3.1.2, shall have an average cumulative permeation that does not exceed 4.0 $\mu g/cm^2$ for the 1-hour test period, and shall not exceed an average cumulative permeation for the first 15-minute interval of 1.33 $\mu g/cm^2$.

7.1.2.3.2 Where specified for permeation resistance against the liquid chemical warfare agent soman (GD, or O-Pinacolyl methylphosphonofluoridate, CAS No. 96-64-0), the garment, visor, glove, footwear, hood, and elastomeric interface materials and seams in and between these elements and components shall be tested for permeation resistance as specified in 8.3.1.2, shall have an average cumulative permeation that does not exceed 1.25 $\mu g/cm^2$ in the 1-hour test period, and shall not exceed an average cumulative permeation for the first 15-minute interval of 0.43 $\mu g/cm^2$.

7.1.2.4 Permeation Resistance for Low Vapor Pressure Chemicals. Where specified for permeation resistance against low vapor pressure chemicals, the garment, visor, glove, footwear, hood, and elastomeric interface materials and seams in and between these elements and components shall be tested for

permeation resistance as specified in 8.3.1.3, and shall have an average cumulative permeation that does not exceed 6.0 $\mu g/cm^2$ in the 1-hour test period for each specified chemical and for each additional chemical or specific chemical for which the manufacturer is certifying the ensemble.

7.1.2.5 Liquid Chemical Penetration Resistance. Where specified for liquid splash-protection, the garment, visor, glove, footwear, hood, and elastomeric interface materials and seams in and between these elements and components shall be tested for penetration resistance as specified in 8.3.2 and shall exhibit no penetration for at least 1 hour for each of the specified chemicals and for each additional chemical or specific chemical mixture for which the manufacturer is certifying the ensemble or ensemble element.

7.1.2.6 Viral Penetration Resistance. Where specified, the garment, visor, glove, footwear, hood, and elastomeric interface materials and seams in and between these elements and components shall be tested for resistance to liquid- or bloodborne pathogens as specified in 8.3.4 and shall allow no penetration of the Phi-X-174 bacteriophage above the test interpretation threshold for at least 1 hour.

7.1.2.7 Liquid Repellency Resistance. Where specified, the garment, visor, glove, footwear, and hood shall be tested for resistance to liquid- or bloodborne pathogens as specified in 8.3.5 and shall a repellency of 80 percent or better.

7.1.3 Garment Performance Requirements.

7.1.3.1 Full Garment Performance Requirements. When not tested as part of an ensemble, garments shall be tested for overall function and integrity as specified 8.6.1 and shall meet the applicable criteria as specified in 7.1.1.1.4.

7.1.3.2 Garment Material Performance Requirements.

7.1.3.2.1 Garment materials shall be tested for bursting strength as specified in 8.5.1 and shall have a bursting strength as specified in Table 7.1.3.2.1.

7.1.3.2.2 Garment materials shall be tested for puncture propagation tear resistance as specified in 8.5.2 and shall have a puncture propagation tear resistance as specified in Table 7.1.3.2.2.

Table 7.1.3.2.1 Performance Requirements for Garment Material Burst Strength

Level	Burst Strength
High	≥200 N (≥45 lbf)
Moderate	≥156 N (≥35 lbf)
Low	≥135 N (≥30 lbf)

Table 7.1.3.2.2 Performance Requirements for Garment Material Puncture Propagation Tear Resistance

Level	Puncture Propagation Tear Resistance
High	≥49 N (≥11 lbf)
Moderate	≥31 N (≥7 lbf)
Low	≥25 N (≥5.6 lbf)

7.1.3.2.3 Garment materials shall be tested for cold temperature bending as specified in 8.5.11.1and shall have a bending moment not greater than 0.057 N·m (½ in.·lbf) at an angular deflection of 60 degrees at –25°C (–13°F).

7.1.3.3 Garment Seam and Closure Assembly Performance Requirements.

7.1.3.3.1 Garment seams, including seams to other ensemble elements or components, shall be tested for seam strength as specified in 8.5.3 and shall have a breaking strength as specified in Table 7.1.3.3.1.

7.1.3.3.1.1 Seam breaking strength shall be considered acceptable where the material strength is less than the required seam strength specified in 7.1.3.3.1, provided the material fails without failure of the seam below the applicable forces specified in 7.1.3.3.1.

7.1.3.3.2 Garment closure assemblies shall be tested for closure strength as specified in 8.5.3 and shall have a breaking strength as specified in Table 7.1.3.3.2.

7.1.3.4 Visor Component Performance Requirements.

7.1.3.4.1 Where present, garment visor materials shall be tested for high-mass impact resistance as specified in 8.5.10 and shall have no full-thickness punctures, cracks, holes, or fractures.

7.1.3.4.2 Where present, garment visor materials shall be tested for cold temperature bending as specified in 8.5.11.2 and shall not crack or show evidence of visible damage.

7.1.3.5 Garment Elastomeric Interface Material Performance Requirements.

7.1.3.5.1* Elastomeric interface materials shall have an elongation at rupture of not less than 125 percent when tested as specified in 8.5.6.

7.1.3.5.2 Where garments include elastomeric interface materials, each elastomeric interface material shall be tested for cut resistance as specified in 8.5.7 at a load of 50 g (1.76 oz) and shall have a blade travel distance of not less than 20 mm (0.8 in.).

7.1.3.5.3 Where garments include elastomeric interface materials, each elastomeric interface material shall be tested for puncture resistance as specified in 8.5.8.1 and shall have a puncture resistance of not less than 7 N (1.6 lbf).

Table 7.1.3.3.1 Performance Requirements for Garment Seam Strength

Level	Seam Strength
High	≥67 N/25 mm (≥15 lbf/in.)
Moderate	≥34 N/25 mm (≥7.6 lbf/in.)

Table 7.1.3.3.2 Performance Requirements for Closure Assembly Strength

Level	Closure Assembly Strength
High	≥67 N/25 mm (≥15 lbf/in.)
Moderate	≥34 N/25 mm (≥7.6 lbf/in.)

7.1.3.5.4 Where garments include elastomeric interface materials, each elastomeric interface material shall be tested for ultimate tensile strength as specified in 8.5.6 and shall have an ultimate tensile strength of not less than 4 MPa (580 psi).

7.1.3.5.5 Where garments include elastomeric interface materials, each elastomeric interface material shall be tested for cold temperature bending as specified in 8.5.11.1 and shall have a bending moment of not greater than 0.057 N·m (½ in.·lbf) at an angular deflection of 60 degrees at –25°C (–13°F).

7.1.3.6 Garment Material Breathability Performance Requirements.

7.1.3.6.1* Where specified, garment materials shall be tested for total heat loss as specified in 8.6.4.1 and shall have a total heat loss as specified in Table 7.1.3.6.1.

7.1.3.6.2* Where specified, garment materials shall be tested for evaporative resistance as specified in 8.6.4.2 and shall have an evaporative resistance of not greater than 30 Pa·m^2/W.

7.1.4 Glove Element Performance Requirements.

7.1.4.1 Overall Glove Performance Requirements.

7.1.4.1.1 Gloves shall be tested for liquidtight integrity as specified in 8.2.3.2 and shall show no leakage.

7.1.4.1.2 Gloves shall be tested for hand function as specified in 8.6.5 and shall have an average percent increase over barehanded control as specified in Table 7.1.4.1.2.

7.1.4.2 Glove Material Performance Requirements.

7.1.4.2.1 Glove materials shall be tested for cut resistance under the loads provided in Table 7.1.4.2.1 as specified in 8.5.7 and shall have a blade travel distance of not less than 20 mm (0.8 in.).

7.1.4.2.2 Glove materials shall be tested for puncture resistance as specified in 8.5.8.1 and shall have a puncture resistance as specified in Table 7.1.4.2.2.

7.1.4.2.3 Glove materials shall be tested for cold temperature bending as specified in 8.5.11.1 and shall have a bending moment of not greater than 0.057 N·m (½ in.·lbf) at an angular deflection of 60 degrees at –25°C (–13°F).

Table 7.1.3.6.1 Performance Requirements for Total Heat Loss

Level	Total Heat Loss
High	≥450 W/m^2
Moderate	≥325 W/m^2
Low	≥200 W/m^2

Table 7.1.4.1.2 Performance Requirements for Glove Hand Function

Level	Percent Increase Over Barehanded Control
High	≤200
Moderate	≤300
Low	≤600

Table 7.1.4.2.1 Test Loads for Glove Material Cut Resistance

Level	Test Load
High	150 g (5.29 oz)
Moderate	75 g (2.64 oz)
Low	50 g (1.76 oz)

Table 7.1.4.2.2 Performance Requirements for Glove Material Puncture Resistance

Level	Puncture Resistance
High	≥22 N (≥5 lbf)
Moderate	≥15 N (≥3.8 lbf)
Low	≥9 N (≥2 lbf)

7.1.5 Footwear Element Performance Requirements.

7.1.5.1 Full Footwear Performance Requirements.

7.1.5.1.1 Footwear shall be tested for liquidtight integrity as specified in 8.2.3.3 and shall show no leakage.

7.1.5.1.2 Footwear upper materials shall be tested for cut resistance under a load of 350 g (12.35 oz) as specified in 8.5.7 and shall have a blade travel distance of not less than 20 mm (0.8 in.).

7.1.5.1.3 Footwear upper materials shall be tested for puncture resistance as specified in 8.5.8.1 and shall have a puncture resistance of not less than 36 N (8 lbf).

7.1.5.1.4 Footwear soles and heels shall be tested for abrasion resistance as specified in 8.5.9.1 and the volume loss shall be not greater than 250 mm^3.

7.1.5.1.5 Footwear soles and heels shall be tested for slip resistance as specified in 8.6.6 and shall have a coefficient of friction of 0.40 or greater.

7.1.5.1.6 Footwear shall meet the performance requirements specified in ASTM F2413, *Standard Specification for Performance Requirements for Protective (Safety) Toe Cap Footwear*, for impact-, compression-, and puncture-resistant footwear, with the exception of flex resistance to cracking. Testing shall be performed as specified in ASTM F2412, *Standard Test Methods for Foot Protection.*

7.1.5.2 Sock Performance Requirements. Sock materials shall meet the applicable garment materials requirements specified in 7.1.3.

7.1.5.3 Outer Boot Performance Requirements.

7.1.5.3.1 Footwear shall be tested for liquidtight integrity as specified in 8.2.3.3 and shall show no leakage.

7.1.5.3.2 Footwear upper materials shall be tested for cut resistance under a load of 350 g (12.35 oz) as specified in 8.5.7 and shall have a blade travel distance of not less than 20 mm (0.8 in.).

7.1.5.3.3 Footwear upper materials shall be tested for puncture resistance as specified in 8.5.8.1 and shall have a puncture resistance of not less than 36 N (8 lbf).

7.1.5.3.4 Footwear soles and heels shall be tested for abrasion resistance as specified in 8.5.9.2 and the volume loss shall be not greater than 250 mm^3 (327 yd^3).

7.1.5.3.5 Footwear soles and heels shall be tested for slip resistance as specified in 8.6.6 and shall have a coefficient of friction of 0.40 or greater.

7.1.5.3.6 Where specified, footwear shall meet the performance requirements specified in ASTM F2413, *Standard Specification for Performance Requirements for Protective (Safety) Toe Cap Footwear*, for impact-, compression-, and puncture-resistant footwear with the exception of flex resistance to cracking. Testing shall be performed as specified in ASTM F2412, *Standard Test Methods for Foot Protection*.

7.1.5.4 Footwear Cover Performance Requirements.

7.1.5.4.1 Footwear covers shall be tested for liquidtight integrity as specified in 8.2.3.2 and shall show no leakage.

7.1.5.4.2 Footwear cover materials shall be tested for cut resistance under a load of 150 g (5.29 oz) as specified in 8.5.7 and shall have a blade travel distance of not less than 20 mm (0.8 in.).

7.1.5.4.3 Footwear cover materials shall be tested for puncture resistance as specified in 8.5.8.1 and shall have a puncture resistance of not less than 15 N (3.8 lbf).

7.1.5.4.4 Footwear cover materials shall be tested for cold weather performance as specified in 8.5.11.1 and shall have a bending moment of not greater than 0.057 N·m (½ in.·lbf) at an angular deflection of 60 degrees at –25°C (–13°F).

7.1.5.4.5 Footwear cover materials shall be tested for cold weather flexibility as specified in 8.5.11.2 and shall not show a pressure change of more than 100 Pa (2.1 lb/ft^2).

7.1.5.4.6 Footwear cover materials shall be tested for abrasion resistance as specified in 8.5.9.2 and shall show no wear-through after 3000 cycles.

7.1.5.4.7 The wear surface of footwear covers shall be tested for slip resistance as specified in 8.6.6 and shall have a coefficient of friction of 0.40 or greater.

7.1.6 Hood Element Performance Requirements.

7.1.6.1 Materials in the hood element shall meet the applicable garment materials requirements specified in 7.1.3.

7.1.6.2 Where hoods are provided as a separate element that is not attached to the garment, the hood materials shall be permitted to not meet the breathability requirements in 7.1.3.6.

7.1.7 General Flammability and High Heat Performance Requirements.

7.1.7.1 Where specified, garment, visor, glove, and footwear materials shall be tested for resistance to flame impingement as specified in 8.4.1 and shall have an afterflame time of not greater than 2.0 seconds and shall not melt and drip.

7.1.7.2 Where specified, visor, glove, and footwear materials shall be tested for flame break open resistance as specified in 8.4.4 and shall not show a pressure change of more than 100 Pa (2.1 lb/ft^2).

7.1.8 Optional Flash Fire Protection Performance Requirements.

7.1.8.1 Ensembles and garment elements shall be tested for overall flash protection as specified in 8.4.4 and shall meet the following criteria:

(1) Afterflame times shall be no longer than 5 seconds on any part of the ensemble or garment.
(2) Where a hood with a visor is provided, test subjects shall have a visual acuity of 20/100.
(3) Materials and structural seams of the ensembles or garment elements shall not exhibit a material or seam break that creates an opening greater than 51 mm (2 in.) as a result of simulated flash fire exposure.
(4) There shall be no evidence of dripping from any of the ensembles or garment elements.

7.1.8.1.1 Where manufacturers choose to report the predicted average percentage area of a burn injury, testing shall be performed using the options specified in 8.4.3 and provided as part of the technical data package.

7.1.8.2 Garment materials and, where applicable, visor, glove, and footwear materials shall be tested for heat transfer performance (HTP) as specified in 8.4.2 and shall have an average HTP rating as specified in Table 7.1.8.2.

7.1.8.3 Garment materials and, where applicable, visor, glove, footwear, and elastomeric interface materials shall be tested for flame resistance as specified in 8.4.1 and shall meet the following criteria:

(1) Materials shall not burn across a distance greater than 100 mm (4 in.).
(2) Materials shall not burn for more than 2 seconds.
(3) Materials shall not melt and drip.

7.1.9 Optional Stealth Performance Requirements.

7.1.9.1 Garment, glove, footwear, and hood outer materials shall be tested for color/visibility in accordance with 8.7.1 and shall have a Y brightness value less than 25 and an L* value less than 55.

7.1.9.2 Ensembles shall be tested for audible signature as specified in 8.7.2 and the audible signature in dBA shall be reported on both the product label and in the technical data package.

7.2 Specific Performance Requirements for NFPA 1991 Vapor-Protective Ensembles and Elements.

7.2.1 NFPA 1991-certified ensembles and ensemble elements shall be tested in accordance with the general performance requirements in Section 7.1 as specified in Table 7.2.1.

Table 7.1.8.2 Performance Requirements for Heat Transfer Performance

Level	Heat Transfer Performance
High	≥20 cal/cm^2
Moderate	≥8 cal/cm^2

Table 7.2.1 Performance Requirements for NFPA 1991-Certified Ensembles and Ensemble Elements

Requirement	Paragraph(s)	Ensemble	Gloves	Footwear
Ensemble Performance				
Inward vapor leakage	7.1.1.1.1	Ultrahigh	—	—
Liquid integrity	7.1.1.1.2	Ultrahigh	—	—
Overall function and integrity	7.1.1.1.4	Ultrahigh	—	—
Airflow capacity	7.1.1.1.5 7.1.1.1.5.1	Yes	—	—
Exhaust valve inward leakage	7.1.1.2.1	Yes	—	—
Exhaust valve mounting strength	7.1.1.2.2	Yes	—	—
External fitting integrity	7.1.1.3.1	Yes	—	—
External fitting pull-out strength, tethered	7.1.1.3.3	As applicable	—	—
External fitting pull-out strength, non-tethered	7.1.1.3.4	As applicable	—	—
Material and Seam Barrier Performance				
Ultrahigh permeation resistance	7.1.2.1	Yes, for chemicals specified in 7.2.2		
Chemical warfare agent permeation resistance	7.1.2.3.1 7.1.2.3.2	Yes		
Liquid chemical penetration resistance	7.1.2.5.1	Yes *(See 7.2.3.)*	—	—
Garment Performance				
Material burst strength	7.1.3.2.1	High	—	—
Material puncture propagation tear resistance	7.1.3.2.2	High	—	—
Material cold temperature bending	7.1.3.2.3	Yes	—	—
Seam strength	7.1.3.3.1	High	—	—
Closure strength	7.1.3.3.2	High	—	—

(continues)

Table 7.2.1 *Continued*

Requirement	Paragraph(s)	Ensemble	Gloves	Footwear
Visor Performance				
High-mass impact resistance	7.1.3.4.1	Yes	—	—
Cold temperature bending	7.1.3.4.2	Yes	—	—
Elastomeric Interface Material Performance				
Elongation	7.1.3.5.1	As applicable	—	—
Cut resistance	7.1.3.5.2	As applicable	—	—
Puncture resistance	7.1.3.5.3	As applicable	—	—
Ultimate tensile strength	7.1.3.5.4	As applicable	—	—
Cold temperature bending	7.1.3.5.5	As applicable	—	—
Glove Performance				
Liquidtight integrity	7.1.4.1.1	Yes	Yes	—
Hand function	7.1.4.1.2	Low	Low	—
Cut resistance	7.1.4.2.1	High	High	—
Puncture resistance	7.1.4.2.2	High	High	—
Cold temperature bending	7.1.4.2.3	Yes	Yes	—
Footwear Performance				
Full Footwear Performance				
Liquidtight integrity	7.1.5.1.1	If used	—	Yes
Upper cut resistance	7.1.5.1.2	If used	—	Yes
Upper puncture resistance	7.1.5.1.3	If used	—	Yes
Sole/heel abrasion resistance	7.1.5.1.4	If used	—	Yes
Sole/heel slip resistance	7.1.5.1.5	If used	—	Yes
ASTM F2413 compliance	7.1.5.1.6	If used	—	Yes
Sock Performance				
General requirements	7.1.5.2.1	As applicable	—	—
Outer Boot Performance				
Liquidtight integrity	7.1.5.3.1	If used	—	—

(continues)

Table 7.2.1 *Continued*

Requirement	Paragraph(s)	Ensemble	Gloves	Footwear
Upper cut resistance	7.1.5.3.2	If used	—	—
Upper puncture resistance	7.1.5.3.3	If used	—	—
Sole/heel abrasion resistance	7.1.5.3.4	If used	—	—
Sole/heel slip resistance	7.1.5.3.5	If used	—	—
ASTM F2413 compliance	7.1.5.3.6	If used	—	—
General Flammability and High Heat Performance Requirements				
Flame impingement resistance	7.1.7.1	Yes	Yes	Yes
Flame break open resistance	7.1.7.2	Yes	Yes	Yes
Overall flash protection				
Overall flash fire protection	7.1.8.1	Optional	Optional	Optional
Material heat transfer performance	7.1.8.2	Optional (moderate)	Optional (moderate)	Optional (moderate)
Flame resistance	7.1.8.3	Optional	Optional	Optional
Stealth Performance				
Color/visibility	7.1.9.1	Optional	—	—
Acoustic signature	7.1.9.2	Optional	—	—

7.2.2 Garment, visor, glove, footwear, hood, and elastomeric interface materials and seams in and between elements and components shall be tested for ultrahigh permeation resistance against the following chemicals:

(1) The following chemicals shall be tested as gases:
   (a) Ammonia, anhydrous (NH_3), CAS No. 7664-41-7, >95 percent, w/w
   (b) 1,3-Butadiene, CAS No. 106-99-0, >95 percent, w/w
   (c) Chlorine (Cl_2), CAS No. 7782-50-5, >95 percent, w/w
   (d) Ethylene oxide (ETO), CAS No. 75-21-8, >95 percent, w/w
   (e) Hydrogen chloride (HCl), CAS No. 7647-01-0, >95 percent, w/w
   (f) Methyl chloride, CAS No. 74-87-3, >95 percent, w/w
(2) The following chemicals shall be tested as liquids:
   (a) Acetone, CAS No. 67-64-1, >95 percent, w/w
   (b) Acetonitrile, CAS No. 75-05-8, >95 percent, w/w
   (c) Acrolein (allyl aldehyde), CAS No. 107-02-8, >95 percent, w/w
   (d) Acrylonitrile (VCN, cyanoethylene), CAS No. 107-13-1, >95 percent, w/w
   (e) Carbon disulfide, CAS No. 75-15-0, >95 percent, w/w
   (f) Dichloromethane, CAS No. 75-09-2, >95 percent, w/w
   (g) Diethylamine, CAS No. 109-89-7, >95 percent, w/w
   (h) Dimethylformamide (DMF), CAS No. 68-12-2, >95 percent, w/w
   (i) Dimethyl sulfate (DMS, sulfuric acid dimethyl ester), CAS No. 77-78-1, >95 percent, w/w
   (j) Ethyl acetate (acetic ether, acetic ester), CAS No. 141-78-6, >95 percent, w/w
   (k) Hexane, CAS No. 110-54-3, >95 percent, w/w
   (l) Methanol, CAS No. 67-56-1, >95 percent, w/w
   (m) Nitrobenzene, CAS No. 98-95-3, >95 percent, w/w
   (n) Sodium hydroxide, CAS No. 1310-73-2, 50 percent, w/w

(o) Sulfuric acid, CAS No. 7664-93-9, 93.1 percent, w/w
(p) Tetrachloroethylene (perchloroethylene), CAS No. 127-18-4, >95 percent, w/w
(q) Tetrahydrofuran (THF), CAS No. 109-99-9, >95 percent, w/w
(r) Toluene (toluol), CAS No. 108-88-3, >95 percent, w/w

7.2.3 Garment closure assemblies shall be tested for chemical penetration resistance as specified in 8.3.3 and shall show no penetration of the following liquid chemicals for at least 1 hour and of any additional chemicals or specific chemical mixtures for which the manufacturer is certifying the garment:

(1) Acetone, CAS No. 67-64-1, >95 percent, w/w
(2) Acetonitrile, CAS No. 75-05-8, >95 percent, w/w
(3) Carbon disulfide, CAS No. 75-15-0, >95 percent, w/w
(4) Dichloromethane, CAS No. 75-09-2, >95 percent, w/w
(5) Diethylamine, CAS No. 109-89-7, >95 percent, w/w
(6) Dimethylformamide (DMF), CAS No. 68-12-2, >95 percent, w/w
(7) Ethyl acetate (acetic ether, acetic ester), CAS No. 141-78-6, >95 percent, w/w
(8) Hexane, CAS No. 110-54-3, >95 percent, w/w
(9) Methanol, CAS No. 67-56-1, >95 percent, w/w
(10) Nitrobenzene, CAS No. 98-95-3, >95 percent, w/w
(11) Sodium hydroxide, CAS No. 1310-73-2, 50 percent, w/w
(12) Sulfuric acid, CAS No. 7664-93-9, 93.1 percent, w/w
(13) Tetrachloroethylene (perchloroethylene), CAS No. 127-18-4, >95 percent, w/w
(14) Tetrahydrofuran (THF), CAS No. 109-99-9, >95 percent, w/w
(15) Toluene (toluol), CAS No. 108-88-3, >95 percent, w/w

7.2.4 Optional Liquefied Gas Protection Performance Requirements. NFPA 1991-certified garment, glove, and footwear element materials shall be tested for liquefied gas permeation resistance as specified in 8.3.1.1 and shall not show signs of damage nor exceed a cumulative permeation of 60 mg/m^2 (6.0 $\mu g/cm^2$) for the following list of gaseous industrial chemicals:

(1) Ammonia, anhydrous (NH_3), CAS No. 7664-41-7, >95 percent, w/w
(2) Chlorine (Cl_2), CAS No. 7782-50-5, >95 percent, w/w
(3) Ethylene oxide (ETO), CAS No. 75-21-8, >95 percent, w/w

7.3 Specific Requirements for NFPA 1992 Liquid Splash-Protective Ensembles and Elements.

7.3.1 NFPA 1992-certified ensembles and ensemble elements shall be tested to the general performance requirements in Section 7.1 as specified in Table 7.3.1.

7.3.2 NFPA 1992-certified garment, visor, glove, footwear, hood, and elastomeric interface materials shall be tested for ultrahigh permeation resistance against the following liquid chemicals:

(1) Butyl acetate, CAS No. 123-86-4, >95 percent, w/w
(2) Dimethylformamide (DMF), CAS No. 68-12-2, >95 percent, w/w
(3) Fuel H — surrogate gasoline (42.5 percent toluene, 42.5 percent isooctane, and 15 percent denatured ethanol, v/v), as defined in ASTM D471, *Standard Test Method for Rubber Property — Effect of Liquids*
(4) Isopropyl alcohol, CAS No. 67-63-0, >91 percent, w/w
(5) Methyl isobutyl ketone, CAS No. 108-10-1, >95 percent, w/w
(6) Nitrobenzene, CAS No. 98-95-3, >95 percent, w/w
(7) Sodium hydroxide, CAS No. 1310-73-2, 50 percent, w/w
(8) Sodium hypochlorite, 10 percent (made within 72 hours of use), w/w
(9) Sulfuric acid, CAS No. 7664-93-9, 93.1 percent, w/w
(10) Tetrachloroethylene (perchloroethylene), CAS No. 127-18-4, >95 percent, w/w

7.3.3 NFPA 1992-certified garment, visor, glove, footwear, hood, and elastomeric interface seams in and between elements and components shall be tested for ultrahigh permeation resistance against the following chemicals:

(1) Fuel H — surrogate gasoline (42.5 percent toluene, 42.5 percent isooctane, and 15 percent denatured ethanol, v/v), as defined in ASTM D471, *Standard Test Method for Rubber Property — Effect of Liquids*
(2) Methyl isobutyl ketone, CAS No. 108-10-1, >95 percent, w/w
(3) Sulfuric acid, CAS No. 7664-93-9, 93.1 percent, w/w

7.3.4 Where the manufacturer designates NFPA 1992-certified garments or hoods as "breathable," the following shall apply *(see A.7.1.3.6.1)*:

(1) The total heat loss shall be measured for the garment and hood materials in the ensemble as specified in 8.6.4.1 and meet at least the "Low" level of performance specified in Table 7.1.3.6.1.
(2) The evaporative resistance shall be measured for the garment and hood material in the ensemble as specified in 8.6.4.2 and meet the performance requirement specified in 7.1.3.6.2.
(3) The results for the total heat loss and evaporative resistance shall be provided in the technical data package.
(4) "Breathable (see manufacturer's technical data package)" shall be added to the product label as specified in 5.3.1.1.1.

7.3.5 Where socks are used as part of a NFPA 1992-certified ensemble and the manufacturer permits the use of any outer boot of the footwear element that is certified to NFPA 1951, NFPA 1971, NFPA 1991, NFPA 1992, or NFPA 1999, the outer boot of the footwear element shall meet the minimum height requirement specified in 6.1.5.4 and cut resistance performance requirement specified in 7.1.5.1.2 and 7.1.5.3.2.

7.4 Specific Requirements for NFPA 1994 Hazardous Materials Emergencies and CBRN Terrorism Incidents.

7.4.1 NFPA 1994-certified ensembles shall be tested to the general performance requirements of Section 7.1 as specified in Table 7.4.1.

Table 7.3.1 Performance Requirements for NFPA 1992-Certified Ensembles and Ensemble Elements

Requirement	Paragraph(s)	Ensemble	Garment	Gloves	Footwear	Hoods
Ensemble Performance						
Liquid integrity	7.1.1.1.2	High	—	—	—	—
Overall function and integrity	7.1.1.1.4	High	—	—	—	—
Airflow capacity	7.1.1.1.5 7.1.1.1.5.2	As applicable	—	—	—	—
Exhaust valve mounting strength	7.1.1.2.2	As applicable	—	—	—	—
External fitting integrity	7.1.1.3.2	As applicable	—	—	—	—
External fitting pull-out strength, tethered	7.1.1.3.3	As applicable	—	—	—	—
External fitting pull-out strength, non-tethered	7.1.1.3.4	As applicable	—	—	—	—
Material and Seam Barrier Performance						
Liquid chemical penetration resistance	7.1.2.5	Yes, for chemicals specified in 7.3.2 and 7.3.3				
Garment Performance						
Overall function and integrity	7.1.3.1.1	Addressed in 7.1.1.1.4	Yes	—	—	—
Material burst strength	7.1.3.2.1	Low	Low	—	—	—
Material puncture propagation tear resistance	7.1.3.2.2	Low	Low	—	—	—
Material cold temperature bending	7.1.3.2.3	Yes	Yes	—	—	—
Seam strength	7.1.3.3.1	Moderate	Moderate	—	—	—
Closure strength	7.1.3.3.2	Moderate	Moderate	—	—	—
Visor Performance						
High-mass impact resistance	7.1.3.4.1	If present	If present	—	—	—
Cold temperature bending	7.1.3.4.2	If present	If present	—	—	—
Elastomeric Interface Material Performance						
Elongation	7.1.3.5.1	If present	If present	—	—	—
Cut resistance	7.1.3.5.2	If present	If present	—	—	—
Puncture resistance	7.1.3.5.3	If present	If present	—	—	—
Ultimate tensile strength	7.1.3.5.4	If present	If present	—	—	—
Cold temperature bending	7.1.3.5.5	If present	If present	—	—	—

(continues)

Table 7.3.1 *Continued*

Requirement	Paragraph(s)	Ensemble	Garment	Gloves	Footwear	Hoods
Garment Material Breathability Performance						
Total heat loss	7.1.3.6.1	Moderate (report only if breathability is claimed per 7.3.4)	Moderate (report only if breathability is claimed per 7.3.4)	—	—	—
Evaporative resistance	7.1.3.6.2	Yes (report only if breathability is claimed per 7.3.4)	Yes (report only if breathability is claimed per 7.3.4)	—	—	—
Glove Performance						
Liquidtight integrity	7.1.4.1.1	Yes	—	Yes	—	—
Hand function	7.1.4.1.2	High	—	High	—	—
Cut resistance	7.1.4.2.1	Low	—	Low	—	—
Puncture resistance	7.1.4.2.2	Low	—	Low	—	—
Cold temperature bending	7.1.4.2.3	Yes	—	Yes	—	—
Footwear Performance						
Full Footwear Performance						
Liquidtight integrity	7.1.5.1.1	If used	—	—	Yes	—
Upper cut resistance	7.1.5.1.2	If used	—	—	Yes	—
Upper puncture resistance	7.1.5.1.3	If used	—	—	Yes	—
Sole/heel abrasion resistance	7.1.5.1.4	If used	—	—	Yes	—
Sole/heel slip resistance	7.1.5.1.5	If used	—	—	Yes	—
ASTM F2413 compliance	7.1.5.1.6	If used	—	—	Yes	—
Sock Performance						
General requirements	7.1.5.2.1	If used	As applicable	—	—	—
Outer Boot Performance						
Liquidtight integrity	7.1.5.3.1	If used	—	—	Yes	—
Upper cut resistance	7.1.5.3.2	If used	—	—	Yes	—
Upper puncture resistance	7.1.5.3.3	If used	—	—	Yes	—
Sole/heel abrasion resistance	7.1.5.3.4	If used	—	—	Yes	—
Sole/heel slip resistance	7.1.5.3.5	If used	—	—	Yes	—
ASTM F2413 compliance	7.1.5.3.6	If used	—	—	Yes	—
Footwear Cover Performance						
Liquidtight integrity	7.1.5.4.1	If used	—	—	Yes	—

(continues)

Table 7.3.1 *Continued*

Requirement	Paragraph(s)	Ensemble	Garment	Gloves	Footwear	Hoods
Upper cut resistance	7.1.5.4.2	If used	—	—	Yes	—
Upper puncture resistance	7.1.5.4.3	If used	—	—	Yes	—
Cold temperature bending	7.1.5.4.4	If used	—	—	Yes	—
Abrasion resistance	7.1.5.4.6	If used	—	—	Yes	—
Slip resistance	7.1.5.4.7	If used	—	—	Yes	—
Hood Performance						
General requirements	7.1.6.1	As applicable	As applicable	—	—	Yes
Overall Flash Protection Performance						
Overall flash fire protection	7.1.8.1	Optional	Optional	—	—	—
Material heat transfer performance	7.1.8.2	Optional (moderate)	Optional (moderate)	—	—	—
Flame resistance	7.1.8.3	Optional	Optional	—	—	—
Stealth Performance						
Color/visibility	7.1.9.1	Optional	—	—	—	—
Acoustic signature	7.1.9.2	Optional	—	—	—	—

7.4.2 NFPA 1994-certified Class 1 garment, visor, glove, footwear, hood, and elastomeric interface materials shall be tested for toxic industrial chemical permeation resistance against the following chemicals:

(1) The following toxic industrial chemicals shall be tested as gases or vapors:
   (a) Acrolien (allyl aldehyde), CAS No. 107-02-8, >95 percent, w/w
   (b) Acrylonitrile (VCN, cyanoethylene), CAS No. 107-13-1, >95 percent, w/w
   (c) Ammonia, anhydrous (NH_3), CAS No. 7664-41-7, >95 percent, w/w
   (d) Chlorine (Cl_2), CAS No. 7782-50-5, >95 percent, w/w
   (e) Diethylamine, CAS No. 109-89-7, >95 percent, w/w
   (f) Ethyl acetate (acetic ether, acetic ester), CAS No. 141-78-6, >95 percent, w/w
(2) The following toxic industrial chemicals shall be tested as liquids:
   (a) Dimethyl sulfate (DMS, sulfuric acid dimethyl ester), CAS No. 77-78-1, >95 percent, w/w
   (b) Tetrachloroethylene (perchloroethylene), CAS No. 127-18-4, >95 percent, w/w
   (c) Toluene (toluol), CAS No. 108-88-3, >95 percent, w/w

7.4.3 NFPA 1994-certified Class 2 and Class 3 garment, visor, glove, footwear, hood, and elastomeric interface materials shall be tested for toxic industrial chemical permeation resistance against the following chemicals:

(1) The following toxic industrial chemicals shall be tested as gases or vapors:
   (a) Acrolein (allyl aldehyde), CAS No. 107-02-8, >95 percent, w/w
   (b) Acrylonitrile (VCN, cyanoethylene), CAS No. 107-13-1, >95 percent, w/w
   (c) Ammonia, anhydrous (NH_3), CAS No. 7664-41-7, >95 percent, w/w
   (d) Chlorine (Cl_2), CAS No. 7782-50-5, >95 percent, w/w
(2) The toxic industrial chemical dimethyl sulfate (DMS, sulfuric acid dimethyl ester), CAS No. 77-78-1, >95 percent, w/w, shall be tested as liquid.

7.4.4 NFPA 1994-certified Class 1 garment, visor, glove, footwear, hood, and elastomeric interface materials shall be tested for low vapor pressure chemical permeation resistance against sulfuric acid, CAS No. 7664-93-9, 93.1 percent, w/w.

7.4.5 If used as part of a sock, NFPA 1994-certified Class 1 garment materials shall be tested for bursting strength as specified in 8.5.1 and shall have a bursting strength of not less than 156 N (35 lbf).

7.4.6 If used as part of a sock, NFPA 1994-certified Class 1 garment materials shall be tested for puncture propagation tear resistance as specified in 8.5.2 and shall have a puncture propagation tear resistance of not less than 31 N (7 lbf).

7.4.7 If used as part of a sock, NFPA 1994-certified Class 2R garment materials shall be tested for bursting strength as specified in 8.5.1 and shall have a bursting strength of not less than 156 N (35 lbf).

Table 7.4.1 Performance Requirements for NFPA 1994-Certified Ensembles

Requirement	Paragraph(s)	Class 1	Class 2 and Class 2R	Class 3 and Class 3R	Class 4 and Class 4R	Class 5
Ensemble Performance						
Inward vapor leakage	7.1.1.1.1	High	Moderate	Low	—	—
Liquid integrity	7.1.1.1.2	High	High	Moderate	Low	—
Inward particle leakage	7.1.1.1.3	—	—	—	Yes	—
Overall function and integrity	7.1.1.1.4	High	High	Moderate	Low	—
Airflow capacity	7.1.1.1.5 7.1.1.1.5.2	Yes, if encapsulating	—	—	—	—
Exhaust valve inward leakage	7.1.1.2.1	As applicable	As applicable	As applicable	As applicable	—
Exhaust valve mounting strength	7.1.1.2.2	As applicable	As applicable	As applicable	As applicable	—
External fitting integrity (gastight integrity)	7.1.1.3.1	As applicable	—	—	—	—
External fitting integrity (liquidtight integrity)	7.1.1.3.2	—	As applicable	As applicable	As applicable	—
External fitting pull-out strength, tethered	7.1.1.3.3	As applicable	As applicable	As applicable	As applicable	—
External fitting pull-out strength, non-tethered	7.1.1.3.4	As applicable	As applicable	As applicable	As applicable	—
Material and Seam Barrier Performance						
Toxic industrial chemical permeation resistance	7.1.2.2	Yes, for chemicals specified in 7.4.2	Yes, for chemicals specified in 7.4.3	Yes, for chemicals specified in 7.4.3	—	—
Chemical warfare agent permeation resistance	7.1.2.3.1 7.1.2.3.2	Yes	Yes	Yes	—	—
Low vapor pressure chemical permeation resistance	7.1.2.4	Yes, for chemical specified in 7.4.4	—	—	—	—
Viral penetration resistance	7.1.2.6	—	Yes	Yes	Yes	—
Liquid repellency resistance	7.1.2.7	—	—	—	—	Yes
Garment Performance						
Material burst strength	7.1.3.2.1	High	Moderate High (Class 2R)	Low Moderate (Class 3R)	Low Moderate (Class 4R)	—
Material puncture propagation tear resistance	7.1.3.2.2	High	Moderate High (Class 2R)	Low Moderate (Class 3R)	Low Moderate (Class 4R)	—
Material cold temperature bending	7.1.3.2.3	Yes	Yes	Yes	Yes	—

(continues)

Table 7.4.1 *Continued*

Requirement	Paragraph(s)	Class 1	Class 2 and Class 2R	Class 3 and Class 3R	Class 4 and Class 4R	Class 5
Seam strength	7.1.3.3.1	High	Moderate	Moderate	Moderate	—
Closure strength	7.1.3.3.2	High	Moderate	Moderate	Moderate	—
Visor Performance						
High-mass impact resistance	7.1.3.4.1	Yes	Yes	Yes	Yes	—
Cold temperature bending	7.1.3.4.2	Yes	Yes	Yes	Yes	—
Elastomeric Interface Material Performance						
Elongation	7.1.3.5.1	As applicable	As applicable	As applicable	As applicable	—
Cut resistance	7.1.3.5.2	As applicable	As applicable	As applicable	As applicable	—
Puncture resistance	7.1.3.5.3	As applicable	As applicable	As applicable	As applicable	—
Ultimate tensile strength	7.1.3.5.4	As applicable	As applicable	As applicable	As applicable	—
Cold temperature bending	7.1.3.5.5	As applicable	As applicable	As applicable	As applicable	—
Garment Material Breathability Performance						
Total heat loss	7.1.3.6.1	—	Moderate (report only if breathability is claimed per 7.3.4)	Low	High	High
Evaporative resistance	7.1.3.6.2	—	Yes (report only if breathability is claimed per 7.3.4)	Yes	Yes	Yes
Glove Performance						
Liquidtight integrity	7.1.4.1.1	Yes	Yes	Yes	Yes	Yes
Hand function	7.1.4.1.2	Moderate	Moderate	High	High	Moderate
Cut resistance	7.1.4.2.1	Moderate	Moderate	Low	Low	High
Puncture resistance	7.1.4.2.2	Moderate	Moderate	Low	Low	High
Cold temperature bending	7.1.4.2.3	Yes	Yes	Yes	Yes	Yes
Footwear Performance						
Full Footwear Performance						
Liquidtight integrity	7.1.5.1.1	Yes	Yes	Yes	Yes	Yes
Upper cut resistance	7.1.5.1.2	Yes	Yes	Yes	Yes	Yes
Upper puncture resistance	7.1.5.1.3	Yes	Yes	Yes	Yes	Yes
Sole/heel abrasion resistance	7.1.5.1.4	Yes	Yes	Yes	Yes	Yes
Sole/heel slip resistance	7.1.5.1.5	Yes	Yes	Yes	Yes	Yes
ASTM F2413 compliance	7.1.5.1.6	Yes	Yes	—	—	Yes

(continues)

Table 7.4.1 *Continued*

Requirement	Paragraph(s)	Class 1	Class 2 and Class 2R	Class 3 and Class 3R	Class 4 and Class 4R	Class 5
Sock Performance						
General requirements	7.1.5.2.1	As applicable	As applicable	As applicable	As applicable	As applicable
Outer Boot Performance						
Liquidtight integrity	7.1.5.1.1	Yes	Yes	Yes	Yes	Yes
Upper cut resistance	7.1.5.1.2	Yes	Yes	Yes	Yes	Yes
Upper puncture resistance	7.1.5.1.3	Yes	Yes	Yes	Yes	Yes
Sole/heel abrasion resistance	7.1.5.1.4	Yes	Yes	Yes	Yes	Yes
Sole/heel slip resistance	7.1.5.1.5	Yes	Yes	Yes	Yes	Yes
ASTM F2413 compliance	7.1.5.1.6	Yes	Yes	—	—	Yes
Footwear Cover Performance						
Liquidtight integrity	7.1.5.4.1	If used	If used	If used	If used	If used
Upper cut resistance	7.1.5.4.2	If used	If used	If used	If used	If used
Upper puncture resistance	7.1.5.4.3	If used	If used	If used	If used	If used
Cold temperature bending	7.1.5.4.4	If used	If used	If used	If used	If used
Abrasion resistance	7.1.5.4.6	If used	If used	If used	If used	If used
Slip resistance	7.1.5.4.7	If used	If used	If used	If used	If used
General Flammability and High Heat Performance Requirements						
Flame impingement resistance	7.1.7.1	Yes, for garment, visor, glove, full footwear, outer boot, and hood, as applicable	—	—	—	—
Flame break open resistance	7.1.7.2	Yes, for garment, visor, glove, full footwear, outer boot, and hood, as applicable	—	—	—	—
Overall flash protection						
Overall flash fire protection	7.1.8.1	Optional	Optional	Optional	Optional	Yes
Material heat transfer performance	7.1.8.2	Optional, Moderate	Optional, Moderate	Optional, Moderate	Optional, Moderate	High
Flame resistance	7.1.8.3	Optional	Optional	Optional	Optional	Yes
Stealth Performance						
Color/visibility	7.1.9.1	Optional	Optional	Optional	Optional	Optional
Acoustic signature	7.1.9.2	Optional	Optional	Optional	Optional	Optional

7.4.8 If used as part of a sock, NFPA 1994-certified Class 2R garment materials shall be tested for puncture propagation tear resistance as specified in 8.5.2 and shall have a puncture propagation tear resistance of not less than 31 N (7 lbf).

7.4.9 Where the manufacturer designates the garment and hood portions of NFPA 1994-certified Class 2 and Class 2R ensembles as "breathable," the following shall apply *(see A.7.1.3.6.1)*:

(1) The total heat loss shall be measured for the garment and hood materials in the ensemble as specified in 8.6.4.1 and meet at least the "Low" level of performance specified in Table 7.1.3.6.1.
(2) The evaporative resistance shall be measured for the garment and hood material in the ensemble as specified in 8.6.4.2 and meet the performance requirement specified in 7.1.3.6.2.
(3) The results for the total heat loss and evaporative resistance shall be provided in the technical data package.
(4) "Breathable (see manufacturer's technical data package)" shall be added to the product label as specified in 5.4.1.3.

7.4.10 Where socks are used as part of a NFPA 1992-certified ensemble and the manufacturer permits the use of any outer boot of the footwear element that is certified to NFPA 1951, NFPA 1971, NFPA 1991, NFPA 1992, or NFPA 1999, the outer boot of the footwear element shall meet the minimum height requirement specified in 6.1.5.4 and cut resistance performance requirement specified in 7.1.5.1.2 and 7.1.5.3.2.

7.4.11 Class 5 garments shall meet the performance requirements specified for technical rescue protective ensemble garment elements specified in Section 7.1 of NFPA 1951.

7.4.11.1 Class 5 garments shall be permitted to meet the optional performance requirements for blood-born pathogen protective technical rescue garments specified in Section 7.2 of NFPA 1951.

Chapter 8 Test Methods

8.1 Sample Preparation Procedures.

8.1.1 Application.

8.1.1.1 The sample preparation procedures contained in this section shall apply to each test method in this chapter as specifically referenced in the sample preparation section of each test method.

8.1.1.2 Only the specific sample preparation procedure(s) referenced in the sample preparation section of each test method shall be applied to that test method.

8.1.2 Room Temperature Conditioning Procedure.

8.1.2.1 Samples shall be conditioned at a temperature of 21°C ± 3°C (70°F ± 5°F) and a relative humidity of 65 percent ± 5 percent until equilibrium is reached, as specified in ASTM D1776/D1776M, *Standard Practice for Conditioning and Testing Textiles*, or for at least 24 hours, whichever is shorter.

8.1.2.2 Specimens shall be tested within 5 minutes after removal from conditioning.

8.1.3 Flexural Fatigue Procedure for Garment Materials.

8.1.3.1 Samples shall be subjected to flexural fatigue in accordance with ASTM/F392M F392, *Standard Practice for Conditioning Flexible Barrier Materials for Flex Durability*, with the following modifications:

(1) In lieu of the flexing conditions provided by ASTM F392/F392M, test specimens for class types other than Class Type R shall have a flex period of 100 cycles at 45 cycles per minute. A cycle shall be full flex and twisting action.
(2) In lieu of the flexing conditions provided by ASTM F392/F392M, test specimens for Class Type R shall have a flex period of 1000 cycles at 45 cycles per minute. A cycle shall be a full flex and twisting action.
(3) Anisotropic materials shall be tested in both machine and transverse directions.
(4) Samples for flexing shall consist of all the layers of garment material in the proper order in which they appear in the ensemble with the outermost layer facing the outside during flex conditioning.

8.1.3.2 Preconditioning shall be performed according to the sequence specified in the test methods of this chapter.

8.1.4 Abrasion Procedure. Samples shall be abraded in accordance with ASTM D4157, *Standard Test Method for Abrasion Resistance of Textile Fabrics (Oscillatory Cylinder Method)*, under the following conditions:

(1) The tension weight used shall be 2.3 kg (5 lb).
(2) The head weight used shall be 1.6 kg (3.5 lb).
(3) The abradant types shall be as follows:
    (a) For NFPA 1991-compliant ensembles, the abradant for the outer surface shall be 80 grit abradant trimite open coat or equivalent.
    (b) For NFPA 1992- and NFPA 1994-compliant elements, the abradant shall be 600 grit ultrafine silicon carbide.
(4) The specimen shall be as shown in Figure 8.1.4.
(5) The abrasion cycles shall be as follows:
    (a) For NFPA 1991- and NFPA 1992-compliant ensembles, the outer surface shall be abraded for 25 continuous cycles.
    (b) NFPA 1994-compliant ensemble elements shall be as follows:
        i. Standard class type specimens shall be abraded for 10 continuous cycles.
        ii. Class Type R specimens shall be abraded for 100 continuous cycles.
(6) If the element sample consists of separable layers, all the layers shall be subjected to abrasion conditioning with the outermost layer as the exterior layer.

8.1.5 Flexural Fatigue Procedure for Gloves.

8.1.5.1 Sample gloves shall be subjected to one full cycle of testing for hand function as specified in 8.6.5.

8.1.5.2 All glove material layers shall be present during flex conditioning.

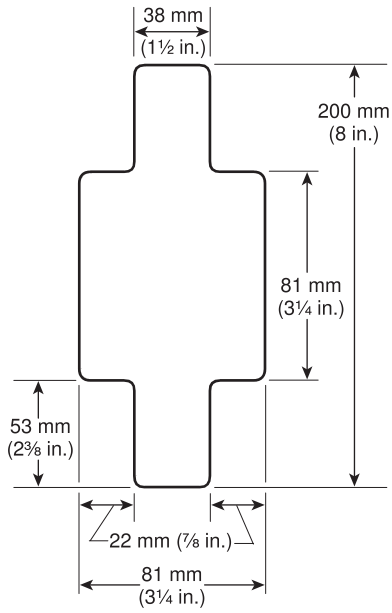


FIGURE 8.1.4 Specimen Configuration.

8.1.6 Flexural Fatigue Procedure for Footwear. Sample footwear shall be subjected to 100,000 flexes in accordance with Appendix B of FIA 1209, *Whole Shoe Flex*, with the following modifications:

(1) Water shall not be used.
(2) The flex speed shall be 60 ± 2 cycles per minute.
(3) Alternative flexing equipment shall be permitted to be used if it meets the following parameters:
    (a) It provides the angle of flex as described in FIA 1209.
    (b) It is capable of a flex speed of 60 ± 2 cycles per minute.
    (c) It provides a means of securing the footwear during flexing.

8.1.7 Fatigue Procedure for Garment Closure Assemblies. Sample garment closure assemblies shall be exercised a total of 50 openings and 50 closings.

8.1.8 Embrittlement Procedure for Garment, Visor, Glove, and Footwear Materials. Sample garment, visor, glove, and footwear materials shall be embrittled in accordance with ASTM D2136, *Standard Test Method for Coated Fabrics — Low-Temperature Bend Test*, with the following modifications:

(1) Embrittlement shall be conducted in a freezer having a temperature no higher than –25°C (–13°F).
(2) The material sample shall first be placed on a flat sheet of dry ice with the outer surface of the material in contact with the dry ice for a period of 15 minutes under a pressure of 3.5 kPa (½ psi).
(3) The material sample shall be removed from the dry ice after 15 minutes of contact and immediately placed in the test apparatus.
(4) The bending action of the test apparatus shall be immediately activated while the sample is still in the freezer.

8.1.9 Elevated Temperature and Humidity Conditioning Procedure.

8.1.9.1 Samples or specimens shall be conditioned at a temperature of 32°C ± 2°C (90°F ± 4°F) and a relative humidity of 80 percent ± 5 percent until equilibrium is reached as specified in ASTM D1776/D1776M, *Standard Practice for Conditioning and Testing Textiles*, or for at least 24 hours, whichever is shorter.

8.1.9.2 Specimens shall be tested within 5 minutes after removal from conditioning.

8.1.10 NFPA 1994-Compliant Class Type R Ensemble Preconditioning Procedure.

8.1.10.1 Samples shall be washed and dried alternately for a total of five washing cycles and five drying cycles.

8.1.10.2 Samples shall be washed and dried with all closures fastened.

8.1.10.3 A front-loading washer/extractor shall be used for washing the samples.

8.1.10.4 The wash load shall be two-thirds the rated capacity of the washer.

8.1.10.4.1 If ballast is needed to reach two-thirds capacity, ballast shall be used.

8.1.10.4.2 Two-thirds of the rated capacity shall not be exceeded.

8.1.10.5 The wash cycle procedure in Table 8.1.10.5 shall be followed.

8.1.10.6 A tumble dryer with a dry stack temperature of 38°C to 49°C (100°F to 120°F) measured 20 minutes into the drying cycle shall be used for drying the samples.

8.1.10.7 Samples shall be removed from the dryer after 20 minutes of tumble drying. At the conclusion of the final drying cycle, the sample shall be allowed to dry completely for at least 48 hours in accordance with 8.1.2.

8.2 Integrity Tests.

8.2.1 Gastight Integrity Test.

8.2.1.1 Application. This test method shall apply to NFPA 1991- and NFPA 1994-compliant encapsulating Class 1 ensembles.

8.2.1.2 Samples.

8.2.1.2.1 Samples shall be complete NFPA 1991– or NFPA 1994-compliant Class 1 ensembles.

8.2.1.2.2 Samples shall be conditioned as specified in 8.1.2.

8.2.1.3 Specimens.

8.2.1.3.1 Specimens shall be complete NFPA 1991– or NFPA 1994-compliant Class 1 ensembles.

8.2.1.3.2 At least three specimens shall be tested.

8.2.1.4 Procedure.

8.2.1.4.1 Specimens shall be tested in accordance with ASTM F1052, *Standard Test Method for Pressure Testing Vapor Protective Suits*.

Table 8.1.10.5 Wash Cycle Procedure for Type R Ensembles

Operation	Time (min)	Temperature °C ± 3°C	Temperature °F ± 5°F	Water Level
Suds using AATCC detergent #1993, 1.0 g/4 L (1 gal) water	—	—	—	—
Drain	1	—	—	—
Carryover	5	49	120	Low
Drain	1	—	—	—
Rinse	2	38	100	High
Drain	1	—	—	—
Rinse	2	38	100	High
Drain	1	—	—	—
Rinse	2	38	100	High
Drain	1	—	—	—
Extract	5	—	—	—

8.2.1.4.2 The following pressures shall be used during testing:

(1) Pre-test expansion pressure of 125 mm (5 in.) water gauge
(2) Test pressure of 100 mm (4 in.) water gauge

8.2.1.4.3 Where the ensemble is nonencapsulating, devices or plugs described in ASTM F1052, *Standard Test Method for Pressure Testing Vapor Protective Suits*, shall be used to seal off open areas, such as the opening of a hood for a respirator facepiece. The laboratory shall be permitted to use an appropriate fixture for isolating the area of the ensemble where the specific external fitting is installed for the evaluation.

8.2.1.5 Report. The ending pressure shall be recorded and reported for each specimen.

8.2.1.6 Interpretation.

8.2.1.6.1 The ending pressure shall be used to determine pass or fail performance.

8.2.1.6.2 Failure of the test by any one specimen shall constitute failure of the test as a whole.

8.2.2 Man-in-Simulant Test (MIST).

8.2.2.1 Application. This test shall apply to complete vapor-protective ensembles at all levels.

8.2.2.2 Samples.

8.2.2.2.1 Samples for conditioning shall be complete ensembles and include the respirator where the ensemble utilizes the respirator facepiece as the ensemble visor.

8.2.2.2.2 Class Type R samples shall be conditioned as specified in 8.1.10.

8.2.2.2.3 Samples shall be conditioned as specified in 8.1.2.

8.2.2.3 Specimens.

8.2.2.3.1 The specimen shall be a complete ensemble with gloves and footwear and include the respirator where applicable.

8.2.2.3.2 Where the ensemble utilizes the respirator facepiece as the ensemble visor, the ensemble shall be tested with each type or model of the respirator specified by the manufacturer.

8.2.2.3.3 Where the respirator is completely encapsulated by the ensemble, the ensemble shall be tested with a respirator specified by the manufacturer.

8.2.2.3.4 A minimum of four specimens representing a minimum of two different ensemble sizes shall be tested.

8.2.2.3.5 Where the ensemble has multiple types of external fittings, each type of external fitting shall be present on each specimen at the time of testing.

8.2.2.3.6 Specimens shall fit or be adjustable to fit the selected test subjects in accordance with the manufacturer's sizing provisions specific to each ensemble.

8.2.2.3.7* None of the ensembles or ensemble components to be tested shall have been previously subjected to MIST testing unless it can be demonstrated that the ensemble or ensemble components are free of contamination.

8.2.2.3.8 Underclothing and socks shall be permitted to be reused, provided they have been laundered with a detergent that has been demonstrated not to cause interference with the analytical method.

8.2.2.3.9 Where socks are used as part of the protective ensemble, testing shall be permitted to be performed on only one representative outer boot style for the evaluation of the ensemble.

8.2.2.4 Apparatus.

8.2.2.4.1 Test Facility.

8.2.2.4.1.1 The test facility shall include dressing areas, a first stage undressing area adjacent and accessible to the chamber, and a second stage undressing area adjacent and accessible to the first stage undressing area.

8.2.2.4.1.2 The test shall be conducted in a test chamber with a minimum volume of sufficient dimensions to permit free movement of the test subject(s) when fully dressed in the ensemble and for the test subject(s) to carry out the physical exercise routine specified in 8.2.2.5.8.

8.2.2.4.1.3 More than one test subject shall be permitted in the chamber at the same time, provided they can complete all tasks completely in the appropriate time and they have an unobstructed direct path to the wind stream.

8.2.2.4.1.4 The test chamber shall have a temperature of 25°C ± 2°C, relative humidity of 55 percent ± 10 percent, and a nominal wind speed of 0.9 to 2.2 m/sec (2 to 5 mph). The average wind speed shall be 1.6 m/sec ± 0.2 m/sec (3.5 mph ± 0.5 mph).

8.2.2.4.2 Test Chemical and Analytical Equipment.

8.2.2.4.2.1 The test simulant shall be methyl salicylate (MeS; $C_8H_8O_3$) CAS No. 119-36-8, more commonly known as oil of wintergreen, with a minimum purity of 95 percent. Vapor doses shall be measured using passive adsorbent dosimeters (PADs).

8.2.2.4.2.2* The standard concentration of MeS in the vapor chamber shall be 150 mg/m^3 ± 10 mg/m^3, as measured by a real-time infrared analysis of the chamber air or other validated real-time analytical technique.

8.2.2.4.2.3 Readings shall be taken every 60 seconds to verify compliance with the concentration requirement, and an air sample shall be taken at least every 10 minutes for validation of readings.

8.2.2.4.2.4 Every step shall be taken to avoid generation of liquid aerosol.

8.2.2.4.2.5 The sensitivity of the analytical technique used for the measurement of MeS in the PADs shall provide a detection limit of 30 ng MeS per PAD. The analytical technique shall have an upper limit of quantification of 50,000 ng.

8.2.2.4.3 Passive Adsorbent Dosimeters (PADs). The test shall be conducted using PADs that affix directly to the skin of test subjects and that have the following characteristics:

(1) The PADs shall be a foil packet, which contains an adsorbent material covered by a high-density polyethylene film that acts as a pseudo-skin barrier.
(2)* The high-sensitivity polyethylene film shall have an uptake rate of approximately 2.0 cm/min.

8.2.2.4.4 Test Subjects.

8.2.2.4.4.1 All test subjects shall be medically and physically suitable to perform these tests without danger to themselves. A medical certificate for each test subject shall have been issued within 12 months prior to testing.

8.2.2.4.4.2 Test subjects shall be familiar with the use of chemical-protective ensembles and with the selected CBRN SCBA.

8.2.2.4.4.3 The test subject shall be identified by a unique number or other designation.

8.2.2.4.4.4 The test subject's body measurements and clothing sizes shall be taken and shall include, but not be limited to, the subject's height, weight, neck circumference, chest circumference, waist circumference, sleeve length, inseam, glove size, shoe size, and facepiece size.

8.2.2.4.4.5 Photographs shall be taken of the test subject wearing the test ensemble that show the front, back, left, and right sides while maintaining the anonymity of that test subject.

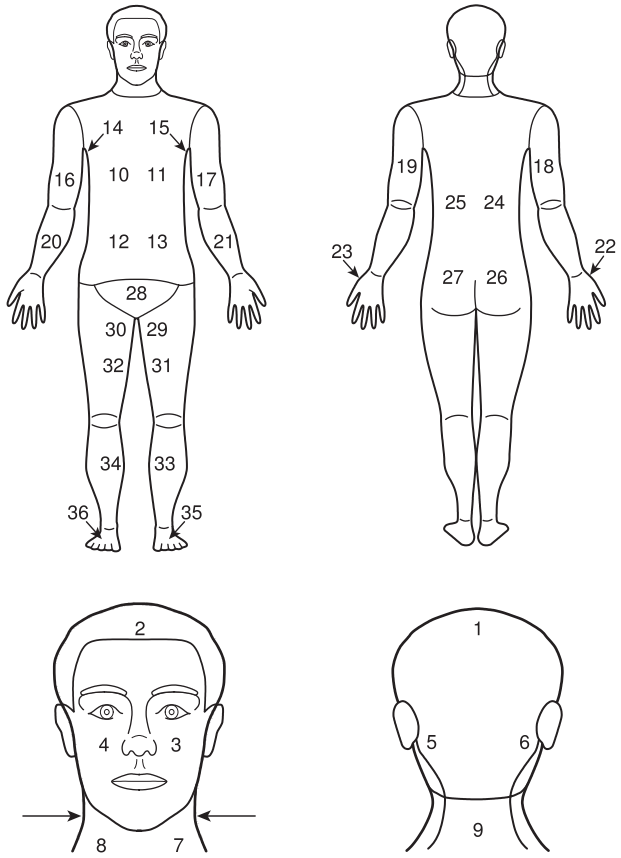
8.2.2.5 Procedure.

8.2.2.5.1 Test subjects shall perform, at a minimum, the following pretrial procedures:

(1) Hydrate properly
(2) Avoid personal hygiene products that could contain MeS
(3) Minimize contamination

8.2.2.5.2 PADs shall be placed on test subjects at the body region locations indicated in Figure 8.2.2.5.2.

8.2.2.5.2.1 All PADs shall be applied in a clean dressing area by personnel who have followed pretrial procedures in accordance with 8.2.2.5.1.



1: scalp (SCA)
2: forehead (F)
3: cheek (LC)
4: cheek (RC)
5: behind left ear (LE)
6: behind right ear (RE)
7: neck left (LN)
8: neck right (NR)
9: nape (NA)
10: right upper chest (RUC)
11: left upper chest (LUC)
12: right lower abdomen (RLA)
13: left lower abdomen (LLA)
14: right armpit (RA)
15: left armpit (LA)
16: right inner upper arm (RIU)
17: left inner upper arm (LIU)
18: right outer upper arm (ROU)
19: left outer upper arm (LOU)
20: right forearm (RFA)
21: left forearm (LFA)
22: right hand (RH)
23: left hand (LH)
24: right middle back (RMB)
25: left middle back (LMB)
26: right lower back/buttock (RLB)
27: left lower back/buttock (LLB)
28: groin (GR)
29: left crotch (LC)
30: right crotch (RC)
31: left inner thigh (LIT)
32: right inner thigh (RIT)
33: left inner shin (LIS)
34: right inner shin (RIS)
35: left foot (LF)
36: right foot (RF)

FIGURE 8.2.2.5.2 Locations of PADs on Test Subjects.

8.2.2.5.2.2 Cheek PADs shall be located entirely within the respirator facepiece with all other PADs located entirely outside the seal of the respirator facepiece.

8.2.2.5.3 Three additional PADs — located in the dressing area, the stage 1 undress area, and the stage 2 undress area — shall be used to conduct background sampling and for quality control during the trial.

8.2.2.5.4 The test subject shall don the protective ensemble and respirator in accordance with the manufacturer's instructions in an area located away from the test chamber. The test subject shall wear clothing under the CBRN protective ensemble as specified by the manufacturer. If no undergarments are specified or required by the manufacturer, the test subject shall wear a short-sleeve cotton shirt and shorts or underwear.

8.2.2.5.5 After sealing the ensemble, the test subject shall enter the test chamber and the test chamber shall be sealed.

8.2.2.5.6 The test duration will be 30 minutes in the chamber with a 5-minute decontamination period.

8.2.2.5.7 The start of the test, in which the test subject enters the MIST chamber, shall be initiated within 60 minutes once the ensemble is removed from the conditioning environment.

8.2.2.5.8 Physical Exercise Routine.

8.2.2.5.8.1 Once the chamber concentration is established, the test subject(s) shall perform the following physical activity protocol and the chamber concentration shall remain within acceptable limits:

(1) With both hands, drag 70 kg (154 lb) human dummy for 10 m (33 ft) over a 15-second period. Stop and rest for 15 seconds. Repeat exercise twice.
(2) Duck squat, pivot right, pivot left, stand. Rotate orientation 90 degrees to wind stream between each repetition. Repeat exercise twice in each orientation for a total of 1 minute.
(3) Stand erect. With arms at sides, bend body to left and return, bend body forward and return, bend body to right and return. Rotate orientation 90 degrees to wind stream between each repetition. Repeat exercise twice in each orientation for a total of 1 minute.
(4) Stand erect. Extend arms overhead in the lateral direction, then bend elbows. Extend arms overhead in the frontal direction, then bend elbows. Rotate orientation 90 degrees to wind stream between each repetition. Repeat exercise twice in each orientation for a total of 1 minute.
(5) Stand erect. Extend arms perpendicular to the sides of torso. Twist torso left and return, twist torso right and return. Rotate orientation 90 degrees to wind stream between each repetition. Repeat exercise twice in each orientation for a total of 1 minute.
(6) Stand erect. Reach arms across chest completely to opposite sides. Rotate orientation 90 degrees to wind stream between each repetition. Repeat exercise twice in each orientation for a total of 1 minute.
(7) Climb two steps of the ladder and touch the ceiling with one hand (use alternate hands each time). Climb down, squat, and touch the floor with both hands. Repeat exercise three times within 1 minute.
(8) Crawl in place for 1 minute. Rotate orientation 90 degrees to wind stream every 15 seconds.
(9) Sit on stool (facing wind) and slowly turn head from side to side between extreme positions on each side. Pause momentarily at each extreme position and inhale. Repeat the exercise for 1 minute.
(10) Sit on stool (back to wind) and slowly move head up and down. Pause momentarily at each extreme position and inhale. Repeat the exercise for 1 minute.

8.2.2.5.8.2 Physical activities and rest periods shall be performed in a chamber location that provides an unobstructed exposure of the protective ensemble to the required wind stream.

8.2.2.5.8.3 Each physical activity and rest cycle shall be 10 minutes. The cycle of exercise and rest shall be completed a total of three times, for a total chamber exposure of 30 minutes. Each exercise cycle shall consist of eight 1-minute activities followed by a 2-minute rest (sitting) period.

8.2.2.5.8.4 The test subject shall begin the first repetition of each activity facing the wind stream and shall rotate 90 degrees between each repetition until the time for that exercise has ended.

8.2.2.5.8.5 All physical activities shall be a full range of motion and performed at a moderate speed.

8.2.2.5.9 Decontamination and Doffing.

8.2.2.5.9.1 After completion of the 30-minute MIST exposure, the test subjects shall move to a decontamination area and remain for at least 5 minutes. This area shall be well ventilated to assist in off-gassing of the outside of the ensemble.

8.2.2.5.9.2 In the decontamination area, all exposed ensemble surfaces, including the respirator, boots, gloves, and helmets, shall be washed with a liquid soap solution.

(A) If the garment is designed for wet decontamination, it shall also be washed with the liquid soap solution.

(B) Alternative decontamination methods, such as an air wash, shall be permitted if the selected decontamination method can be demonstrated to remove MeS to levels that do not result in contamination of the test subjects during the doffing of the protective ensemble.

8.2.2.5.9.3 The decontaminated test subject shall move to the first stage undressing room where all remaining items of clothing, except for underclothes, shall be doffed within 5 minutes.

8.2.2.5.9.4 As soon as the garment is unsealed and the PADs on the test subject's body are exposed to the ambient atmosphere in the first stage undressing room, three fresh PADs shall be placed near the test subject to detect background MeS concentrations.

8.2.2.5.9.5 As soon as all items of clothing except the underwear are removed, the decontaminated test subject shall proceed to the second stage undressing room and the background PADs shall be collected and handled as specified in 8.2.2.5.9.7. The exposure time for the first stage undressing room background PADs shall be recorded.

8.2.2.5.9.6 When the test subject enters the second stage undressing room, three additional PADs shall be placed near the test subject and the exposure PADs shall be removed from the test subject's body. Both the second stage undressing room background PADs and the exposure PADs taken off the test subject's body shall be handled as specified in 8.2.2.5.9.7. The

exposure time for the second stage undressing room PADs shall be recorded.

8.2.2.5.9.7 Where an adhesive is used on the back of the PADs, each PAD shall be backed with aluminum foil, placed in individual sealed glass vials with a nonabsorbent lid liner, and remain at room temperature of 25°C ± 3°C (77°F ± 5°F) for 30 minutes ± 5 minutes immediately after exposure.

8.2.2.6 PAD Qualification and Analysis.

8.2.2.6.1 The uptake rate for each lot of PADs shall be determined in accordance with 8.2.2.6.2 using a minimum of seven PADs selected randomly from the lot.

8.2.2.6.2* Measurement of PAD Uptake Rate.

8.2.2.6.2.1 The PAD uptake rate shall be measured by exposing PADs in a small-scale chamber under the following conditions:

(1) The concentration of MeS shall be 1 mg/m^3 ± 0.5 mg/m^3.
(2) The temperature shall be 35°C ± 2°C (94°F ± 4°F).
(3) The relative humidity shall be 55 percent ± 20 percent.
(4) The flow of MeS in the humidified air or nitrogen shall be at a rate of 1 cm/sec ± 0.2 cm/sec over the PAD.
(5) The exposure shall be conducted for a period of 30 minutes +1/–0 minutes.

8.2.2.6.2.2 The PAD uptake rate shall be calculated in accordance with the procedures provided in 8.2.2.6.4 The average of all PAD uptake rates shall be calculated and used in the calculation of MeS dosage on the test subject PADs.

8.2.2.6.3 After their initial 30 minutes at room temperature, the PADs shall be subjected to one of the following handling and analysis procedures:

(1) The PADs shall be stored at a cold temperature sufficient to prevent the migration of MeS from the adhesive until extraction or analysis.
(2) The PADS shall be extracted within 4 hours.
(3) The adsorbent shall be removed and thermally desorbed within 4 hours.

8.2.2.6.3.1 The determination of a sufficiently low temperature that prevents migration of MeS from the adhesive shall be made by exposing 12 PADs simultaneously in the test chamber in a vertical position at a concentration of 100 mg/m^3 of MeS for 30 minutes +5/–0 minutes. After this exposure, the PADs shall each be covered in foil, placed in sealed containers, and stored at 25°C ± 3°C (77°F ± 5°F) for 30 minutes ± 5 minutes. Four of these PADs shall be packed in dry ice for 24 hours, four placed in the proposed cold storage temperature for 24 hours, and four extracted and analyzed within 4 hours. The average mass absorbed on the four PADs stored at the proposed cold storage temperature shall equal, with 95 percent confidence, the average mass absorbed on four PADs stored for 24 hours in dry ice and the four PADs analyzed immediately after exposure.

8.2.2.6.3.2 Where liquid extraction of the sample PADs is performed, the liquid extracts shall be stored at 0°C to 4°C (32°F to 39°F) for up to 14 days following their exposure before analysis.

8.2.2.6.4 The actual MeS vapor exposure concentration and the actual time of exposure shall be used to determine the uptake rate from the following equation:

[8.2.2.6.4]

$$u = m / ACt$$

where:
u = the uptake rate in cm/min
m = the total mass of MeS measured on the PAD in mg
A = the average active area of the PAD in cm^2
Ct = the exposure vapor dosage in mg/min/cm^3

8.2.2.6.5 The range of the analytical technique shall be sufficient to measure the expected range of MeS dosage on the test subject PADs.

8.2.2.6.5.1 When liquid extraction is used as the analytical technique, the calibration curve used for determining the equipment response to MeS shall be established using at least four MeS concentration standards accounting for the proper density of the extraction solvent.

8.2.2.6.6 For the test results to be considered valid for a given ensemble, no more than one PAD from each of the body region locations tested (i.e., no more than one PAD out of all replicates for any particular region) shall be permitted to be lost to analysis.

8.2.2.7 Calculations.

8.2.2.7.1 The dosage measured by each PAD ($Ct_{inside,i}$) shall be determined using the average uptake rate determined for the PAD lot used in the evaluation of a specific ensemble using the following equation:

[8.2.2.7.1]

$$Ct_{inside\ i} = m_i / u_{avg} A$$

where:
$Ct_{inside,i}$ = the MeS vapor dosage at the specific PAD in mg/min/cm^3
m_i = the MeS vapor dosage at the specific PAD in mg/min/cm^3
u_{avg} = the average uptake of the PAD lot in cm/min
A = the average active area of the PA in cm^2

8.2.2.7.1.1 The protection factor at each PAD location shall be calculated using the following equation:

[8.2.2.7.1.1]

$$PF_i = Ct_{outside} / Ct_{inside.i}$$

where:
$Ct_{outside}$ = average of chamber MeS concentration readings taken during the test subject exposure period, determined from the measured chamber vapor dosage of the individual trial over the entire exposure

8.2.2.7.1.2 Where the measured total mass of MeS for a given PAD falls below 30 ng, the value of 30 ng shall be used for that specific PAD.

8.2.2.7.2 All results for each PAD location shall be expressed in terms of the local physiological protective dosage factor ($PPDF_i$) value and shall be calculated according to the following equation:

[8.2.2.7.2]

$$Local\ PPDF_i = \left(OSED_i / 25\right) * PF$$

where:
$OSED_i$ = onset of symptoms exposure dosages
PF = protection factor

8.2.2.7.2.1* The site-specific onset of symptoms exposure dosages ($OSED_i$) for each PAD shall be based on ECt_{10} values for mustard blistering/ulceration according to Table 8.2.2.7.2.1.

8.2.2.7.2.2 The average local *PPDF* values at each PAD location for all specimens tested shall be calculated.

8.2.2.7.3 A systemic *PPDF* shall also be calculated from the PAD data. The systemic protection analysis shall use the systemic weighting body region hazard analysis values from the Defence Research Establishment's "Final Report: Development of a Standard Vapour Systems Test to Assess the Protection Capability of NBC Individual Protective Ensembles" and the National Research Council's *Technical Assessment of the Man-in-Simulant Test Program* to calculate the systemic physiological protective dosage factor for each ensemble test ($PPDF_{sys}$). The $PPDF_{sys}$ for each specimen is calculated as follows, where each of the terms is calculated using the information in Table 8.2.2.7.3:

[8.2.2.7.3]

$$PPDF_{sys} = \sum_1 \left(dz_i / ED_{50i}\right) / \sum_i \left(dz_i / ED_{50i} * PF_i\right)$$

8.2.2.7.3.1 The average $PPDF_{sys}$ for all specimens tested shall be calculated.

8.2.2.7.3.2* The protection factor PF_i used in the calculation of $PPDF_{sys}$ shall be the average *PF* of all PADs in a specific body region.

8.2.2.8 Report.

8.2.2.8.1 The individual specimen and average local $PPDF_i$ values for each PAD location shall be recorded and reported.

Table 8.2.2.7.2.1 Site-Specific OSED by PAD Location

Body Region	PAD Location	OSED (mg × min × m^{-3})
Head/neck	1, 2, 3, 4, 5, 6, 7, 8, 9	100
Torso/buttocks (excluding perineum)	10, 11, 12, 13, 24, 25, 26, 27, 28	100
Arm/hand	14, 15, 16, 17, 18, 19, 20, 21, 22, 23	50
Leg/foot	31, 32, 33, 34, 35, 36	100
Perineum	29, 30	25

8.2.2.8.2 The $PPDF_{sys}$ value for each specimen and the average $PPDF_{sys}$ value for the ensemble tested shall be recorded and reported.

8.2.2.8.3 A spreadsheet shall be prepared that shows all the test measurements and calculations, including at least the following:

(1) The MeS vapor exposure concentration for PAD lot qualification
(2) The exposure time used for PAD lot qualification
(3) The measured MeS mass for each PAD used for PAD lot qualification
(4) Each test subject and the average PAD uptake rate
(5) The measured MeS mass for each PAD used in the dressing room, stage 1 undressing room, and stage 2 undressing room
(6) The measured MeS mass for each PAD placed on the test subject
(7) The calculated vapor dosage for each PAD placed on the test subject
(8) The unique number or other designation of the test subject
(9) The size of the ensemble and other ensemble elements assigned to the test subject
(10) The specific body measurements and clothing sizes of the test subject
(11) Photographs as specified in 8.2.2.4.4.5

8.2.2.9 Interpretation. The average local $PPDF_i$ values at each PAD location and the average $PPDF_{sys}$ value shall be used to determine pass or fail performance.

8.2.3 Liquidtight Integrity Tests.

8.2.3.1 Liquidtight Integrity Test One.

8.2.3.1.1 Application.

8.2.3.1.1.1 This test method shall apply to all garment elements, nonencapsulating ensembles, and encapsulating ensembles.

8.2.3.1.1.2 Specific requirements for this test method include the following:

(1) All areas of the manikin body covered by the specimen being tested shall be evaluated for liquidtight integrity.
(2) The configuration and placement of the glove and sleeve interface shall be the same on both arms.
(3) If outer gloves are worn in conjunction with gloves attached to the ensemble or if outer boots are worn in conjunction with garment socks to meet foot protection requirements, these elements shall not collect liquid.
(4) Where socks are used as part of an encapsulating ensemble, it shall be permitted that testing be performed on only one representative outer boot style for the evaluation of the ensemble.
(5) Specific requirements for testing garment elements, nonencapsulating ensembles, and encapsulating ensembles are shown in Table 8.2.3.1.1.2.

8.2.3.1.2 Sample Preparation.

8.2.3.1.2.1 Samples shall be complete garment elements or complete ensembles with gloves, footwear, hoods, and, if applicable, respirator.

8.2.3.1.2.2 Samples shall be conditioned as specified in 8.1.2.

Table 8.2.2.7.3 ED_{50i} Values by PAD and Body Location

Body Region *i* for BRHA Model	PADs Mapped to This Region (Average Dosage from Each PAD, Then Calculate PF_i)	Area of Body Region (dz_i, cm^2)	ED_{50i} for Severe Effects (VX) for Body Region (mg/Individual)
Scalp	1, 2	350	0.76
Ears	5, 6	50	0.46
Face, cheeks, and neck	3, 4, 7, 8	300	0.48
Chin and neck	7, 8	200	0.36
Nape	9	100	1.72
Chest/abdomen	10, 11, 12, 13	2858	2.23
Back	24, 25, 26, 27	2540	2.65
Axillae	14, 15	200	2.07
Upper arm medial	16, 17	488	2.8
Upper arm lateral	18, 19	706	6.57
Elbow fold	16, 17, 18, 19, 20, 21	50	2.09
Elbow	16, 17, 18, 19, 20, 21	50	2.25
Forearm extensor	20, 21	487	2.8
Forearm flexor	20, 21	706	6.57
Hands dorsum	22, 23	200	2.91
Hands palmar	22, 23	200	9.24
Buttocks	26, 27	953	4.26
Groin	28	300	1.22
Scrotum	29, 30	200	0.11
Thigh anterior	31, 32	2845	6.57
Thigh posterior	31, 32	1422	4.26
Knee	31, 32, 33, 34	200	7.14
Popliteal space (back of knees)	31, 32, 33, 34	100	2.09
Shins	33, 34	1897	6.57
Calves	33, 34	948	2.8
Feet dorsum	35, 36	500	6.6
Feet plantar	35, 36	300	7.14

8.2.3.1.2.3 Samples for Class Type R shall be conditioned as specified in 8.1.10.

8.2.3.1.3 Specimens.

8.2.3.1.3.1 Specimens shall be complete ensembles with all layers required for the compliance of the ensemble assembled.

8.2.3.1.3.2 At least three specimens shall be tested.

8.2.3.1.3.3 The size of the garment or ensemble comprising the specimens shall be the same as the manikin in terms of chest circumference, waist circumference, and inseam length for proper fit of the specimens on the manikin in accordance with the manufacturer's sizing system.

8.2.3.1.3.4 Where the ensemble offers multiple types of external fittings, each type of external fitting shall be installed in the ensemble prior to testing.

8.2.3.1.3.5 Where the ensemble utilizes the respirator facepiece as the ensemble visor, each style of the ensemble shall be tested with each style of the respirator specified by the manufacturer.

Table 8.2.3.1.1.2 Test Duration for Liquid Integrity Testing

Level	Applicability	Test Duration (min)	Duration in Each Orientation
Ultrahigh	NFPA 1991	60	15
High	NFPA 1992; NFPA 1994 Class 1, Class 2, and Class 2R	20	5
Moderate	NFPA 1994 Class 3 and Class 3R	8	2
Low	NFPA 1994 Class 4	4	1

8.2.3.1.3.6 Where socks are used as part of the protective ensemble, it shall be permitted that testing be performed on only one representative outer boot style for the evaluation of the ensemble.

8.2.3.1.4 Apparatus. The apparatus and supplies for testing shall be those specified in ASTM F1359/F1359M, *Standard Test*

Method for Liquid Penetration Resistance of Protective Clothing or Protective Ensembles Under a Shower Spray While on a Manikin.

8.2.3.1.5 Procedure.

8.2.3.1.5.1 Liquidtight integrity testing of garments shall be conducted in accordance with Procedure A of ASTM F1359/F1359M, *Standard Test Method for Liquid Penetration Resistance of Protective Clothing or Protective Ensembles Under a Shower Spray While on a Manikin*, with the following modifications:

(1) No provisions for garments with a partial barrier layer shall be allowed.
(2) The method used for mounting the manikin in the spray chamber shall not interfere with the water spray.
(3) At the end of the liquid spray exposure period, excess liquid shall be removed from the surface of the specimen.

8.2.3.1.5.2 The specimen shall be inspected within 5 minutes of the end of the liquid spray exposure period for evidence of liquid penetration.

8.2.3.1.5.3 Where outer gloves and outer boots are used as part of the ensemble, the interior of the outer gloves or outer boots shall be inspected to determine if collection of liquid has occurred.

8.2.3.1.6 Report. A diagram shall be prepared for each test that identifies the locations of any liquid leakage as detected on the liquid-absorptive garment inside the specimen or on the interior surface of the specimen.

8.2.3.1.7 Interpretation.

8.2.3.1.7.1 Evidence of liquid on the liquid-absorptive garment inside the specimen or on the interior surface of the encapsulating or nonencapsulating ensemble as determined by visual, tactile, or absorbent toweling shall constitute failure of the specimen.

(A) For NFPA 1992 garment elements, evidence of liquid on the liquid-absorptive garment shall constitute a failure. The presence of liquid inside the specimen garment or on the interior surface of the specimen garment extending greater than 2 in. (50 mm) from the leading edge of the coat bottom, coat sleeve ends, or pant leg ends shall constitute a failure.

8.2.3.1.7.2 For the glove and footwear parts of ensembles that consist of multiple separate layers, accumulation of liquid between any layers shall constitute failure.

8.2.3.2 Liquidtight Integrity Test Two.

8.2.3.2.1 Application. This test method shall apply to gloves.

8.2.3.2.2 Samples.

8.2.3.2.2.1 Samples shall be whole gloves with all layers that are required for the compliance of the element assembled.

8.2.3.2.2.2 Samples shall be conditioned as specified in 8.1.2 after the conditioning specified in the modifications.

8.2.3.2.3 Specimens.

8.2.3.2.3.1 Specimens shall be whole gloves with all layers that are required for the compliance of the element assembled.

8.2.3.2.3.2 At least 10 specimens shall be tested.

8.2.3.2.4 Procedure. Liquidtight integrity testing of gloves and footwear shall be conducted in accordance with ASTM D5151, *Standard Test Method for Detection of Holes in Medical Gloves*, with the following modifications:

(1) The surface tension of the water used in testing shall be 34 dynes/cm ± 2 dynes/cm (32 N/m ± 2 N/m).
(2) A sufficient amount of surfactant-treated water shall be added to the specimen so that the water is within 25 mm (1 in.) of the edge of the glove opening.
(3) The surfactant-treated water shall remain in the specimen for a period of 1 hour +5/–0 minutes.
(4) Observations for leakage shall be performed at the end of the test period.
(5) Blotting paper shall be permitted for use in determining that liquid leakage has occurred.

8.2.3.2.5 Report. Observations of water leakage shall be recorded and reported by specific area on the test specimen.

8.2.3.2.6 Interpretation. Any evidence of water leakage as determined by visual, tactile, or absorbent blotting shall constitute failure of the specimen.

8.2.3.3 Liquidtight Integrity Test Three.

8.2.3.3.1 Application.

8.2.3.3.1.1 This test method shall apply to footwear.

8.2.3.3.2 Samples.

8.2.3.3.2.1 Samples shall be whole footwear with all layers that are required for the compliance of the element assembled.

8.2.3.3.2.2 Samples shall be conditioned as specified in 8.1.2 after the conditioning specified in the modifications.

8.2.3.3.3 Specimens.

8.2.3.3.3.1 Specimens shall be whole footwear with all layers that are required for the compliance of the element assembled.

8.2.3.3.3.2 At least 3 specimens shall be tested.

8.2.3.3.4 Procedure.

8.2.3.3.4.1 Footwear functionality shall be determined by flexing the specimen for 100,000 cycles performed in accordance with Appendix B of FIA 1209, *Whole Shoe Flex*, with the following modifications:

(1) Water shall not be used.
(2) The flex speed shall be 60 ± 2 cycles per minute.
(3) Alternative flexing equipment shall be permitted to be used if it meets the following criteria:
    (a) It provides the angle of flex as described in FIA 1209.
    (b) It is capable of a flex speed of 60 ± 2 cycles per minute.
    (c) It provides a means of securing the footwear during flexing.

8.2.3.3.4.2 After flexing, specimens shall then be examined for evidence of seam separation or component breakage. The outer sole shall be examined for evidence of sole separation. Separation occurring in this test shall be recorded and reported if it is at least 1.4 mm × 18 mm (0.05 in. × 0.7 in.) in any orientation.

8.2.3.3.4.3 After flexing and observation of separation, the footwear specimen shall be marked with a water height line on the exterior at a height of 75 mm (3 in.) below the height of

the boot as defined in 6.1.5.4 but no lower than 125 mm (5 in.) where measured up from the center of the insole at the heel. The measurement shall be made on the interior and transferred to the exterior. Plain white paper toweling shall be placed inside the footwear specimen such that the paper toweling intimately contacts all areas inside the footwear specimen to at least the water height line. The footwear specimen shall then be placed in a container that allows its immersion in tap water that is treated with a dye and a surfactant that achieves a surface tension of 35 dynes/cm ± 5 dynes/cm, to the water height line.

8.2.3.3.4.4 After 2 hours ± 10 minutes, the paper toweling shall be removed and examined for evidence of liquid leakage. The test specimen shall also be reexamined for evidence of sole separation or seam separation.

8.2.3.3.4.5 Footwear not remaining functional after flexing shall be recorded and reported as a failure for the tested specimen. The appearance of any liquid on the removed paper toweling shall be recorded and reported as a failure for the tested specimen. One or more footwear specimens failing this test shall constitute failing performance.

8.2.3.3.5 Report. Outer sole separation or the appearance of water leakage on the removed paper toweling shall be recorded and reported as failure for the tested specimen.

8.2.3.3.6 Interpretation. One or more footwear specimens failing this test shall constitute failing performance.

8.2.4 Particle Inward Leakage Test.

8.2.4.1 Application. This test shall apply to Class 4 and Class 4R ensembles.

8.2.4.2 Samples.

8.2.4.2.1 Samples for conditioning shall be complete ensembles and include the respirator where the ensemble utilizes the respirator facepiece as the ensemble visor.

8.2.4.2.2 Samples shall be conditioned at 21°C ± 6°C and 50 percent ± 30 percent RH for at least 4 hours.

8.2.4.2.3 Samples for Class 4R shall be conditioned as specified in 8.1.10.

8.2.4.3 Specimens.

8.2.4.3.1 The specimen shall be a complete ensemble with gloves and footwear and shall include, if applicable, the respirator.

8.2.4.3.2 Where the ensemble utilizes the respirator facepiece as the ensemble visor, the ensemble shall be tested with each type or model of the respirator specified by the manufacturer.

8.2.4.3.3 A minimum of four specimens shall be tested and a minimum of two test subjects shall be used.

8.2.4.3.4 Where the ensemble has multiple types of external fittings, each type of external fitting shall be present on each specimen at the time of testing.

8.2.4.3.5 Specimens shall fit or be adjustable to fit the selected test subjects in accordance with the sizing provisions provided by the manufacturer that are specific to each element.

8.2.4.3.6 None of the components to be tested shall have been previously subjected to particle inward leakage testing.

8.2.4.3.7 Underclothing and socks shall be permitted to be reused, provided they have been laundered with a detergent that has been demonstrated not to cause interference with the analytical method.

8.2.4.3.8 Where socks are used as part of the protective ensemble, it shall be permitted that testing be performed on only one representative outer boot style for the evaluation of the ensemble.

8.2.4.4 Apparatus.

8.2.4.4.1 The test shall be conducted in a chamber large enough to conduct testing on at least one test subject.

8.2.4.4.2 The test chamber shall have a system capable of providing a stable, uniform airflow directed at the test subject.

8.2.4.4.3 The test chamber shall prevent significant aerosol contact with any areas of the facility not intended as exposure areas to prevent contamination.

8.2.4.4.4 The test chamber shall have an aerosol generator capable of maintaining the aerosol mass concentration as specified in the procedure.

8.2.4.4.5 The challenge aerosol shall be a combination of amorphous silica, 50 percent by weight; tetraethylene glycol, 42 percent by weight; uranine, 6 percent by weight; and tinopal, 2 percent by weight.

8.2.4.4.6 Test subjects shall wear a close-fitting, one- or multiple-piece full-body indicator garment made of black synthetic material that is sized to the individual test subject. The indicator garment shall be clean and free of visible lint, to the extent practicable, prior to donning by the test subject.

8.2.4.4.7 Visual inspection of the test subject wearing the indicator garment shall be performed under illumination by black light in a dark room after doffing the candidate garments. Inspection shall be performed while the test subject is fully illuminated by black light with a wavelength of 365 nm.

8.2.4.4.8 A separate handheld black light with a wavelength of 365 nm and an intensity of 1200 $\mu W/cm^2$ at 380 nm shall be used to inspect areas where the presence of fluorescent particles might be unclear.

8.2.4.4.9 A 35 mm camera or digital equivalent with the appropriate capabilities and settings for taking photographs under UV light shall be provided for documenting the visual condition of the test subject before and after exposure to the aerosol.

8.2.4.4.10 The test facility shall have separate garment storage, donning, doffing, and control room areas to prevent contamination.

8.2.4.4.11 All test subjects shall have a medical doctor's certificate issues within 12 months prior to testing that substantiates they are medically and physically suitable to perform these tests without danger to themselves.

8.2.4.4.12 Test subjects shall be familiar with the use of chemical protective ensembles and with the selected respirator.

8.2.4.4.13 The test subject shall be identified by a unique number or other designation.

8.2.4.4.14 The test subject's body measurements and clothing sizes shall be taken and shall include, but not be limited to, the

subject's height, weight, neck circumference, chest circumference, waist circumference, sleeve length, inseam, glove size, shoe size, and facepiece size.

8.2.4.5 Procedure.

8.2.4.5.1 The test chamber shall be stabilized with the following conditions:

(1) Average wind speed shall be 4.8 kph ± 3.2 kph (3 mph ± 2 mph) at the test subject location.
(2) Temperature shall be 21°C ± 2°C (70°F ± 5°F).
(3) Relative humidity shall be 45 percent ± 15 percent.
(4) Average aerosol concentration shall be 20 mg/m^3 +5 mg/m^3/–0 mg/m^3.
(5) Aerosol aerodynamic mass median diameter shall be 2.75 μm ± 0.75 μm.

8.2.4.5.2 The test subject shall don black undergarments that cover the torso, arms, legs, and head, excluding the face. The indicator garments shall provide a dark uniform appearance under black light illumination.

8.2.4.5.3* At least 10 specific areas of the indicator garments shall be masked with tape or masking product that will remain in place during testing and not affect the indicator garments.

8.2.4.5.4 The 10 masked areas shall each have a minimum area of 13 cm^3 (0.8 $in.^3$) and shall be distributed over the indicator garment.

8.2.4.5.5 The test subject shall don the protective ensemble and respirator in accordance with the manufacturer's instructions in a clean area separated from the test chamber.

8.2.4.5.6 Once the test chamber has reached the conditions specified in 8.2.4.5.1, the test subject shall enter the chamber and be properly positioned in the wind.

8.2.4.5.7 The 30-minute test period shall begin when the test subject is positioned in the wind.

8.2.4.5.8* During the 30-minute test period, the test subject shall perform the following series of stationary exercises as specified in Procedure A of ASTM F1154, *Standard Practices for Evaluating the Comfort, Fit, Function, and Durability of Protective Ensembles, Ensemble Elements, and Other Components*, three times with the following modifications:

(1) Duck squat, pivot right, pivot left, stand. Rotate orientation 90 degrees to wind stream between each repetition. Repeat exercise twice in each orientation for a total of 1 minute.
(2) Stand erect. With arms at sides, bend body to left and return, bend body forward and return, bend body to right and return. Rotate orientation 90 degrees to wind stream between each repetition. Repeat exercise twice in each orientation for a total of 1 minute.
(3) Stand erect. Extend arms overhead in the lateral direction, then bend elbows. Extend arms overhead in the frontal direction, then bend elbows. Rotate orientation 90 degrees to wind stream between each repetition. Repeat exercise twice in each orientation for a total of 1 minute.
(4) Stand erect. Extend arms perpendicular to the sides of torso. Twist torso left and return, twist torso right and return. Rotate orientation 90 degrees to wind stream between each repetition. Repeat exercise twice in each orientation for a total of 1 minute.
(5) Stand erect. Reach arms across chest completely to opposite sides. Rotate orientation 90 degrees to wind stream between each repetition. Repeat exercise twice in each orientation for a total of 1 minute.
(6) Walk in place (facing wind) for 1 minute.
(7) Rest (standing, facing wind) for 1 minute.
(8) Walk in place (back to wind) for 1 minute.
(9) Rest (standing, back to wind) and slowly turn head from side to side between extreme positions on each side. Pause momentarily at each extreme position and inhale. Repeat for 1 minute.
(10) Rest (standing, facing wind) and slowly move head up and down. Pause momentarily at each extreme position and inhale. Repeat the exercise for 1 minute.

8.2.4.5.9 At the conclusion of the 30-minute test period, the test subject shall exit the test chamber and enter the doffing area.

8.2.4.5.10 The test subject shall then be assisted in doffing the ensemble to prevent contact of the outside contaminated surface of the ensemble with the subject's skin or black indicator garments.

8.2.4.5.10.1 If accidental contact occurs, the specific location of contact shall be noted and the test shall be repeated or the specific affected area shall not be considered when interpreting whether or not the garment passes or fails.

8.2.4.5.11 After doffing, the control covered areas shall be uncovered on the black indicator garment and the test subject shall be examined under black light in the viewing area for evidence of particulate inward leakage.

8.2.4.5.12 Photographs shall be taken of the test subject under black light with the following minimum positions:

(1) Front, right, back, and left side of test subject's neck and head
(2) Front, right, back, and left side of test subject's upper torso
(3) Front, right, back, and left side of test subject's lower torso

8.2.4.5.12.1 The exposure of the test subject under black light should be bracketed in the f-stop settings of the camera to provide photographs with varying contrast to permit documentation of any observed fluorescence.

8.2.4.5.12.2 Specific areas of known fluorescence that are not attributed to other sources, e.g., lint, cross-contamination during doffing, or residual detergent on the black indicator garment or test subject's skin, shall be included as part of the report on a chart showing their specific location.

8.2.4.5.13 A separate black light shall be used to inspect any areas where the presence of fluorescent particles might be unclear.

8.2.4.5.14 Where fluorescence on the black indicator garment is observed or suspected, those specific areas shall be sampled for particle contamination using the procedures established in 8.2.4.6.

8.2.4.6 Sampling and Analysis of Black Indicator Garment.

8.2.4.6.1 The test subject's black indicator garment shall be sampled using the following procedures to recover any aerosol that has been deposited:

(1) The number of areas sampled shall be limited to up to five areas that appear to show the greatest level of fluorescence when examined under the black light.
(2) At least one sample shall be taken from an area that shows no fluorescence during the examination under UV light and shall serve as a baseline for testing.
(3) Garment rinse sampling shall be performed by pressing a tube of a suitable diameter against the portion of the black indicator garment to be sampled and adding 20 mL (0.68 oz) of 0.01 N sodium hydroxide (NaOH).
(4) The solution shall be washed over the black indicator garment for approximately 10 seconds, then pipetted into a clean container.
(5) All samples shall be labeled appropriately in the specific sampling location before they are analyzed.
(6) For each of the black indicator garment rinse samples, approximately 5 mL (0.17 oz) of each shall be analyzed in a fluorometer to determine the mass of the aerosol that is present in the sample.
(7) The results shall be recorded and verified to identify and eliminate any errors in reading or recording the data.
(8) Test results shall be reported in $\mu g/cm^2$ at each sampling location.

8.2.4.7 After each trial, upon completion of the skin-rinse sampling and black light photography, the test subject shall return to a locker room and shower.

8.2.4.8 Report.

8.2.4.8.1 Photographic records documenting the test ensemble and results shall include the following:

(1) Photographs of the test subject in the full test ensemble immediately before entering the aerosol chamber, with additional photographs included as warranted of the test subject in the ensemble showing the design details
(2) Black light photographs of the test subject after doffing that cover all body locations, with the test subject wearing shorts and, for female test subjects, a sports bra
(3) Test conditions, including the following:
    (a) Challenge aerosol mass concentration averaged for the duration of the test
    (b) Average wind speed, temperature, and relative humidity for the test
    (c) Date of test and test operator
(4) Specific observations about the location of any aerosol deposited on the test subject
(5) Any notable observations by the test operators (especially system openings, mask breaches, or poorly fit ensemble elements)
(6) Any supplemental test data sampling and analysis of the black indicator garments that provide the level of fluorescent particles present

8.2.4.8.2 If post-exposure photographs show no aerosol deposits and show only a black garment in a dark room, the following statement shall be permitted to be used in lieu of post-exposure photographs: "No visible aerosol deposits were revealed in the photographs."

8.2.4.8.3 The following additional information about the test ensembles and test subjects shall be reported:

(1) The unique number of other designation of the test subject
(2) The size of the ensemble and other ensemble elements assigned to the test subject
(3) The specific body measurements and clothing sizes for each test subject

8.2.4.9 Interpretation.

8.2.4.9.1 The absence of any evidence of particulate inward leakage on any test subject's indicator garments as determined by visual inspection under a black light shall constitute a passing performance.

8.2.4.9.2 Where the measurement of the surface concentrations of fluorescent particles is performed, the specific surface concentration at each location shall be reported and used to determine passing or failing performance.

8.3 Chemical/Barrier Performance Tests.

8.3.1 Chemical Permeation Resistance Tests.

8.3.1.1 Chemical Permeation Resistance Test One.

8.3.1.1.1 Application.

8.3.1.1.1.1 This test method shall apply to garment, visor, glove, and footwear element materials included in NFPA 1991-compliant ensembles, and shall apply to selected elements' seams.

8.3.1.1.1.2 Modifications to this test method for testing garment materials after flexing and abrading shall be as specified in 8.3.1.1.7.

8.3.1.1.1.3 Modifications to this test method for testing glove materials after abrading shall be as specified in 8.3.1.1.8.

8.3.1.1.1.4 Modifications to this test method for testing footwear materials after abrading shall be as specified in 8.3.1.1.9.

8.3.1.1.1.5 Modifications to this test method for testing seams shall be as specified in 8.3.1.1.10.

8.3.1.1.1.6 Modifications to this test method for testing primary materials against liquefied gases shall be as specified in 8.3.1.1.11.

8.3.1.1.2 Sample Preparation.

8.3.1.1.2.1 Samples shall be either NFPA 1991-compliant ensembles or garment materials, visor materials, gloves, and footwear of the sizes specified in the modifications.

8.3.1.1.2.2 Samples shall be conditioned as specified in 8.1.9 after the conditioning specified in the modifications.

8.3.1.1.3 Specimens.

8.3.1.1.3.1 Specimens shall be the size specified in ASTM F739, *Standard Test Method for Permeation of Liquids and Gases Through Protective Clothing Materials Under Conditions of Continuous Contact.*

8.3.1.1.3.2 At least three specimens shall be tested per challenge chemical.

8.3.1.1.3.3 For composite materials, only the chemical protection layer shall be the sample for testing for chemical permeation resistance.

8.3.1.1.4 Procedures.

8.3.1.1.4.1* Permeation resistance shall be measured in accordance with ASTM F739, *Standard Test Method for Permeation of Liquids and Gases Through Protective Clothing Materials Under Conditions of Continuous Contact*, with the following modifications:

(1) Total cumulative permeation shall be measured for a period of 1 hour +1 minute/–0 minutes, and for the first 15-minute interval of the 1-hour exposure.
(2) Testing shall be performed at a temperature of 32°C ± 2°C (90°F ± 4°F).
(3) The minimum detectable cumulative permeation mass shall be determined for each chemical tested and shall be at least 0.6 μg/cm^2 or lower.

8.3.1.1.4.2 Permeation resistance shall be measured for each of the following chemicals at a 95 percent or greater concentration unless noted otherwise, with gases at a concentration of 99.0 percent or greater, except as indicated in the following list:

(1) Acetone
(2) Acetonitrile
(3) Acrolein
(4) Acrylonitrile
(5) Anhydrous ammonia (gas)
(6) 1,3-Butadiene (gas)
(7) Carbon disulfide
(8) Chlorine (gas)
(9) Dichloromethane
(10) Diethyl amine
(11) Dimethyl formamide
(12) Dimethyl sulfate
(13) Ethyl acetate
(14) Ethylene oxide (gas)
(15) Hexane
(16) Hydrogen chloride (gas)
(17) Methanol
(18) Methyl chloride (gas)
(19) Nitrobenzene
(20) Sodium hydroxide, 50 percent w/w
(21) Sulfuric acid, 96.1 percent w/w
(22) Tetrachloroethylene
(23) Tetrahydrofuran
(24) Toluene

8.3.1.1.5 Report.

8.3.1.1.5.1 The following information and results shall be recorded and reported:

(1) Material type or name
(2) Chemical or chemical mixture (volume composition of mixture)
(3) Cumulative permeation mass (μg/cm^2) for the first 15-minute interval and for the entire 1-hour test period
(4) Minimum detectable cumulative permeation mass (μg/cm^2)
(5) Detection method
(6) Date of test
(7) Testing laboratory

8.3.1.1.5.2 The average cumulative permeation mass for each chemical shall be determined for the first 15-minute interval and for the entire 1-hour test period.

(A) If no chemical is detected for any replicate permeation resistance test, then that replicate test shall represent the minimum detectable cumulative permeation mass for purposes of calculating the average cumulative permeation mass.

(B) If no chemical is detected for all replicates in a specific chemical test, then the average cumulative permeation mass shall be reported as a value less than the minimum detectable cumulative permeation mass.

8.3.1.1.5.3 The manufacturer shall report the average cumulative permeation masses for the first 15-minute interval and for the entire 1-hour test period in the technical data package.

8.3.1.1.6 Interpretation. The average cumulative permeation masses for the first 15-minute interval and for the total 1-hour exposure period shall be used in determining compliance for the particular material/chemical combination.

8.3.1.1.7 Specific Requirements for Testing Garment Materials After Flexing and Abrading.

8.3.1.1.7.1 Samples for conditioning shall be 200 mm × 280 mm (8 in. × 11 in.) rectangles and shall consist of all layers as configured in the garment.

8.3.1.1.7.2 Two samples shall first be conditioned by flexing as specified in 8.1.3.

(A) One sample shall be flexed with the longitudinal axis parallel to the machine direction of the material, and the second sample shall be flexed with the longitudinal axis parallel to the cross-machine direction of the material.

(B) Following flexing, two samples for abrasion conditioning measuring 45 mm × 230 mm (1¾ in. × 9 in.) each shall be cut from the center of the flexed samples.

(C) At least one specimen for abrasion conditioning shall be taken from a sample flexed in the machine direction, and at least one specimen for abrasion conditioning shall be taken from a sample flexed in the cross-machine direction for each chemical tested.

8.3.1.1.7.3 The new samples for abrasion conditioning shall then be conditioned by abrading as specified in 8.1.4.

(A) Following abrasion, only one specimen for permeation resistance testing shall be taken from each sample subjected to abrasion.

(B) The permeation test specimen shall be taken from the exact center of the abraded sample so that the center of the permeation test and the center of the abraded sample coincide.

8.3.1.1.8 Specific Requirements for Testing Glove Materials After Abrading.

8.3.1.1.8.1 Samples for conditioning shall be whole glove components or whole glove individual elements.

8.3.1.1.8.2 Three samples for abrasion conditioning measuring 45 mm × 230 mm (1 ¾ in. × 9 in.) each shall be cut from the gauntlet portion of the sample.

8.3.1.1.8.3 The new samples for abrasion conditioning shall then be conditioned by abrading as specified in 8.1.4.

(A) Following abrasion, only one specimen for permeation resistance testing shall be taken from each sample subjected to abrasion.

(B) The permeation test specimen shall be taken from the exact center of the abraded sample so that the center of the permeation test and the center of the abraded sample coincide.

8.3.1.1.8.4 Where the glove chemical protection layer has a seam, straight seam specimens shall be permitted to be tested in lieu of material specimens. The seam specimens shall be tested after the conditioning specified in 8.1.4. The test cell shall include both the chemical protection layer material and the chemical protection layer seam. The seam shall be located in the approximate center of the test cell.

8.3.1.1.9 Specific Requirements for Testing Footwear Materials After Abrading.

8.3.1.1.9.1 This test shall apply to all types of footwear configurations. Where the footwear incorporates a sock constructed of garment material, the garment material flex fatigue resistance test shall be permitted to be substituted for this test.

8.3.1.1.9.2 Samples for conditioning shall be whole footwear components or whole footwear individual elements.

8.3.1.1.9.3 Samples for abrasion conditioning measuring 45 mm × 230 mm (1¾ in. × 9 in.) each shall be cut from the center of the footwear upper.

8.3.1.1.9.4 The new samples for abrasion conditioning shall then be conditioned by abrading as specified in 8.1.4.

(A) Following abrasion, only one specimen for permeation resistance testing shall be taken from each sample subjected to abrasion.

(B) The permeation test specimen shall be taken from the exact center of the abraded sample so that the center of the permeation test and the center of the abraded sample coincide.

8.3.1.1.10 Specific Requirements for Testing Seams.

8.3.1.1.10.1 Samples for conditioning shall be 600 mm (23 $^{9}/_{16}$ in.) lengths of prepared straight seams or seams cut from the ensemble.

8.3.1.1.10.2 Seam specimens shall be prepared from straight seam samples that have a minimum of 75 mm (3 in.) of material on each side of the seam center.

8.3.1.1.10.3 Seam specimens shall be cut such that the exact seam center divides the specimen in half.

8.3.1.1.10.4 Seam specimens shall be prepared such that they represent each different stitch and sealing method. Specimens shall be permitted to be taken from the finished product.

8.3.1.1.10.5 Garment seams shall include, at a minimum, the garment-to-garment material seams and the garment-to-visor material seams.

8.3.1.1.11 Specific Requirements for Testing Primary Materials Against Liquefied Gases.

8.3.1.1.11.1 Samples for conditioning shall be garment material, visor material, glove material from the glove gauntlet, and footwear material from the footwear upper.

(A) Glove material specimens shall include all layers used in construction of the glove system.

(B) Where the footwear consists of a sock and outer boot, the footwear specimens shall include all layers in the footwear system.

8.3.1.1.11.2 Specimens shall be conditioned as specified in 8.1.8. Specimens shall be exposed on their normal outside surface.

8.3.1.1.11.3 Only one specimen for permeation resistance testing shall be taken from each sample subjected to embrittlement conditioning. The permeation test specimen shall be taken from the exact center of the folded sample so that the center of the permeation test and the center of the folded sample coincide.

8.3.1.1.11.4 The test cell and test chemical shall be maintained at a temperature sufficient to keep the test chemical as a liquid at ambient pressure such that a 13 mm (½ in.) liquid layer is maintained at all times during the test.

8.3.1.1.11.5 Cumulative permeation shall be measured for a period of 15 minutes +1/−0 minutes.

8.3.1.2 Chemical Permeation Resistance Test Two.

8.3.1.2.1 Application.

8.3.1.2.1.1 This method shall apply to NFPA 1991– and NFPA 1994-compliant ensembles and ensemble elements.

8.3.1.2.1.2 Specific requirements for testing garment materials shall be as specified in 8.3.1.2.17.

8.3.1.2.1.3 Specific requirements for testing visors shall be as specified in 8.3.1.2.18.

8.3.1.2.1.4 Specific requirements for testing glove materials shall be as specified in 8.3.1.2.19.

8.3.1.2.1.5 Specific requirements for testing sock materials shall be as specified in 8.3.1.2.21.

8.3.1.2.1.6 Specific requirements for testing footwear materials shall be as specified in 8.3.1.2.22.

8.3.1.2.1.7 Specific requirements for testing hood materials shall be specified in 8.3.1.2.21.

8.3.1.2.1.8 Specific requirements for testing seams shall be as specified in 8.3.1.2.21.

8.3.1.2.1.9 Specific requirements for testing elastomeric interface materials shall be specified in 8.3.1.2.22.

8.3.1.2.2 Samples. Samples shall be either NFPA 1991– or NFPA 1994-compliant ensembles, garment materials, visor materials, gloves, socks, or footwear of the sizes specified in the modifications.

8.3.1.2.2.1 Samples for conditioning shall be as specified in 8.1.1, as appropriate.

8.3.1.2.2.2 All layers of the samples during conditioning shall be present and configured in the order and orientation as worn.

8.3.1.2.2.3 Samples shall be cut to the specimen size.

8.3.1.2.3 Specimens.

8.3.1.2.3.1 Specimens shall be of a size required to fit the permeation test cell.

8.3.1.2.3.2 A minimum of three specimens shall be tested against each challenge chemical.

8.3.1.2.3.3 Any outer shell or other composite layers normally worn over the specimen shall be permitted to be included on top of the specimen in the test. The outer shell or other composite layers shall be placed on the test specimen through the cell cap port after the test cell has been assembled.

8.3.1.2.3.4 If the specimen is the outermost layer of the composite, then it shall be tested without any additional layers on top.

8.3.1.2.3.5 Any separable layers normally worn underneath the specimen shall not be permitted to be included in the test.

8.3.1.2.3.6 Specimens with nonuniform surfaces shall be permitted to be treated with an impermeable nonreactive sealant outside the area of the specimen exposed to the challenge chemical to allow sealing of the test cell to a uniform surface of the specimen.

8.3.1.2.3.7 Following any sample preparation, the specimens shall be conditioned at a temperature of 32°C ± 1°C (90°F ± 2°F) and a relative humidity of 80 percent ± 5 percent for at least 24 hours prior to testing in accordance with 8.1.9.

8.3.1.2.4 Apparatus.

8.3.1.2.4.1 A controlled environmental chamber shall be used to maintain the test cell, air flow control system, and reagent chemicals within ± 1.0°C (± 2.0°F) of the test temperature and ± 5 percent of the test relative humidity. The controlled environment chamber shall be sized so that it can be used for conditioning test materials, test cells when not in use, challenge chemicals, and other test apparatus prior to testing, as well as holding the test cells horizontally during use while connected to the air delivery system with manifold and to the effluent sampling mechanism.

8.3.1.2.4.2* The test cell shall be a two-chambered cell for contacting the specimen with the challenge chemical on the specimen's normal outside surface and for flowing a collection medium on the specimen's normal inside surface, consisting of parts shown in Figure 8.3.1.2.4.2(a) [individual part detail shown in Figure 8.3.1.2.4.2(b) through Figure 8.3.1.2.4.2(f)].

8.3.1.2.4.3* An air delivery system and manifold shall be used to provide oil-free, conditioned air to the test cell/fixtures at a rate of 2 L/min (33.33 cm^3/sec) per test cell/fixture with a temperature precision of ± 0.2°C (± 32.6°F) and a relative humidity precision of ± 5 percent. The manifold shall be designed to deliver 0.3 L/min (5 cm^3/sec) for the challenge side of the test cell, deliver 1 L/min (16.67 cm^3/sec) for the collection side of the test cell, and maintain at the test temperature. All parts of the air delivery system and manifold shall be chemically inert and nonabsorptive to the challenge chemical.

8.3.1.2.4.4 An analytical system shall be used to evaluate the amount of challenge chemical in the effluent air streams from the collection side of the test cell and shall be able to measure the challenge chemical at 0.1 μg/cm^2 over a 60-minute exposure period. The analytical system shall be permitted to include a bubbler tube, solid sorbent, or real-time chemical analyzer. The analytical system shall be able to determine all of the challenge chemical permeating through the specimen in 60 minutes.

8.3.1.2.4.5* A vacuum pump capable of creating vacuum of at least 0.18 psi (5 in.) water column shall be used for testing the integrity of the assembled test cell.

8.3.1.2.4.6* A manometer or pressure gauge capable of measuring pressures or vacuums to 0.36 psi (10 in.) water column with an accuracy of 5 percent of scale shall be used for testing the integrity of the assembled test cell.

8.3.1.2.5 Supplies.

8.3.1.2.5.1 Syringe needles capable of delivering 1 μL droplets ± 1 percent of the challenge chemical shall be used for dispensing liquid challenge chemical onto the surface of the specimen in the test cell.

8.3.1.2.5.2 Replacement O-rings shall be available for use in the permeation test cell.

(A) If unknown, the compatibility of the O-ring material with the challenge chemical shall be verified before use.

(B) If an O-ring shows any signs of chemical degradation in the form of softening, hardening, swelling, deterioration, or loss of shape or function, an O-ring of different material shall be used that does not show chemical degradation.

8.3.1.2.5.3* An inert impermeable surrogate material shall be used as a negative control during validation tests.

8.3.1.2.6 Chemicals.

8.3.1.2.6.1* The following challenge chemicals shall be tested as liquids at a concentration of 95 percent or greater, except where otherwise specified:

(1) Liquid chemical warfare agents for NFPA 1991– and NFPA 1994-compliant Class 1, Class 2, Class 2R, Class 3, and Class 3R ensemble element materials and seams, as follows:
   (a) Sulfur mustard, distilled [HD, or bis(2-chloroethyl) sulfide, CAS 505-60-2]
   (b) Soman (GD, or O-Pinacolyl methylphosphonofluoridate, CAS 96-64-0)

(2) Liquid toxic industrial chemicals for NFPA 1994-compliant Class 1 ensemble elements materials and seams, as follows:
   (a) Dimethyl sulfate (DMS, sulfuric acid dimethyl ester, CAS 77-78-1)
   (b) Tetrachloroethylene (perchloroethylene, CAS 127-18-4)
   (c) Toluene (toluol, CAS 108-88-3)

(3) Liquid toxic industrial chemical dimethyl sulfate (DMS, sulfuric acid dimethyl ester, CAS 77-78-1) for NFPA 1994-compliant Class 2, Class 2R, Class 3, and Class 3R ensemble element materials and seams

8.3.1.2.7 Process for Determining the Mass of Liquid Challenge Chemical Applied.

8.3.1.2.7.1 Prior to assembling the test cell and conducting the test, the mass of the applied challenge chemical shall be determined using the procedure specified in 8.3.1.2.7.2 to 8.3.1.2.7.4.

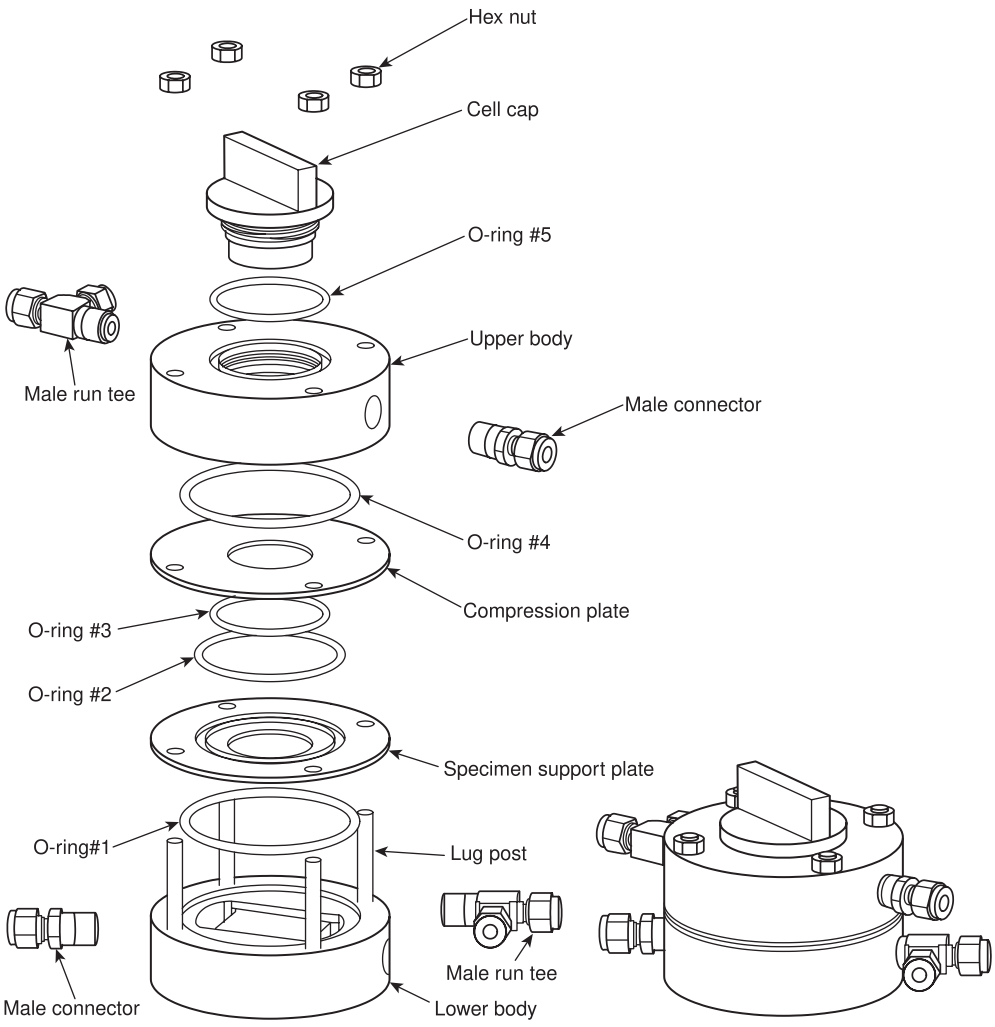


FIGURE 8.3.1.2.4.2(a) Diffusion Test Cell Assembly. (Copyright ©2006 W. L. Gore & Associates, Inc. Used with permission).

8.3.1.2.7.2* The challenge chemical shall be applied to an inert impermeable surrogate specimen in the pattern described in 8.3.1.2.12.

8.3.1.2.7.3 After application, the inert impermeable surrogate specimen shall be visually inspected to verify that the liquid challenge chemical was correctly applied.

8.3.1.2.7.4 The inert impermeable surrogate specimen with the applied liquid challenge chemical shall be placed in a closed large vial containing a known volume of solvent and analyzed in accordance with the procedure from 8.3.1.2.7.5 through 8.3.1.2.7.8.

8.3.1.2.7.5 The large vial with solvent and impermeable surrogate specimen with the applied liquid challenge chemical shall be agitated for at least 1 hour to ensure complete extraction of the challenge chemical.

8.3.1.2.7.6 After agitation, the solvent vial shall be removed and submitted for analysis of the liquid challenge chemical using a procedure capable of detecting 1.0 mg of the liquid challenge chemical.

8.3.1.2.7.7 Using the mass of the liquid challenge chemical detected in the extraction procedure and the exposed area of the test specimen defined by the test cell, the exposure concentration shall be as follows:

(1) 100 g/m^2 +1.0/–0.0 g/m^2 for NFPA 1991-compliant ensemble materials
(2) 20 g/m^2 +1.0/–0.0 g/m^2 for NFPA 1994-compliant Class 1 ensemble materials
(3) 10 g/m^2 +1.0/–0.0 g/m^2 for Class 2 and Class 3 ensemble materials

8.3.1.2.7.8 The number of 1 μL liquid droplets shall be adjusted to conform to the appropriate concentration required by 8.3.1.2.7.7 for the class of ensemble materials being tested.

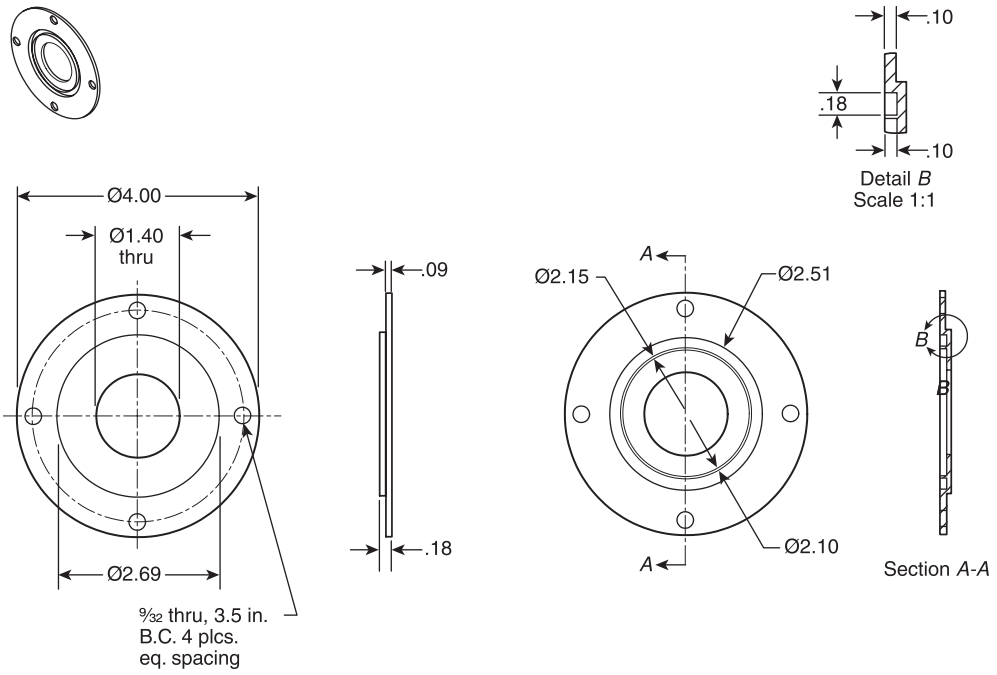


FIGURE 8.3.1.2.4.2(b) Sample Support Plate. (Copyright ©2006 W. L. Gore & Associates, Inc. Used with permission).

8.3.1.2.8* The following challenge chemicals shall be tested as gases or vapors in dry air or nitrogen:

(1) Toxic industrial gases for NFPA 1994-compliant Class 1 ensemble element materials and seams, as follows:
   (a) Acrolien (allyl aldehyde), CAS 107-02-8
   (b) Acrylonitrile (VCN, cyanoethylene), CAS 107-13-1
   (c) Ammonia, anhydrous (NH_3), CAS 7664-41-7
   (d) Chlorine (Cl_2), CAS 7782-50-5
   (e) Diethylamine, CAS 109-89-7
   (f) Ethyl acetate (acetic ether, acetic ester), CAS 141-78-6

(2) Toxic industrial gases and vapors for NFPA 1994-compliant Class 2, Class 2R, Class 3, and Class 3R ensemble elements materials and seams, as follows:
   (a) Ammonia (NH_3), CAS 7664-41-7
   (b) Chlorine (Cl_2), CAS 7782-50-5
   (c) Acrolein (allyl aldehyde), CAS 107-02-8
   (d) Acrylonitrile (VCN, cyanoethylene), CAS 107-13-1

8.3.1.2.9 Procedures.

8.3.1.2.9.1 Preconditioning.

(A) The test specimen, test equipment, and test cell assembly shall be placed in an environmental chamber for a minimum of 24 hours at 32°C ± 1°C (90°F ± 2°F) and at a relative humidity of 80 percent ± 5 percent prior to testing.

(B) Liquid challenge chemicals shall be at room temperature prior to testing.

8.3.1.2.10 Test Cell Assembly.

8.3.1.2.10.1 The test cell shall be assembled in the environmental chamber at 32°C ± 2°C (90°F ± 4°F) and at a relative humidity of 80 percent ± 5 percent.

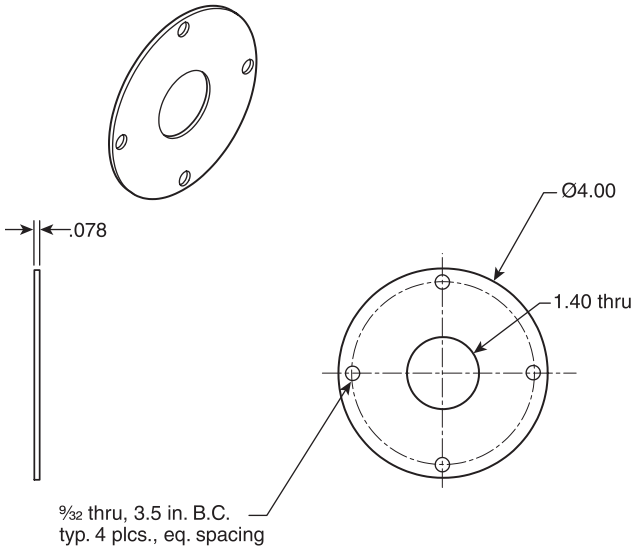


FIGURE 8.3.1.2.4.2(c) Compression Plate. (Copyright ©2006 W. L. Gore & Associates, Inc. Used with permission).

8.3.1.2.10.2 O-ring #1 shall be placed on the lower body (collection side) of the test cell.

8.3.1.2.10.3 The sample support plate shall be placed on the lower body (collection side) of the test cell.

8.3.1.2.10.4 O-ring #2 (outer) and O-ring #3 (inner) shall be placed in the respective grooves on the sample support plate.

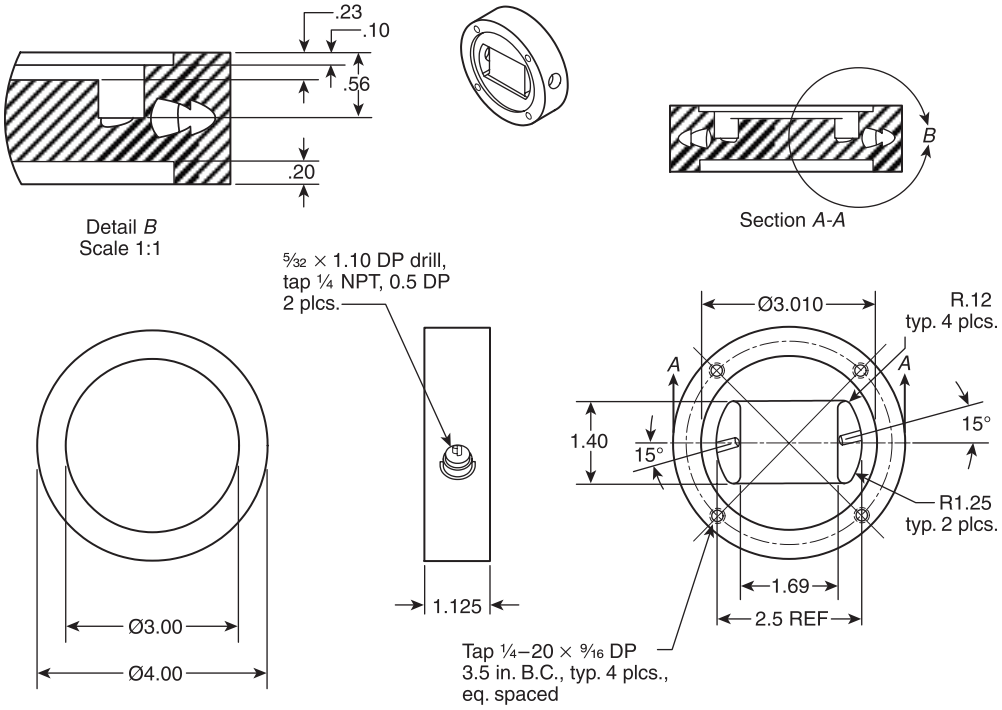


FIGURE 8.3.1.2.4.2(d) Lower Body (Collection Side). (Copyright ©2006 W. L. Gore & Associates, Inc. Used with permission).

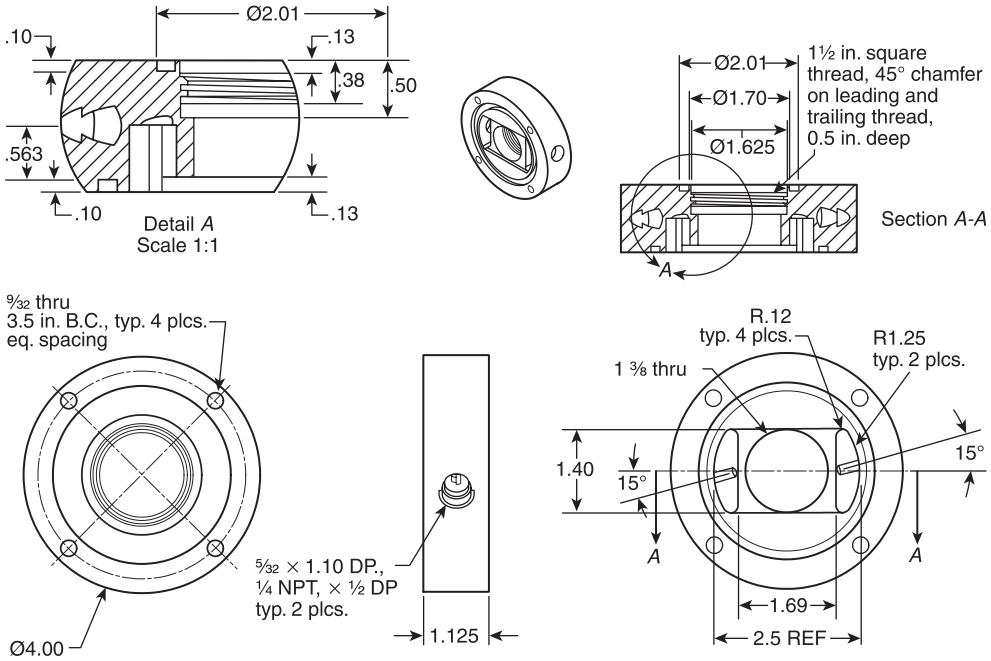


FIGURE 8.3.1.2.4.2(e) Upper Body (Challenge Side). (Copyright ©2006 W. L. Gore & Associates, Inc. Used with permission).

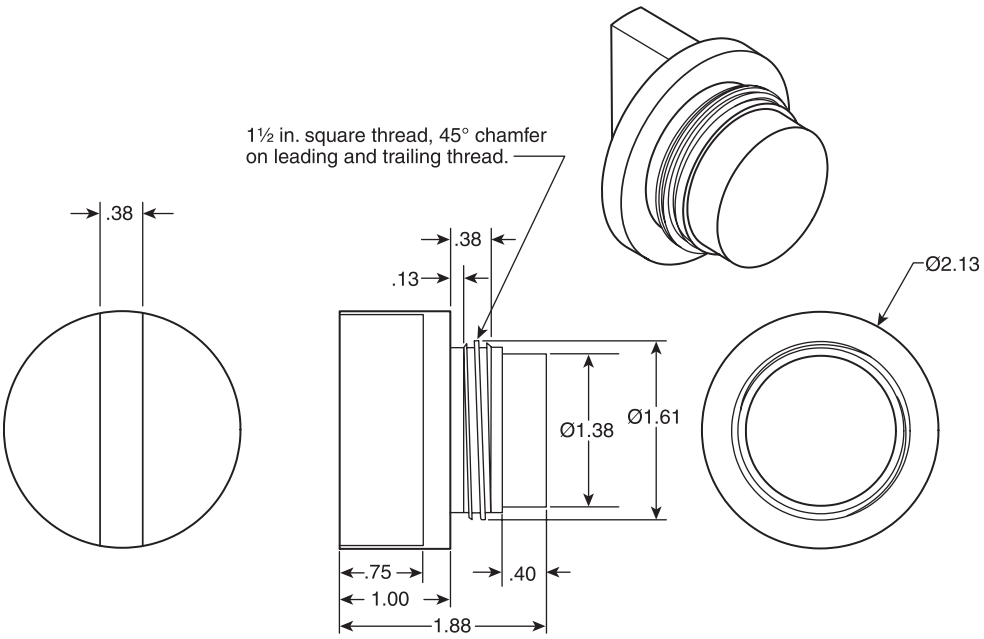


FIGURE 8.3.1.2.4.2(f) Top Cap. (Copyright ©2006 W. L. Gore & Associates, Inc. Used with permission).

8.3.1.2.10.5 The specimen shall be removed from the conditioning location in the environmental chamber and shall be placed on top of the sample support plate.

8.3.1.2.10.6 With the upper body (challenge side) of the test cell upside down, O-ring #4 shall be placed in the upper body of the test cell on the specimen side and the compression plate shall be positioned over O-ring #4.

8.3.1.2.10.7 The upper body (challenge side) of the test cell with O-ring #4 and the compression plate shall be inverted, aligned with the lug posts, and joined with the lower body (collection side) of the test cell.

8.3.1.2.10.8 Using the four cell sealing lugs, the cell halves shall be clamped together and 51.8 cm/kg (45 in./lb) of torque shall be applied to each lug to ensure a proper cell seal.

8.3.1.2.10.9 O-ring #5 shall be inserted into the groove around the agent challenge port in the upper body of the test cell and the cell top cap shall be screwed into place.

8.3.1.2.10.10 The integrity of the test cell assembly shall be verified using the procedure in 8.3.1.2.11.

8.3.1.2.10.11 Each test cell shall be labeled with the challenge chemical to be used in it.

8.3.1.2.11 Verification of Test Cell Integrity.

8.3.1.2.11.1 Test cell integrity shall be performed in the environmental chamber at 32°C ± 2°C (90°F ± 4°F) and at a relative humidity of 80 percent ± 5 percent.

8.3.1.2.11.2 Valves on the outlet ports of the upper and lower body of the test cell shall be closed.

8.3.1.2.11.3 Both the upper and lower body inlet ports of the test cell shall be connected to a manometer.

8.3.1.2.11.4 Both inlet ports shall be connected to a vacuum and the test cell upper body and test cell lower body shall be depressurized to 75 mm (3 in.) water column pressure.

8.3.1.2.11.5 If the test cell pressure drops below 50 mm (2 in.) of water column within 2 minutes, the test cell shall be reassembled according to the steps in 8.3.1.2.10.

8.3.1.2.11.6 Only test cells that have passed this integrity test shall be used for testing.

8.3.1.2.12 Determination of Procedure for Applying Liquid Challenge Chemicals.

8.3.1.2.12.1 The liquid challenge chemical concentration shall be 100 g/m^2 +1.0 /– 0.0 g/m^2 for NFPA 1991-compliant ensembles.

8.3.1.2.12.2 The liquid challenge chemical concentration shall be 20 g/m^2 +1.0/–0.0 g/m^2 for Class 1 ensembles.

8.3.1.2.12.3 The liquid challenge chemical concentration shall be 10 g/m^2 +1.0/–0.0 g/m^2 for Class 2, Class 2R, Class 3, and Class 3R ensemble materials.

8.3.1.2.12.4 The number of 1 μL droplets shall be permitted to vary, depending on the density of the liquid challenge chemical.

(A) For NFPA 1991-compliant ensemble materials, 80 droplets shall be applied evenly spaced around the perimeter and the remaining droplets placed in the center. If more than 1 droplet is required in the center, the droplets shall be spaced 8.1 mm (⅓ in.) apart. For seams, the droplets in the center shall be spaced along the seam juncture.

(B) For Class 1 ensemble materials, 16 droplets shall be applied evenly spaced around the perimeter and the remaining droplets placed in the center. If more than 1 droplet is

required in the center, the droplets shall be spaced 8.1 mm (⅓ in.) apart. For seams, the droplets in the center shall be spaced along the seam juncture.

(C) For Class 2 and Class 3 ensemble materials, 8 droplets shall be applied evenly spaced around the perimeter and the remaining droplets placed in the center. If more than 1 droplet is required in the center, the droplets shall be spaced 8.1 mm (⅓ in.) apart. For seams, the droplets in the center shall be spaced along the seam juncture.

8.3.1.2.12.5 A mechanical or automated device shall be permitted for uniformly dispensing the droplets onto the surface of the specimen.

8.3.1.2.12.6 When testing any liquid chemical, a quality control trial shall be conducted to verify that the application process delivers either 10 g/m^2 +1.0/–0.0 g/m^2 or 20 g/m^2 +1.0/–0.0 g/m^2 using the procedures in 8.3.1.2.7 specific to the class of ensemble materials being evaluated.

8.3.1.2.13 Procedure for Liquid Challenge Chemicals.

8.3.1.2.13.1 The test cell shall be mounted horizontally and connected to the air delivery system in the environmental chamber at 32°C ± 1°C (90°F ± 2°F) and at a relative humidity of 80 percent ± 5 percent. All connections shall be secured.

8.3.1.2.13.2 The calibrated analytical detection system shall be assembled and initiated according to its instructions.

(A) If bubblers are used, each bubbler shall be filled with the proper collection solvent using a calibrated pipette or equivalent device; the collection solvent shall incorporate an internal standard so adjustments can be made for solvent evaporation/water condensation during sampling.

(B) If solid sorbent tubes are to be used, each sorbent tube shall be cleaned by heating and purging; the absence of any residual chemical shall be verified by the appropriate analysis technique.

(C) Sampler tubes shall be attached to the test cell immediately prior to the application of challenge chemical to avoid potentially adverse effects caused by the presence of moisture in the collection media stream.

(D) At the conclusion of the specified sampling interval, sampling tubes shall be replaced in a manner that ensures permeant is not lost.

(E) Permeant shall be desorbed from sampler tubes immediately following removal from the test chamber.

(F) Analysis of permeant extracts shall be performed within 24 hours of extraction.

8.3.1.2.13.3 The air delivery shall be flowing filtered air at a temperature of 32°C ± 1°C (90°F ± 2°F) and at a relative humidity of 80 percent ± 5 percent to the collection side of the test cell at least 15 minutes prior to the application of the challenge chemical.

8.3.1.2.13.4 With the cell top cap removed, 1 µL droplets shall be placed through the agent challenge port of the test cell on the specimen's outer surface within 20 seconds, according to the procedure determined in 8.3.1.2.12.

8.3.1.2.13.5 After placing the liquid challenge chemical on the specimen in the test cell, the cell top cap shall be sealed within 5 seconds.

(A) For testing of NFPA 1991– and NFPA 1994-compliant Class 1, Class 2, and Class 2R ensemble materials, the filtered air at a temperature of 32°C ± 1°C (90°F ± 2°F) and at a relative humidity of 80 percent ± 5 percent shall be flowed only to the collection side of the test cell at a rate of 1.0 L/min ± 0.1 L/min (16.67 cm^3/sec ± 1.67 cm^3/sec). No air shall be flowed across the challenge side of the test cell.

(B) For testing of Class 3 and Class 3R ensemble materials, the filtered air at a temperature of 32°C ± 1°C (90°F ± 2°F) and at a relative humidity of 80 percent ± 5 percent shall be flowed to the challenge side of the test cell at a rate of 0.3 L/min ± 0.03 L/min (5 cm^3/sec ± 1.05 cm^3/sec) and to the collection sides of the test cell at a rate of 1.0 L/min ± 0.1 L/min (16.67 cm^3/sec ± 1.67 cm^3/sec).

8.3.1.2.13.6 The challenge chemical in the effluent air stream shall be collected, measured, and analyzed using either discrete or cumulative methods for the first 15-minute +1.0/–0 minutes interval and overall for 60 minutes +1.0/–0 minutes.

8.3.1.2.13.7 The collection media for the challenge chemical shall be analyzed using an appropriate analytical procedure.

8.3.1.2.13.8 At least one test shall be conducted with a specimen, but without the challenge chemical, as a negative control.

8.3.1.2.13.9 At least one test shall be conducted with an inert impermeable surrogate specimen as a negative control.

8.3.1.2.13.10 The results from tests accompanied by unsuccessful negative controls shall not be used and the test shall be repeated.

8.3.1.2.14 Procedure for Gas or Vapor Challenge Chemicals.

8.3.1.2.14.1 The test cell shall be mounted horizontally and connected to the air delivery system in the environmental chamber at 32°C ± 1°C (90°F ± 2°F) and at a relative humidity of 80 percent ± 5 percent. All connections shall be secured.

8.3.1.2.14.2 The air delivery shall be connected and flowing 1 L/min (16.67 cm^3) of filtered air at a temperature of 32°C ± 1°C (90°F ± 2°F) and at a relative humidity of 80 percent ± 5 percent to the collection side of the test cell at least 15 minutes prior to the initiation of any gas or vapor challenge chemical.

8.3.1.2.14.3 The calibrated analytical detection system shall be assembled and initiated according to its instructions.

(A) If bubblers are used, each bubbler shall be filled with the proper collection solvent using a calibrated pipette or equivalent device; the collection solvent shall incorporate an internal standard so adjustments can be made for solvent evaporation/water condensation during sampling.

(B) If solid sorbent tubes are to be used, each sorbent tube shall be cleaned by heating and purging; the absence of any residual chemical shall be verified by the appropriate analysis technique.

(C) Sampler tubes shall be attached to the test cell immediately prior to the application of challenge chemical to avoid potentially adverse effects caused by the presence of moisture in the collection media stream.

(D) At the conclusion of the specified sampling interval, sampling tubes shall be replaced in a manner that ensures permeant is not lost.

(E) Permeant shall be desorbed from sampler tubes immediately following removal from the test chamber.

(F) Analysis of permeant extracts shall be performed within 24 hours of extraction.

8.3.1.2.14.4 The initiation of the test shall occur when the gas or vapor challenge chemical is introduced into the challenge side of the test cell.

(A) The supply of the gas or vapor challenge chemical shall be sufficient to maintain the gas or vapor challenge chemical concentration during the exposure period of 60 minutes +1.0/–0.0 minutes.

(B) The gas or vapor challenge chemical shall be at a temperature of 32°C ± 1°C (90°F ± 2°F).

(C) For testing of Class 1 ensemble materials, the concentration of the gas or vapor challenge chemical shall be 10,000 ppm +1,000/–0 ppm (by volume).

(D) For testing of Class 2 and Class 2R ensemble materials, the concentration of the gas or vapor challenge chemical shall be 350 ppm +35/–0 ppm (by volume).

(E) For testing of Class 3 and Class 3R ensemble materials, the concentration of the gas or vapor challenge chemical shall be 40 ppm +10/–0 ppm (by volume).

8.3.1.2.14.5 The challenge chemical in the effluent air stream shall be collected, measured, and analyzed using either discrete or cumulative methods for the first 15-minute +1.0/–0 minutes interval and overall for 60 minutes +1.0/–0 minutes.

8.3.1.2.14.6 The collection media for the challenge chemical shall be analyzed using an appropriate analytical procedure.

8.3.1.2.14.7 At least one test shall be conducted with the specimen, but without the challenge chemical, as a negative control.

8.3.1.2.14.8 The results from tests accompanied by unsuccessful negative controls shall not be used, and the test shall be repeated.

8.3.1.2.15 Test Conclusion, Test Cell Cleaned, and Specimen Disposal.

8.3.1.2.15.1 At the conclusion of the test, the test cell shall be purged, and the air delivery and analytical system shall be shut down.

8.3.1.2.15.2 Each cell shall be disassembled one at a time.

8.3.1.2.15.3 The tested specimen shall be inspected for degradation or other obvious abnormalities; these observations shall be recorded with the test results.

8.3.1.2.15.4 Disposal of tested specimens and other supplies shall be handled according to local, state, federal or other applicable regulations.

8.3.1.2.15.5 Each component of the test cell shall be rinsed with acetone or other appropriate solvent to remove residual chemicals and allowed to air dry in a clean area.

8.3.1.2.15.6 Test cells shall be free of residual chemicals prior to reuse.

8.3.1.2.16 Report.

8.3.1.2.16.1 The cumulative permeation for the first 15-minute interval and for the overall 60-minute exposure shall be calculated, recorded, and reported in $\mu g/cm^2$ for each specimen for each challenge chemical.

(A) If no challenge chemical is detected at the end of the 60-minute test period, then the cumulative permeation shall be recorded and reported as less than the minimum detectable mass per unit area for the specific chemical being tested.

8.3.1.2.16.2 The average cumulative permeation shall be calculated and reported by averaging the results from all specimens for each challenge chemical.

(A) For the calculation of average cumulative permeation, if the results of one or more of the specimens tested is less than the minimum detectable cumulative permeation, then the minimum detectable cumulative permeation shall be used as the result for those specimens.

(B) For the calculation of average cumulative permeation, if the results of all the specimens tested are less than the minimum detectable cumulative permeation, then the average cumulative permeation shall be reported as the minimum detectable cumulative permeation.

8.3.1.2.16.3 Any observations of degradation or other abnormalities shall be reported at the conclusion of the testing of each specimen.

8.3.1.2.17* Additional Test Information to Be Reported. The following additional information shall be recorded and reported as part of the individual test report for each material-chemical pair:

(1) Material name
(2) Chemical or chemical mixture identification
(3) Sampling technique, including sorbent material
(4) Desorption technique, including extraction solvent if a sorbent tube is used
(5) Analytical instrumentation or analysis technique, including detector
(6) Method of calibration of analytical instrumentation
(7) Desorption and retention efficiency, as applicable to collection method
(8) Limit of detection of analysis technique
(9) Minimum detectable cumulative permeation mass
(10) Date of test
(11) Testing laboratory
(12) Any observations of degradation or other abnormalities at the conclusion of the testing of each specimen

8.3.1.2.18 Interpretation. The average cumulative permeation for the first 15-minute interval and for the overall 60-minute exposure for each challenge chemical shall be used to determine pass or fail performance.

8.3.1.2.19 Specific Requirements for Testing Garment Materials After Flexing and Abrading.

8.3.1.2.19.1 Samples for conditioning shall be 200 mm × 280 mm (8 in. × 11 in.) rectangles and shall consist of all layers as configured in the garment.

8.3.1.2.19.2 Two samples shall first be conditioned by flexing as specified in 8.1.3.

(A) One sample shall be flexed with the longitudinal axis parallel to the machine direction of the material, and the second sample shall be flexed with the longitudinal axis parallel to the cross-machine direction of the material.

(B) Following flexing, two samples for abrasion conditioning measuring 45 mm × 230 mm (1¾ in. × 9 in.) each shall be cut from the center of the flexed samples.

(C) At least one specimen for abrasion conditioning shall be taken from a sample flexed in the machine direction, and at least one specimen for abrasion conditioning shall be taken from a sample flexed in the cross-machine direction for each chemical tested.

8.3.1.2.19.3 The new samples for abrasion conditioning shall then be conditioned by abrading as specified in 8.1.4.

(A) Following abrasion, only one specimen for permeation resistance testing shall be taken from each sample subjected to abrasion.

(B) The permeation test specimen shall be taken from the exact center of the abraded sample so that the center of the permeation test and the center of the abraded sample coincide.

8.3.1.2.20 Specific Requirements for Testing Visors. Samples for conditioning shall be visor materials.

8.3.1.2.21 Specific Requirements for Testing Glove Materials After Abrading.

8.3.1.2.21.1 Samples for conditioning shall be whole glove components or whole glove individual elements.

8.3.1.2.21.2 Three samples for abrasion conditioning measuring 45 mm × 230 mm (1¾ in. × 9 in.) each shall be cut from the center of the gauntlet portion of the sample.

8.3.1.2.21.3 The new samples for abrasion conditioning shall then be conditioned by abrading as specified in 8.1.4.

(A) Following abrasion, only one specimen for permeation resistance testing shall be taken from each sample subjected to abrasion.

(B) The permeation test specimen shall be taken from the exact center of the abraded sample so that the center of the permeation test and the center of the abraded sample coincide.

8.3.1.2.21.4 Where the glove chemical protection layer contains a seam, straight seam specimens shall be permitted to be tested in lieu of material specimens. The seam specimens shall be tested after the conditioning specified in 8.1.4. The test cell shall include both the chemical protection layer material and the chemical protection layer seam. The seam shall be located in the approximate center of the test cell.

8.3.1.2.22 Specific Requirements for Testing Footwear.

8.3.1.2.22.1 This test shall apply to all types of footwear configurations.

8.3.1.2.22.2 Where the footwear incorporates a sock or over boot constructed of garment material, the garment material flex fatigue resistance test as specified in 8.1.3 shall be permitted to be substituted for this test.

8.3.1.2.22.3 Upper samples for conditioning shall be whole footwear items.

8.3.1.2.22.4 Footwear upper samples shall be conditioned by abrading as specified in 8.1.4.

8.3.1.2.22.5 Following abrasion, only one specimen for chemical permeation resistance testing shall be taken from each sample subjected to abrasion.

8.3.1.2.22.6 The chemical permeation test specimen shall be taken from the exact center of the abraded sample so that the center of the permeation test specimen and the center of the abraded specimen coincide.

8.3.1.2.23 Specific Requirements for Testing Seams of Garments, Hoods, Socks, Visors, and Gloves.

8.3.1.2.23.1 Samples for conditioning shall be 600 mm (23 ½ in.) lengths of prepared straight seam or cut from ensembles.

8.3.1.2.23.2 Seam specimens shall be prepared from straight seam samples that have a minimum of 75 mm (3 in.) of material on each side of the seam center.

8.3.1.2.23.3 Seam specimens shall be cut such that the exact seam center divides the specimen in half.

8.3.1.2.23.4 Seam specimens shall be prepared such that they represent each stitch and sealing method. Specimens shall be permitted to be taken from the finished product.

8.3.1.2.23.5 Garment seams shall include, at a minimum, garment-to-garment material seams and garment-to-visor material seams, when applicable.

8.3.1.2.23.6 Seam specimens shall be taken from the gauntlet portion of a glove where an external seam is used in the construction of the glove.

8.3.1.2.24 Specific Requirements for Testing Elastomeric Interface Materials.

8.3.1.2.24.1 Samples shall not be subjected to conditioning by flexing or abrasion.

8.3.1.2.24.2 Specimens shall be taken from elastomeric interface sheet material or formed elastomeric interface items that are representative of the elastomeric interface material nominal thickness.

8.3.1.3 Low Vapor Chemical Permeation Test.

8.3.1.3.1 Application.

8.3.1.3.1.1 The test shall apply to NFPA 1994-certified Class 1 garments, gloves, footwear uppers, socks, hoods, and elastomeric interface materials and seams in the elements and between components.

8.3.1.3.1.2 Specific requirements for testing garment, hood, and sock materials shall be as specified in 8.3.1.3.8.

8.3.1.3.1.3 Specific requirements for testing visors shall be as specified in 8.3.1.3.9.

8.3.1.3.1.4 Specific requirements for testing glove materials shall be as specified in 8.3.1.3.10.

8.3.1.3.1.5 Specific requirements for testing footwear materials shall be as specified in 8.3.1.3.11.

8.3.1.3.1.6 Specific requirements for testing seams shall be as specified in 8.3.1.3.12.

8.3.1.3.1.7 Specific requirements for testing elastomeric interface materials shall be as specified in 8.3.1.3.13.

8.3.1.3.2 Samples. Samples shall be either NFPA 1991- or NFPA 1994-certified ensembles, garment materials, visor materials, gloves, socks, or footwear of the sizes specified in the modifications.

8.3.1.3.2.1 Samples for conditioning shall be as specified according to the specific requirements in 8.1.1, as appropriate.

8.3.1.3.2.2 All layers of the samples during conditioning shall be present and configured in the order and orientation in which they are meant to be worn.

8.3.1.3.2.3 Samples shall be cut to the specimen size.

8.3.1.3.3 Specimens.

8.3.1.3.3.1 Specimens shall be sized as specified in Test Operations Procedure (TOP) 08-2-503, *Low Volatility Agent Permeation (LVAP) Swatch Testing*.

8.3.1.3.3.2 A minimum of three specimens shall be tested.

8.3.1.3.4 Apparatus.

8.3.1.3.4.1 The test apparatus and related equipment specified in TOP 08-2-503 shall be used.

8.3.1.3.4.2 Facilities engaged in this testing shall meet the following requirements:

(1) The facility shall have capabilities including the following:
   (a) Storage of hazardous chemicals
   (b) General and specialized chemical analysis specific to the chemicals being tested
   (c) Emergency response preparedness for accidents involving the chemicals
   (d) Hazardous waste storage and disposal
(2) The facility shall have a low volatility agent permeation (LVAP) swatch test fixture and a control/data system with the required test cells that provides the required test conditions and the ability to control the temperature from 10°C (50°F) above ambient to 50°C (± 2°C) [122°F (± 4°F)], as well as to record the test conditions every minute.
(3) The facility shall have a preconditioning chamber that can operate for 24 hours at the specified conditions of 32.2 ± 0.7°C (90 ± 2°F) and 80 ± 5 percent relative humidity (RH). The conditions shall be measured and recorded using calibrated temperature and RH probes.

8.3.1.3.4.3 The test equipment shall include the following:

(1) A polycarbonate Petri dish, a 47 mm (1.85 in.) polytetrafluoroethylene (PTFE) swatch, a sorbent pad, a swatch, a 28 mm (1.1 in.) PTFE disk, and a cylindrical stainless steel weight contained within an inverted, 240 mL (8.1 oz) glass jar, as shown in Figure 8.3.1.3.4.3.
(2) A cylindrical weight shall be individually numbered 316 stainless steel cylinders, each with a mass of 454.0 g (± 1 g) [92 tsp (± 0 tsp)] and a contact diameter of 28.7 mm, where the mass and diameter are capable of delivering 1 psi of pressure to a 6 cm^2 region.
(3) A sorbent material suitable for the test chemical that has a minimum detection mass capability of 6.0 $\mu g/cm^2$.

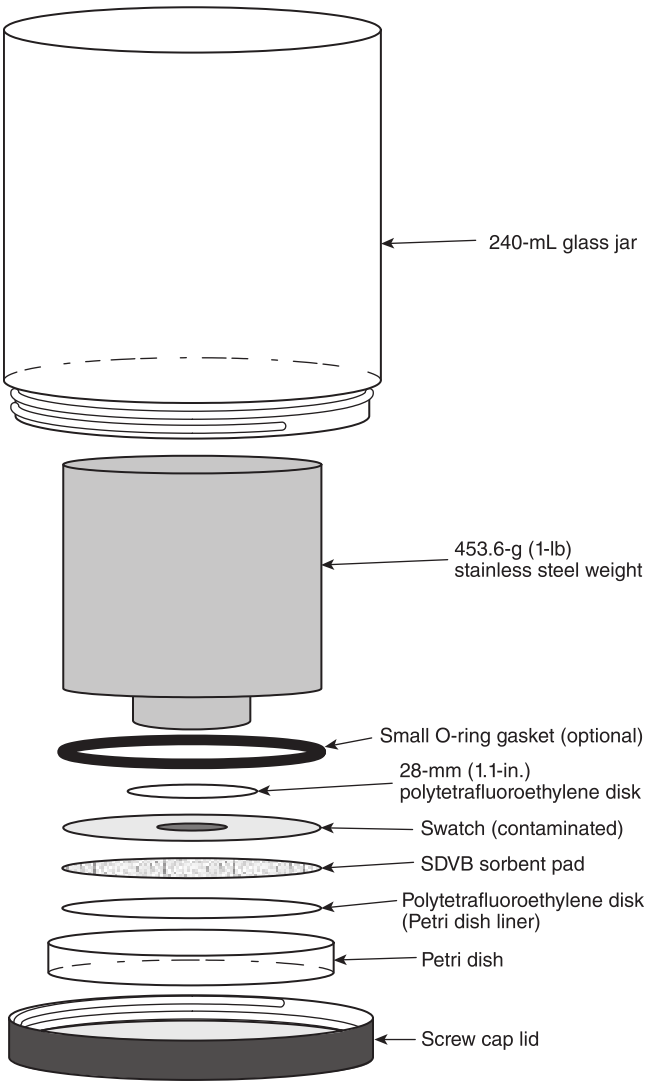


FIGURE 8.3.1.3.4.3 Diagram of Test Apparatus for Low Vapor Pressure Permeation Testing.

(4) A latex swatch to be used as the standard reference material that consists of 10 mil, medium-soft (40A durometer), natural latex rolled sheets with a thickness tolerance of ± 0.05 mm (± 0.002 in.).

8.3.1.3.5 Procedure.

8.3.1.3.5.1 Specimens shall be tested as specified in TOP 08-2-503 against Sulfuric acid, 93.1 percent w/w (aqueous) with the following modifications:

(1) Extraction and analytical techniques shall be utilized to achieve a minimum detection limit of 6.0 $\mu g/cm^2$.
(2) The specific extraction efficiency and update rate for the selected sorbent, extraction, and analytical techniques shall be reported.
(3) The contact period shall be limited to 1 hour.
(4) The selected sorbent, extraction, and analytical techniques shall be applied in the analysis of the exposed test specimens and controls.

8.3.1.3.6 The following information shall be reported for each test:

(1) The identification of the test sample and the location where specimens were taken.
(2) The individual specimen weight and average weight of all specimens in g/m^2.
(3) The individual specimen thickness and average thickness of all specimens in mm.
(4) The identification of the conditioning chamber used, test chamber used, and laboratory used.
(5) A description of specimen preconditioning and pretreatments, if any.
(6) The identification of the challenge test chemical.
(7) The challenge test chemical and its purity or concentration.
(8) The challenge drop volume and pattern applied.
(9) Results for the negative and positive controls.
(10) The mass of the chemical collected in μg for each specimen.
(11) The calculated individual and average cumulative permeation for each specimen in $\mu g/cm^2$.
(12) The test duration.
(13) The test temperature and RH for all the environmental control fixtures during preconditioning and test execution.

8.3.1.3.7 Interpretation. The average cumulative permeation shall be used to determine pass or fail performance.

8.3.1.3.8 Specific Requirements for Testing Garment Materials After Flexing and Abrading.

8.3.1.3.8.1 Samples for conditioning shall be 200 mm × 280 mm (8 in. × 11 in.) rectangles and shall consist of all the layers as configured in the testing garment.

8.3.1.3.8.2 Two samples shall be conditioned by flexing as specified in 8.1.3.

(A) One sample shall be flexed with the longitudinal axis parallel to the machine direction of the material, and the second sample shall be flexed with the longitudinal axis parallel to the cross-machine direction of the material.

(B) After flexing, two samples for abrasion conditioning, each measuring 45 mm × 230 mm (1 ¾ in. × 9 in.), shall be cut from the center of the flexed samples.

(C) At least one specimen for abrasion conditioning shall be taken from a sample flexed in the machine direction, and at least one specimen for abrasion conditioning shall be taken from a sample flexed in the cross-machine direction for each chemical tested.

8.3.1.3.8.3 These new samples shall be conditioned by abrading as specified in 8.1.4.

(A) Following abrasion, only one specimen for permeation resistance testing shall be taken from each sample.

(B) The permeation test specimen shall be taken from the exact center of the abraded sample so that the center of the permeation test and the center of the abraded sample coincide.

8.3.1.3.9 Specific Requirements for Testing Visors.

8.3.1.3.9.1 Samples for conditioning shall be visor materials.

8.3.1.3.10 Specific Requirements for Testing Glove Materials After Abrading.

8.3.1.3.10.1 Samples for conditioning shall be whole glove components or whole glove individual elements.

8.3.1.3.10.2 Three samples for abrasion conditioning, each measuring 45 mm × 230 mm (1 ¾ in. × 9 in.), shall be cut from the center of the gauntlet portion of the sample.

8.3.1.3.10.3 These new samples shall be conditioned by abrading as specified in 8.1.4.

(A) After abrasion, only one specimen for permeation resistance testing shall be taken from each sample.

(B) The permeation test specimen shall be taken from the exact center of the abraded sample so that the center of the permeation test and the center of the abraded sample coincide.

8.3.1.3.11 Specific Requirements for Testing Footwear.

8.3.1.3.11.1 This test shall apply to all types of footwear configurations.

8.3.1.3.11.2 Where the footwear incorporates a sock or over boot constructed of garment material, the garment material flex fatigue resistance test, as specified in 8.1.3, shall be permitted to be substituted for this test.

8.3.1.3.11.3 Footwear upper samples for conditioning shall be whole footwear items.

8.3.1.3.11.4 Footwear upper samples shall be conditioned by abrading as specified in 8.1.4.

8.3.1.3.11.5 After abrasion, only one test specimen for chemical permeation resistance testing shall be taken from each sample.

8.3.1.3.11.6 The chemical permeation test specimen shall be taken from the exact center of the abraded sample so that the center of the permeation test specimen and the center of the abraded specimen coincide.

8.3.1.3.12 Specific Requirements for Testing Seams of Garments, Hoods, Socks, Visors, and Gloves.

8.3.1.3.12.1 Samples for conditioning shall be 600 mm (23 ½ in.) lengths of prepared seam or shall be cut from ensembles.

8.3.1.3.12.2 Seam specimens shall be prepared from seam samples that have a minimum of 75 mm (3 in.) of material on each side of the seam center.

8.3.1.3.12.3 Permeation test specimens shall be cut such that the exact seam center divides the specimen in half.

8.3.1.3.12.4 Seam specimens shall represent each type of seam found in the garment or shall be taken from each type of seam found in the garment, including, at a minimum, the garment-to-garment material seams and the garment-to-visor material seams.

8.3.1.3.12.5 Seam specimens shall be taken from the gauntlet portion of the glove where an external seam is used in the construction of the glove.

8.3.1.3.13 Specific Requirements for Testing Elastomeric Interface Materials.

8.3.1.3.13.1 Samples shall not be subjected to conditioning by flexing or abrasion.

8.3.1.3.13.2 Specimens shall be taken from elastomeric interface sheet material or formed elastomeric interface items that are representative of the elastomeric interface material nominal thickness.

8.3.2 Chemical Penetration Resistance Test.

8.3.2.1 Application.

8.3.2.1.1 This test method shall apply to NFPA 1992– and NFPA 1994-compliant liquid-splash protective garment materials, garment seams, visor materials, glove materials, footwear materials, garment closure assemblies, hood materials, and elastomeric interface materials.

8.3.2.1.2 Modifications to this test method for testing visor materials without abrading or flexing shall be as specified in 8.3.2.7.

8.3.2.1.3 Modifications to this test method for testing garment materials after flexing and abrading shall be as specified in 8.3.2.8.

8.3.2.1.4 Modifications to this test method for testing glove materials after abrading shall be as specified in 8.3.2.9.

8.3.2.1.5 Modifications to this test method for testing footwear materials after abrading shall be as specified in 8.3.2.10.

8.3.2.1.6 Modifications to this test method for testing seams without flexing and abrading shall be as specified in 8.3.2.11.

8.3.2.1.7 Modifications to this test method for testing closure assemblies with fatigue shall be as specified in 8.3.2.12.

8.3.2.1.8 Modifications to this test method for testing hood materials after flexing and abrading shall be as specified in 8.3.2.13.

8.3.2.1.9 Modifications to this test method for testing elastomeric interface materials shall be as specified in 8.3.2.14.

8.3.2.2 Samples.

8.3.2.2.1 Samples shall be the chemical protection layer of the size specified in the modifications and any exterior layers, if integrated.

8.3.2.2.2 Samples shall be conditioned as specified in 8.1.2 after the conditioning specified in the modifications.

8.3.2.2.3 Samples shall be cut to the specimen size.

8.3.2.2.4 All layers of the samples during conditioning shall be present and configured in the order and orientation as worn.

8.3.2.3 Specimens.

8.3.2.3.1 Specimens shall be the size specified in ASTM F903, *Standard Test Method for Resistance of Materials Used in Protective Clothing to Penetration by Liquids.*

8.3.2.3.2 At least three specimens shall be tested against each challenge chemical.

8.3.2.3.3 Any outer shell or other composite layers normally worn over the specimen shall be permitted to be included on top of the specimen in the test. The outer shell or other composite layers shall be placed on the test specimen through the cell cap port after the test cell has been assembled.

8.3.2.3.4 If the specimen is the outermost layer of the composite, then it shall be tested without any additional layers on top.

8.3.2.3.5 Any separable layers normally worn underneath the specimen shall not be permitted to be included in the test.

8.3.2.3.6 Specimens with nonuniform surfaces shall be permitted to be treated with an impermeable nonreactive sealant outside the area of the specimen exposed to the challenge chemical to allow sealing of the test cell to a uniform surface of the specimen.

8.3.2.4 Procedure.

8.3.2.4.1 For NFPA 1994-compliant materials, penetration testing shall be conducted against liquid sulfuric acid, 93.1 percent, CAS No. 7664-93-9, at specific gravity 1.84, 66° Baumé.

8.3.2.4.2 For NFPA 1992-compliant materials, penetration testing shall be conducted against the following liquid chemicals at the specified concentrations:

(1) Butyl acetate, CAS No. 123-86-4, >95 percent, w/w
(2) Dimethylformamide, CAS No. 68-12-2, >95 percent, w/w
(3) Fuel H — surrogate gasoline (42.5 percent toluene, 42.5 percent isooctane, and 15 percent denatured ethanol, v/v), as defined in ASTM D471, *Standard Test Method for Rubber Property — Effect of Liquids*
(4) Isopropyl alcohol, CAS No. 67-63-0, >91 percent, w/w
(5) Methyl isobutyl ketone, CAS No. 108-10-1, >95 percent, w/w
(6) Nitrobenzene, CAS No. 98-95-3, >95 percent, w/w
(7) Sodium hydroxide, CAS No. 1310-73-2, 50 percent, w/w
(8) Sodium hypochlorite, 10 percent (made within 72 hours of use), w/w
(9) Sulfuric acid, CAS No. 7664-93-9, 93.1 percent, w/w
(10) Tetrachloroethylene, CAS No. 127-18-4, >95 percent, w/w

8.3.2.4.3 Penetration resistance shall be measured in accordance with Procedure C in ASTM F903, *Standard Test Method for Resistance of Materials Used in Protective Clothing to Penetration by Liquids*, using the following modifications:

(1) All tests shall be conducted at 25°C ± 3°C (77°F ± 5°F) and 65 percent ± 5 percent relative humidity.
(2) The plexiglass shield shall be omitted from the test cell.
(3) Use of blotting paper at the end of the test shall be permitted to assist in the visual observation of liquid penetration. Visually observed chemical on the blotting paper shall constitute failure of this test.
(4) An observation to determine specimen penetration shall be made at the end of the 60-minute chemical contact period.

8.3.2.5 Report. The pass or fail results for each chemical tested and identification of location where penetration occurs, if discernible, shall be recorded and reported.

8.3.2.6 Interpretation. Observed liquid penetration at the end of the test for any specimen shall constitute failure.

8.3.2.7 Specific Requirements for Testing Visor Materials. Samples for conditioning shall be visor material(s).

8.3.2.8 Specific Requirements for Testing Garment Materials After Flexing and Abrading.

8.3.2.8.1 Samples for conditioning shall be 200 mm × 280 mm (8 in. × 11 in.) rectangles.

8.3.2.8.2 Samples shall first be conditioned by flexing as specified in 8.1.3.

8.3.2.8.3 Following flexing, three samples for abrasion conditioning measuring 75 mm × 230 mm (3 in. × 9 in.) each shall be cut from the center of the flexed sample.

8.3.2.8.4 At least one specimen for abrasion conditioning shall be taken from a sample flexed in the machine direction, and at least one specimen for abrasion conditioning shall be taken from a sample flexed in the cross-machine direction for each chemical tested.

8.3.2.8.5 The new samples shall then be conditioned by abrading as specified in 8.1.4.

8.3.2.8.6 Following abrasion, only one specimen for penetration resistance testing shall be taken from each sample subjected to abrasion.

8.3.2.8.7 The penetration test specimen shall be taken from the exact center of the abraded sample so that the center of the penetration test and the center of the abraded sample coincide.

8.3.2.9 Specific Requirements for Testing Glove Materials After Abrading.

8.3.2.9.1 Samples for conditioning shall be whole gloves or glove materials representative of glove construction.

8.3.2.9.2 A new sample shall be cut from the whole glove or glove material sample that measures 75 mm × 230 mm (3 in. × 9 in.). The new sample shall provide homogeneity across the entire area.

8.3.2.9.3 The new samples shall then be conditioned by abrading as specified in 8.1.4.

8.3.2.9.4 Following abrasion, only one specimen for penetration resistance testing shall be taken from each sample subjected to abrasion.

8.3.2.9.5 The penetration test specimen shall be taken from the exact center of the abraded sample so that the center of the penetration test and the center of the abraded sample coincide.

8.3.2.10 Specific Requirements for Testing Footwear Materials After Abrading.

8.3.2.10.1 This test shall apply to all types of footwear configurations. If the footwear incorporates a sock constructed of garment material, the garment material penetration resistance test shall be permitted to be substituted for this test.

8.3.2.10.2 Samples for conditioning shall be whole footwear items or footwear materials representative of the footwear upper construction.

8.3.2.10.3 New samples shall be taken in areas from the footwear or footwear material measuring 75 mm × 230 mm (3 in. × 9 in.). An attempt shall be made to choose new samples from areas that are homogeneous.

8.3.2.10.4 The new samples shall then be conditioned by abrading as specified in 8.1.4.

8.3.2.10.5 Following abrasion, only one specimen for penetration resistance testing shall be taken from each sample subjected to abrasion.

8.3.2.10.6 The penetration test specimen shall be taken from the exact center of the abraded sample so that the center of the penetration test and the center of the abraded sample coincide.

8.3.2.11 Specific Requirements for Testing Seams of Garments, Hoods, Gloves, or Footwear.

8.3.2.11.1 Samples for conditioning shall be 610 mm (24 in.) lengths of prepared seam or cut from ensembles or ensemble elements.

8.3.2.11.2 Seam specimens shall be prepared from seam samples that have a minimum of 75 mm (3 in.) of material on each side of the seam center.

8.3.2.11.3 Penetration test specimens shall be cut such that the exact seam center divides the specimen in half.

8.3.2.11.4 Seam specimens shall be prepared such that they represent the actual garment or hood construction or shall be taken from each different type of seam found in the garment or hood.

8.3.2.11.5 Glove seam specimens shall be prepared such that they represent the actual glove construction or shall be taken from each different type of seam found in the glove. Only the barrier layer(s) shall be included in the test.

8.3.2.11.6 Footwear seam specimens shall be prepared such that they represent the actual footwear construction or shall be taken from each different type of seam found in the footwear. Only the barrier layer(s) shall be included in the test.

8.3.2.11.7 Sample seams shall be evaluated against a subset of the chemicals specified in 8.3.2.4.2 that shall include the following:

(1) Fuel H — surrogate gasoline (42.5 percent toluene, 42.5 percent isooctane, and 15 percent denatured ethanol, v/v), as defined in ASTM D471, *Standard Test Method for Rubber Property — Effect of Liquids*
(2) Methyl isobutyl ketone, CAS No. 108-10-1, >95 percent, w/w
(3) Sulfuric acid, CAS No. 7664-93-9, 93.1 percent, w/w

8.3.2.12 Specific Requirements for Testing Garment Closure Assemblies After Fatigue.

8.3.2.12.1 Samples for conditioning shall include 150 mm (6 in.) of material on either side of the closure.

8.3.2.12.2 Specimens shall be conditioned as specified in 8.1.9.

8.3.2.12.3 Sample seams shall be evaluated against a subset of the chemicals specified in 8.3.2.4.2that shall include the following:

(1) Fuel H — surrogate gasoline (42.5 percent toluene, 42.5 percent isooctane, and 15 percent denatured ethanol, v/v), as defined in ASTM D471, *Standard Test Method for Rubber Property — Effect of Liquids*

(2) Methyl isobutyl ketone, CAS No. 108-10-1, >95 percent, w/w
(3) Sulfuric acid, CAS No. 7664-93-9, 93.1 percent, w/w

8.3.2.13 Specific Requirements for Testing Hood Materials After Flexing and Abrading.

8.3.2.13.1 Samples for conditioning shall be 200 mm × 280 mm (8 in. × 11 in.) rectangles.

8.3.2.13.2 Samples shall first be conditioned by flexing as specified in 8.1.3.

8.3.2.13.3 Following flexing, three samples for abrasion conditioning measuring 75 mm × 230 mm (3 in. × 9 in.) each shall be cut from the center of the flexed sample.

8.3.2.13.4 At least one specimen for abrasion conditioning shall be taken from a sample flexed in the machine direction, and at least one specimen for abrasion conditioning shall be taken from a sample flexed in the cross-machine direction for each chemical tested.

8.3.2.13.5 The new samples shall then be conditioned by abrading as specified in 8.1.4.

8.3.2.13.6 Following abrasion, only one specimen for penetration resistance testing shall be taken from each sample subjected to abrasion.

8.3.2.13.7 The penetration test specimen shall be taken from the exact center of the abraded sample so that the center of the penetration test and the center of the abraded sample coincide.

8.3.2.14 Specific Requirements for Testing Elastomeric Interface Materials.

8.3.2.14.1 Samples shall not be subjected to conditioning by flexing or abrasion.

8.3.2.14.2 Specimens shall be taken from elastomeric interface sheet material or formed elastomeric interface items that are representative of the elastomeric interface material nominal thickness.

8.3.3 Closure Penetration Resistance Test.

8.3.3.1 Application. This test method shall apply to NFPA 1991-compliant ensemble closure assemblies.

8.3.3.2 Sample Preparation.

8.3.3.2.1 Samples shall be complete vapor-protective ensembles.

8.3.3.2.2 Samples shall be conditioned as specified in 8.1.9.

8.3.3.3 Specimens.

8.3.3.3.1 Specimens shall be the garment closure assemblies consisting of the closures in combination with the seams attaching the closures to the garments.

8.3.3.3.2 At least three specimens shall be tested.

8.3.3.4 Procedure Penetration resistance testing of garment closure assemblies shall be conducted in accordance with Procedure C in ASTM F903, *Standard Test Method for Resistance of Materials Used in Protective Clothing to Penetration by Liquids*, using the following modifications:

(1) All tests shall be conducted at 25°C ± 3°C (77°F ± 5°F) and 65 percent ± 5 percent relative humidity.
(2) The test cell shall be modified to accommodate the shape of the garment closure assembly without affecting other parts of the test procedure. The plexiglass shield shall be omitted from the test cell.
(3) Use of blotting paper at the end of the test shall be permitted to assist in the visual observation of liquid penetration. Visually observed chemical on the blotting paper shall constitute failure of this test.
(4) An observation to determine specimen penetration shall be made at the end of the chemical contact period.
(5) Testing shall be conducted against the 15 liquid chemicals specified in ASTM F1001, *Standard Guide for Selection of Chemicals to Evaluate Protective Clothing Materials.*

8.3.3.5 Report. The pass or fail results for each chemical tested and identification of location where penetration occurs, if discernible, shall be recorded and reported.

8.3.3.6 Interpretation. Observed liquid penetration at the end of the test for any specimen shall constitute failure.

8.3.4 Viral Penetration Resistance Test.

8.3.4.1 Application.

8.3.4.1.1 This test shall apply to NFPA 1994-compliant Class 2, Class 2R, Class 3, Class 3R, Class 4, and Class 4R garments, gloves, and footwear materials; garment and glove seams; and visors.

8.3.4.1.2 Modifications to this test method for testing garment materials after flexing and abrasion shall be as specified in 8.3.4.8.

8.3.4.1.3 Modifications to this test method for testing visor or facepiece materials shall be as specified in 8.3.4.9.

8.3.4.1.4 Modifications to this test method for testing glove materials shall be as specified in 8.3.4.10.

8.3.4.1.5 Modifications to this test method for testing footwear materials after abrasion shall be as specified in 8.3.4.11.

8.3.4.1.6 Modifications to this test method for testing garment and glove seams shall be as specified in 8.3.4.12.

8.3.4.2 Samples.

8.3.4.2.1 Samples shall be as specified in 8.3.4.8 through 8.3.4.12, as appropriate.

8.3.4.2.2 Samples shall be conditioned as specified in 8.3.4.8 through 8.3.4.12, as appropriate, and then as specified in 8.1.2.

8.3.4.3 Specimens.

8.3.4.3.1 Specimens shall be 75 mm (3 in.) squares.

8.3.4.3.2 At least three specimens shall be tested for each material type.

8.3.4.4 Procedure.

8.3.4.4.1 Biopenetration resistance testing shall be conducted in accordance with Procedure A in ASTM F1671, *Standard Test Method for Resistance of Materials Used in Protective Clothing to Penetration by Blood-Borne Pathogens Using Phi-X174 Bacteriophage Penetration as a Test System*, with the exception of the requirement for determining compatibility in Section 13.5 and Section 15.4.

8.3.4.4.2 The normal outer surface of the material shall be exposed to the liquid as oriented in the clothing item.

8.3.4.5 Report.

8.3.4.5.1 The pass or fail result for each specimen shall be recorded and reported.

8.3.4.5.2 The assay titer in PFU/mL of Phi-X174 shall be recorded and report.

8.3.4.6 Interpretation. Specimens shall exhibit no more than 10 PFU/mL of Phi-X174 in the assay titer to pass the test.

8.3.4.7 Specific Requirements for Testing Garment Materials.

8.3.4.7.1 Samples shall be conditioned by flexing as specified in 8.1.3. Samples shall be 200 mm × 280 mm (8 in. × 11 in.). Following flexing, one specimen shall be taken from the center of each sample subjected to flexing for viral penetration testing.

8.3.4.7.2 Samples shall be conditioned by abrading as specified in 8.1.4. Samples shall be as specified in Figure 8.1.4. Following abrading, one specimen shall be taken from the center of each sample subjected to abrading for viral penetration testing.

8.3.4.7.3 Preconditioning one sample to both flexing and abrading shall be permitted prior to viral penetration testing.

8.3.4.8 Specific Requirements for Testing Visor or Facepiece Materials.

8.3.4.8.1 Samples for conditioning shall be visor materials or facepiece materials.

8.3.4.8.2 Where the ensemble utilizes the respirator facepiece as the ensemble visor, this test method shall also apply to each type of material used in the construction of the respirator facepiece that is exposed to the environment.

8.3.4.8.3 The specimen shall also include the respirator, where applicable.

8.3.4.9 Specific Requirements for Testing Glove Materials.

8.3.4.9.1 Samples for conditioning shall be whole gloves.

8.3.4.9.2 Where the glove chemical protection layer contains a seam, seam specimens shall be permitted to be tested in lieu of material specimens. The test cell shall include both the chemical protection layer material and the chemical protection layer seam. The seam shall be located in the approximate center of the test cell.

8.3.4.10 Specific Requirements for Testing Footwear Materials After Abrading.

8.3.4.10.1 This test shall apply to all types of footwear configurations.

8.3.4.10.2 Where the footwear incorporates a sock or over boot constructed of garment material, the garment material flex fatigue resistance test as specified in 8.1.6 shall be permitted to be substituted for this test.

8.3.4.10.3 Upper samples for conditioning shall be whole footwear items.

8.3.4.10.4 Upper samples shall be as specified in Figure 8.1.4.

8.3.4.10.5 The upper samples that were taken in accordance with 8.3.4.11.5 shall be conditioned by abrading as specified in 8.1.4.

8.3.4.10.6 Following abrasion, only one test specimen for viral penetration resistance testing shall be taken from each sample subjected to abrasion.

8.3.4.10.7 The chemical permeation test specimen shall be taken from the exact center of the abraded sample so that the center of the penetration test specimen and the center of the abraded specimen coincide.

8.3.4.11 Specific Requirements for Testing Garment or Glove Seams.

8.3.4.11.1 Samples for conditioning shall be 600 mm (23½ in.) lengths of prepared straight seams or straight seams cut from ensembles.

8.3.4.11.2 Seam specimens shall be prepared from seam samples that have a minimum of 75 mm (3 in.) of material on each side of the seam center. Viral penetration test specimens shall be cut such that the exact seam center divides the specimen in half.

8.3.4.11.3 Seam specimens shall be prepared such that they represent each type of stitch and sealing method found in the garment or glove. Seam specimens shall be permitted to be taken directly from the garment or glove.

8.3.4.11.4 The garment seams shall include, at a minimum, the garment-to-garment material seam and the garment-to-visor material seam.

8.3.4.11.5 The glove seams shall be taken from the gauntlet portion of a glove when an external seam is used in the construction of the glove.

8.3.4.12 Specific Requirements for Testing Elastomeric Interface Materials.

8.3.4.12.1 Samples shall not be subjected to conditioning by flexing or abrasion.

8.3.4.12.2 Specimens shall be taken from elastomeric interface sheet material or formed elastomeric interface items that are representative of the elastomeric interface material nominal thickness.

8.3.5 Liquid Repellency Test.

8.3.5.1 Application.

8.3.5.1.1 This test shall apply to garment and hood materials.

8.3.5.1.2 If the garment or hood element is constructed of several layers, then all the layers, arranged in the correct order, shall be tested together.

8.3.5.2 Sample Preparation.

8.3.5.2.1 Samples shall be at least 1 m (1 yd) squares of material for garments and hoods.

8.3.5.2.2 Samples shall be conditioned as specified in 8.1.10.

8.3.5.3 Specimens.

8.3.5.3.1 Specimens shall be sized as specified in ISO 6530, *Protective clothing — Protection against liquid chemicals — Test method for resistance of materials to penetration by liquids.*

8.3.5.3.2 A minimum of six specimens shall be tested.

8.3.5.4 Apparatus. The test apparatus and related equipment specified in ISO 6530 shall be used.

8.3.5.5 Procedure. Specimens shall be tested as specified in ISO 6530 against the following chemicals:

(1) Sulfuric acid, 30 percent, w/w (aqueous)
(2) Sodium hydroxide, 10 percent, w/w (aqueous)
(3) 1-Butanol, >95 percent, w/w (undiluted)
(4) o-Xylene, >95 percent, w/w (undiluted)

8.3.5.6 Report. Both the index of penetration and the index of repellency shall be reported for each specimen,as well as the index averages for each sample.

8.3.5.7 Interpretation. The average index of repellency shall be used to determine pass or fail performance.

8.4 Flammability and Flash Fire Performance Tests.

8.4.1 Flammability Resistance Test.

8.4.1.1 Application.

8.4.1.1.1 This test method shall be applied to NFPA 1991-compliant ensemble element materials, NFPA 1992-compliant ensemble element materials, NPFA 1994-compliant Class 1 ensemble materials, and the optional flash fire protection performance of all NFPA 1994-compliant ensemble materials.

8.4.1.1.2 Modifications to this test method for base ensemble performance shall be as specified in 8.4.1.7.

8.4.1.1.3 Modifications to this test method for optional chemical flash fire protection performance shall be as specified in 8.4.1.8.

8.4.1.2 Sample Preparation.

8.4.1.2.1 Samples for conditioning shall be at least 1 m (1 yd) squares of material.

8.4.1.2.2 Samples shall be conditioned as specified in 8.1.2.

8.4.1.3 Specimens.

8.4.1.3.1 Specimens shall be the size specified in ASTM F1358, *Standard Test Method for Effects of Flame Impingement on Materials Used in Protective Clothing Not Designated Primarily for Flame Resistance.*

8.4.1.3.2 Five specimens in each of the warp directions, machine or coarse, and the filling directions, cross-machine or wale, shall be tested.

8.4.1.3.3 Where the material is isotropic, 10 specimens shall be tested.

8.4.1.4 Procedure. Flame resistance testing shall be conducted in accordance with ASTM F1358, *Standard Test Method for Effects of Flame Impingement on Materials Used in Protective Clothing not Designated Primarily for Flame Resistance*, with the following modifications:

(1) The test apparatus shall include the test cabinet and accessories, burner, and gas regulation system, as specified in Sections 6.1, 6.2, and 6.3 of ASTM D6413/D6413M, *Standard Test Method for Flame Resistance of Textiles (Vertical Test).*
(2) Specimens shall be observed for the combination of both melting and dripping.

8.4.1.5 Report.

8.4.1.5.1 Afterflame times shall be recorded and reported for each specimen and as the average for each material direction.

8.4.1.5.2 Burn distances shall be recorded and reported for each specimen and as the average for each material direction.

8.4.1.5.3 Ignition during the initial 3-second exposure shall be recorded and reported for each specimen.

8.4.1.5.4 Evidence of both melting and dripping during either the 3-second or the 12-second exposure period shall be recorded and reported for each specimen.

8.4.1.6 Interpretation.

8.4.1.6.1 Ignition of any individual specimen during the initial 3-second exposure shall be used to determine compliance with ignition requirements.

8.4.1.6.2 The average afterflame time in any direction shall be used to determine compliance with afterflame requirements.

8.4.1.6.3 The average burn distance in any direction shall be used to determine compliance with burn distance requirements.

8.4.1.6.4 Evidence of both melting and dripping of any specimen shall be used to determine compliance with melting and dripping requirements.

8.4.1.7 Specific Requirements for Testing Base Ensemble Materials.

8.4.1.7.1 Only the 3-second flame exposure shall be used.

8.4.1.7.2 Burn distances and afterflame times shall only be determined for the 3-second exposure.

8.4.1.8 Specific Requirements for Testing Optional Chemical Flash Fire Protection Ensemble Materials.

8.4.1.8.1 Only the 12-second flame exposure shall be used.

8.4.1.8.2 Burn distances and afterflame times shall be determined only for the 12-second exposure.

8.4.2 Heat Transfer Performance (HTP) Test.

8.4.2.1 Application. This test method shall apply to protective garment, visor, glove, footwear upper, and, if applicable, elastomeric interface materials.

8.4.2.2 Samples.

8.4.2.2.1 Samples for conditioning shall be 150 mm × 150 mm ± 5 mm (6 in. × 6 in. ± ¼ in.) and shall consist of all layers representative of the element materials to be tested, excluding any areas with special reinforcements or seams.

8.4.2.2.2 Samples shall be conditioned as specified in 8.1.2.

8.4.2.3 Specimens.

8.4.2.3.1 Samples shall be 150 mm × 150 mm ± 5 mm (6 in. × 6 in. ± ¼ in.) and shall consist of all layers representative of the element materials to be tested, excluding any areas with special reinforcements or seams.

8.4.2.3.2 At least three specimens shall be tested.

8.4.2.3.3 Specimens shall not be stitched to hold individual layers together.

8.4.2.4 Apparatus. The test apparatus specified in ASTM F2700, *Standard Test Method for Unsteady-State Heat Transfer Evaluation of Flame Resistant Materials for Clothing with Continuous Heating*, shall be used.

8.4.2.5 Procedure. Radiant protective performance testing shall be performed in accordance with ASTM F2700, *Standard Test Method for Unsteady-State Heat Transfer Evaluation of Flame Resistant Materials for Clothing with Continuous Heating*, with the following modifications:

(1) The optional spacer shall not be used for testing of all material specimens.
(2) The HTP value shall be used with calculations made using the heat flux in calories per square centimeter per second and reported as the HTP rating.

8.4.2.6 Report.

8.4.2.6.1 The individual test HTP rating of each specimen shall be recorded and reported.

8.4.2.6.2 The average HTP rating shall be calculated, recorded, and reported.

8.4.2.6.3 Where an HTP rating is greater than 60, then the HTP rating shall be reported as ">60."

8.4.2.7 Interpretation.

8.4.2.7.1 Pass or fail performance determinations shall be separately based on the average reported HTP rating of all specimens.

8.4.2.7.2 Where an individual result from any test set varies more than ±10 percent from the average result, the results from the test set shall be discarded and another set of specimens shall be tested.

8.4.3 Overall Ensemble Flash Test.

8.4.3.1 Application.

8.4.3.1.1 This test method shall be applied to protective ensembles.

8.4.3.1.1.1 Specific requirements for evaluating incomplete ensembles shall be as specified in 8.4.3.7.

8.4.3.1.1.2 Specific requirements for evaluating NFPA 1994-certified Class 2R, Class 3R, and Class 4R ensembles shall be as specified in 8.4.3.8.

8.4.3.1.1.3 The specific requirement for evaluating ensembles or garments where this testing is also performed for the purposes of providing data on the percentage of a predicted burn injury shall be as specified in 8.4.3.9.

8.4.3.2 Sample Preparation.

8.4.3.2.1 Samples for conditioning shall be complete protective ensembles that include respirator facepieces representing at least one ensemble configuration for which the ensemble is certified.

8.4.3.2.1.1 For the certification of ensembles with SCBA, the test samples shall include only the respirator facepiece and exclude the backframe, harness, air tank, pneumatics, and other SCBA components.

8.4.3.2.1.2 For the certification of ensembles using tight-fitting, facepiece powered air-purifying respirators (PAPR), the test samples shall include the respirator facepiece but exclude the blower, battery pack, belt, breathing hose, and canister or cartridges. A filter adaptor or other means shall be used to close off the blower connector to the respirator facepiece.

8.4.3.2.1.3 For the certification of ensembles using loose-fitting, facepiece PAPR, the test samples shall include the full PAPR hood and headgear but shall exclude the blowers, battery packs, belts, breathing hoses, and canisters or cartridges. A filter adaptor or other means shall be used to close off the blower connectors to the respirator facepieces.

8.4.3.2.1.4 For the certification of ensembles using air-purifying respirators, the test samples shall include the respirator facepiece but exclude the canister or cartridges. A filter adaptor or other means shall be used to close off the canister port on the respirator facepiece.

8.4.3.2.1.5 Cutting open the ensemble for the purposes of routing the cabling from the instrumented manikin shall be permitted. Any areas that have been cut open shall be secured with staples to provide a relatively tight fit around the exiting manikin cables.

8.4.3.2.2 Samples shall be conditioned as specified in 8.1.2 for standard ensembles or 8.1.10 for Type R ensembles.

8.4.3.2.3 Where garments are evaluated, the sample ensemble shall be permitted to include other elements to protect exposed portions of the manikin, such as flame-resistant head coverings, insulated gloves, and insulated footwear.

8.4.3.3 Specimens.

8.4.3.3.1 Specimens shall be the complete protective ensembles specified in 8.4.3.2.

8.4.3.3.2 The size of the specimen shall be consistent with the manufacturer's sizing information specific to the manikin's dimensions.

8.4.3.3.2.1 If the recommended manufacturer's sizing overlaps multiple sizes, then the smallest size shall be selected.

8.4.3.3.3 Three specimens shall be tested.

8.4.3.4 Procedure.

8.4.3.4.1 Specimens shall be tested in accordance with ASTM F1930, *Standard Test Method for Evaluation of Flame-Resistant Clothing for Protection Against Fire Simulations Using an Instrumented Manikin*, using an exposure heat flux of 84 kW/m^2 (2.02 cal/cm^2-sec) with the following additional test specifications:

(1) The test exposure shall be calibrated using a nude instrumented manikin.
(2) An alternative manikin that is not the instrumented manikin specified in the standard following the calibration shall be permitted for evaluating ensembles or garments.
(3) Unless burn prediction measurements are performed, a lightweight, one-piece, flame-resistant coverall or any other type of lightweight clothing, including the normally specified 100 percent cotton underwear, shall be used to dress the manikin under the test ensemble or garment.
(4) If the donning of the ensemble or garment onto the manikin requires a portion of the ensemble or garment to be opened to permit the passage of cabling from the instrumented manikin to the data acquisition system, then a suitable technique shall be applied to close the ensemble or garment around the open area.

(5) An exposure time of 3 seconds shall be used.
(6) Immediately following exposure, with the ensemble or garment on the manikin, the ensemble or garment shall be observed for a length of time for any afterflame effects on any part of the ensemble or garment.
(7) After the manikin has cooled, the ensemble or garment shall be removed and inspected for any evidence of material or seam break open and evidence of thermal damage, including the dripping associated with melting.
(8) If material or seam break open is observed, the maximum length of the break open area shall be measured to the nearest 0.2 mm (0.05 in.).

8.4.3.4.2 If the ensemble or garment includes a visor that is worn over a respirator worn as part of the ensemble, the ensemble or garment shall be donned by a test subject that has physical dimensions consistent with the recommended dimensions for the size of the ensemble or garment.

8.4.3.4.2.1 Cutting the upper portion of the ensemble or garment to allow the test subject to more easily don the upper portion of the ensemble or garment shall be permitted.

8.4.3.4.2.2 The test subject shall have a minimum visual acuity of 20/20 in each eye, uncorrected or corrected with contact lenses, as determined in a visual acuity test or doctor's examination.

8.4.3.4.3 Visual acuity testing from within the ensemble shall be conducted using a standard 6.1 m (20 ft) eye chart with a normal lighting range of 100 to 150 foot-candles (fc) and with the test subject positioned at a distance of 6.1 m (20 ft) from the chart.

8.4.3.4.4 The test subject shall then read the standard eye chart through the lens of the SCBA facepiece and ensemble visor(s) to determine his or her visual acuity.

8.4.3.5 Report.

8.4.3.5.1 The length and location of any afterflame shall be reported.

8.4.3.5.2 An illustration of the protective clothing or ensemble, as shown in Figure 8.4.3.5.2, shall be prepared, and the location of any damage shall be recorded on the illustration and reported.

8.4.3.5.2.1 The damage to be reported shall include but not be limited to the following:

(1) Break open of the material and seams
(2) Evidence of material dripping as the result of melting
(3) Delamination
(4) Destruction of any garment components

8.4.3.5.2.2 Photographs showing the areas of damage shall be permitted in lieu of a diagram.

8.4.3.5.2.3 If a hole is cut in the ensemble or garment for the purpose of allowing the passage of cabling from the manikin to the data acquisition system, then the area around the opening shall be excluded from the findings of material or seam break open.

8.4.3.5.3 The visual acuity of each test subject through the visor following the flash fire exposure of the ensemble or garment, if applicable, shall be reported.

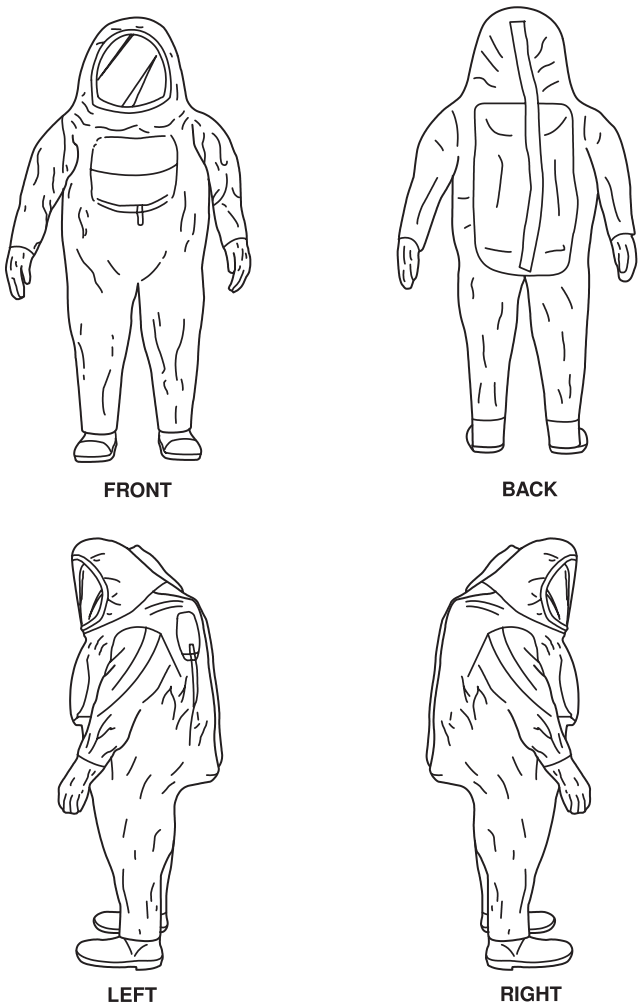


FIGURE 8.4.3.5.2 Garment Diagram (for noting damage location).

8.4.3.6 Interpretation.

8.4.3.6.1 The maximum afterflame time among all the specimens shall be used to determine compliance with the afterflame requirement.

8.4.3.6.2 The visual acuity of the test subject inside the ensemble shall be used to determine pass or fail compliance with the post-flash fire simulation visual acuity requirements.

8.4.3.6.3 Observed dripping as the result of any melted element or component of the tested ensemble or garment shall constitute failure of the ensemble or garment.

8.4.3.6.4 Any measured seam or other area of break open with a maximum dimension of 50 mm (2 in.) shall constitute failure of the ensemble or garment.

8.4.3.7 Specific Requirements for Testing Garments, Hoods, Gloves, and Footwear. Where garments, hoods, gloves, and footwear that do not cover the entire manikin are tested, items of clothing constructed of flame-resistant materials shall be used to cover those exposed portions of the manikin body in a manner that does not cover the item being evaluated.

8.4.3.8 Specific Requirements for Testing Class 2R, 3R, and 4R Ensembles. Samples for Class Type R ensembles shall be conditioned as specified in 8.1.9.

8.4.3.9 Specific Requirements for Measuring Burn Injury Predictions.

8.4.3.9.1 The manikin shall be dressed in 170 g/m^2 (5.0 oz/yd^2) (± 5 percent) of jersey knit, 100 percent cotton underwear briefs, and a short-sleeved crew-neck T-shirt before the garment specimen is placed on the manikin.

8.4.3.9.2 The individual and average predicted second degree, third degree, and total percent body burn injuries based on the total surface area covered by sensors, excluding hands and feet, for each specimen shall be reported.

8.4.3.9.3 A chart shall be prepared that shows the areas on the manikin where a second- or third-degree burn injury would be predicted.

8.4.4 Flame Break Open Resistance Test.

8.4.4.1 Application. Where specified, this test method shall be applied to garments, visors, gloves, and footwear.

8.4.4.2 Sample Preparation.

8.4.4.2.1 Samples for conditioning shall be as follows:

(1) Textile samples shall be at least 1 m (1 yd) squares of material.
(2) Visor components, glove elements, and footwear elements shall have sufficient samples to produce the required number of specimens in 8.4.4.3.

8.4.4.2.2 Samples shall be conditioned as specified in 8.1.2.

8.4.4.3 Specimens.

8.4.4.3.1 Specimens shall be 200 mm × 200 mm ± 5 mm (8 in. × 8 in. ± ¼ in.) and shall consist of all layers representative of the element materials to be tested, excluding any areas with special reinforcement or seams.

8.4.4.3.2 At least three specimens shall be tested.

8.4.4.3.3 Specimens shall not be stitched to hold individual layers together.

8.4.4.4 Apparatus.

8.4.4.4.1 The burner specified in Method 5905.1 of Federal Test Method Standard 191A, *Textile Test Methods*, shall be used.

8.4.4.4.2 A free-standing flame height indicator shall be used to assist in adjusting the burner flame height. The indicator shall mark a flame height of 75 mm (3 in.) above the top of the burner.

8.4.4.4.3 A stopwatch or other suitable timing device shall be used.

8.4.4.4.4* A specimen stand shall be used that provides for the application of the burner flame to the underside of the specimen at a distance of 50 mm + 0/– 3 mm (2 in. +0/–⅛ in.) above the top of the burner. The specimen shall be supported on a bottom 4.75 mm (3/16 in.) or greater thickness steel plate that has a 150 mm ± 5 mm (6 in. ± ¼ in.) diameter opening for the exposure of the specimen. A similarly sized top plate shall be used to hold the specimen in place on top of the specimen.

8.4.4.4.5* A pressure pot shall be used to evaluate the integrity of the specimen in the area of the flame application following the flame exposure. The pressure pot shall be a pressure vessel with dimensions that accommodate the entirety of the exposed specimen area and shall be designed with flanges that provide for the clamping of the specimen in a manner in which to create a seal against the outer surface of the specimen when the pot is subjected to a vacuum. The pressure pot shall have a fitting that provides for the evacuation of air inside the pot and for the measurement of pressure inside the pot. The volume of the pressure pot shall be no larger than 0.5 L (4 ¼ cups).

8.4.4.4.6 A vacuum pump capable of connecting to the pressure pot and drawing a vacuum of at least 1 kPa (4 in. water gauge) shall be used.

8.4.4.5 Procedure.

8.4.4.5.1 The specimen shall be mounted on the specimen stand such that the center of the specimen coincides with the center of the hole in the specimen mounting bottom and top plates. The normal exterior of the specimen shall face the flame.

8.4.4.5.2 The flame height shall be set at 75 mm ± 5 mm (2.95 in. ± 0.2 in.) above the top of the burner away from the specimen.

8.4.4.5.3 The specimen stand shall be moved over the burner such that the flame contacts the center of the underside of the specimen for a period of 3.0 +0.5/–0 second.

8.4.4.5.4 At the end of the flame exposure period, the specimen stand shall be moved away from the flame.

8.4.4.5.5 If no visible hole is observed in the specimen, then the specimen shall be allowed to cool for a minimum of 60 seconds.

8.4.4.5.6 The specimen or portion of the specimen that has been exposed to the flame shall be mounted in the pressure pot with the flame exposure side towards the interior of the pressure pot.

8.4.4.5.7 The pressure inside the pressure pot shall be reduced by 1 kPa ± 50 Pa (4 in. ± 0.2 in. water gauge).

8.4.4.5.8 After the vacuum has been applied to the pressure pot for 1 minute +5/–0 seconds, the change of pressure in the pressure pot shall be observed and recorded.

8.4.4.6 Report. The pressure change shall be reported for each specimen and as the average for each sample.

8.4.4.7 Interpretation. The average pressure change shall be used to determine pass or fail performance.

8.5 Physical Performance Tests.

8.5.1 Burst Strength Test.

8.5.1.1 Application.

8.5.1.1.1 This test shall apply to garment and hood materials.

8.5.1.1.2 Where garment or hood materials are constructed of several separable layers, then all layers, assembled in the order in which they appear in the garment, shall be tested as a composite.

8.5.1.2 Samples.

8.5.1.2.1 Samples for conditioning shall be 1 m (1 yd) squares of material.

8.5.1.2.2 Samples shall be conditioned as specified in 8.1.2.

8.5.1.3 Specimens.

8.5.1.3.1 Specimens shall be the size specified in ASTM D751, *Standard Test Methods for Coated Fabrics*.

8.5.1.3.2 At least 10 specimens shall be tested.

8.5.1.4 Procedure. Specimens shall be tested in accordance with Section 18.2 of ASTM D751, *Standard Test Methods for Coated Fabrics*.

8.5.1.5 Report.

8.5.1.5.1 The burst strength of each specimen shall be recorded and reported to the nearest 1 N (0.25 lbf).

8.5.1.5.2 The average burst strength of all specimens shall be calculated, recorded, and reported.

8.5.1.6 Interpretation. The average burst strength shall be used to determine the pass or fail performance.

8.5.2 Puncture Propagation Tear Resistance Test.

8.5.2.1 Application.

8.5.2.1.1 This test shall apply to garment and hood materials.

8.5.2.1.2 If the garment or hood is constructed of several layers, then all layers, assembled in the order in which they appear in the garment, shall be tested as a composite.

8.5.2.2 Samples.

8.5.2.2.1 Samples for conditioning shall be 1 m (1 yd) squares of material.

8.5.2.2.2 Samples shall be conditioned as specified in 8.1.2.

8.5.2.3 Specimens.

8.5.2.3.1 Specimens shall be of the size required by ASTM D2582, *Standard Test Method for Puncture-Propagation Tear Resistance of Plastic Film and Thin Sheeting*.

8.5.2.3.2 At least five specimens in each of the warp directions, machine or coarse, and the filling directions, cross-machine or wale, shall be tested.

8.5.2.3.3 Where the material is isotropic, 10 specimens shall be tested.

8.5.2.4 Procedure. Specimens shall be tested in accordance with ASTM D2582, *Standard Test Method for Puncture-Propagation Tear Resistance of Plastic Film and Thin Sheeting*.

8.5.2.5 Report.

8.5.2.5.1 The puncture propagation tear resistance of each specimen shall be recorded and reported to the nearest 0.05 kg (0.1 lb) of force.

8.5.2.5.2 An average puncture propagation tear resistance shall be calculated, recorded, and reported for each direction tested.

8.5.2.6 Interpretation.

8.5.2.6.1 Pass or fail performance shall be based on the average puncture propagation tear resistance in each direction tested.

8.5.2.6.2 Failure in any one direction shall constitute failure for the material.

8.5.3 Seam/Closure Breaking Strength Test.

8.5.3.1 Application.

8.5.3.1.1 This test shall be applied to all types of garment seams as well as the garment closure assembly used in the construction of the garment and hood.

8.5.3.1.2 Where the garment consists of multiple separable layers, then the test shall be applied to the seams and closure assemblies of each separable layer.

8.5.3.1.3 Modifications to this test method for testing seams shall be as specified in 8.5.3.7.

8.5.3.1.4 Modifications to this test method for testing closure assemblies shall be as specified in 8.5.3.8.

8.5.3.2 Samples.

8.5.3.2.1 Samples for conditioning shall be the size required by ASTM D751, *Standard Test Methods for Coated Fabrics*, and 8.5.3.7 or 8.5.3.8 as appropriate.

8.5.3.2.2 Samples shall be conditioned as specified in 8.1.2 and 8.5.3.7 or 8.5.3.8 as appropriate.

8.5.3.2.3 Samples shall be cut from the finished garment or ensemble.

8.5.3.2.4 Lengths of seam shall be permitted to be prepared by representatively joining two pieces of garment material instead of cutting from the garment.

8.5.3.2.5 Closure samples shall be permitted to be individual samples cut to the specimen width.

8.5.3.3 Specimens.

8.5.3.3.1 Specimens shall be the size specified in ASTM D751, *Standard Test Methods for Coated Fabrics*.

8.5.3.3.2 At least five specimens shall be tested for each seam and closure assembly type.

8.5.3.3.3 Closure sample specimen width shall be permitted to be 25 mm ± 6 mm (1 in. ± ¼ in.) larger than the required specimen size. The specimen edges at the closure shall be permitted to be secured by stitching or tacking.

8.5.3.4 Procedure. All seams and closure assemblies shall be tested in accordance with ASTM D751, *Standard Test Methods for Coated Fabrics*.

8.5.3.5 Report.

8.5.3.5.1 The breaking strength for each seam or closure assembly specimen shall be recorded and reported.

8.5.3.5.2 The average breaking strength for each seam or closure assembly type shall be recorded and reported.

8.5.3.5.3 The type of seams and closure assemblies tested and whether the specimens were cut from the finished garment or prepared from fabric samples shall be recorded and reported.

8.5.3.6 Interpretation. The average seam breaking strength for each seam type shall be used to determine pass or fail performance.

8.5.3.7 Specific Procedures for Testing Seams.

8.5.3.7.1 Samples for conditioning shall include 150 mm (6 in.) of material on either side of the straight seam.

8.5.3.7.2 Specimens shall be conditioned as specified in 8.1.2.

8.5.3.8 Specific Procedures for Testing Closure Assemblies.

8.5.3.8.1 Samples for conditioning shall include 150 mm (6 in.) of material on either side of the closure.

8.5.3.8.2 Specimens shall be conditioned as specified in 8.1.9.

8.5.4 Exhaust Valve Mounting Strength Test.

8.5.4.1 Application. This test method shall apply to exhaust valves mounted in ensembles.

8.5.4.2 Sample Preparation.

8.5.4.2.1 Samples shall be an exhaust valve mounted into a piece of garment material having a minimum diameter of 200 mm (8 in.). The means of mounting the exhaust valve shall be representative of the construction practices used in the ensemble.

8.5.4.2.2 Samples shall be conditioned as specified in 8.1.2.

8.5.4.3 Specimens.

8.5.4.3.1 Specimens shall be complete exhaust valve assemblies mounted into a piece of ensemble material.

8.5.4.3.2 At least three specimens shall be tested.

8.5.4.4 Apparatus.

8.5.4.4.1 A specimen mounting ring shall be used for clamping the sample.

8.5.4.4.1.1 The mounting ring shall have an inner diameter of 150 mm (6 in.).

8.5.4.4.1.2 The mounting ring shall have a means for tightly clamping the specimen along the circumference of the ring and shall hold the specimen perpendicular to the motion of the pushing force.

8.5.4.4.1.3 The mounting ring shall be designed such that a means is provided for affixing it to the fixed (bottom) arm of a tensile testing machine and that a minimum 50 mm (2 in.) unobstructed space is provided under the specimen.

8.5.4.4.2 A flat plate pushing device shall be 50 mm (2 in.) in diameter and shall have a means for being attached to the movable (upper) arm of a tensile testing machine. The flat plate shall be oriented perpendicular to the motion of the pushing force.

8.5.4.4.3 The tensile testing machine shall meet the following criteria:

(1) The machine shall be capable of holding the specimen mounting ring securely in the fixed lower arm.
(2) The machine shall be capable of holding the flat plate pushing device securely in the movable upper arm.
(3) The machine shall have a calibrated dial, scale, or chart to indicate the applied load and elongation.
(4) The error of the machine shall not exceed 2 percent of any reading within its loading range.
(5) The machine shall be outfitted with a compression cell.
(6) The machine shall be configured with the compression cell on either the lower or upper arm.

8.5.4.5 Procedure.

8.5.4.5.1 Specimens shall be clamped into the specimen mounting ring so that the interior side of the exhaust valve is facing upward and attached to the fixed arm of a tensile testing machine.

8.5.4.5.2 The flat plate pushing device shall be attached to the movable arm of a tensile testing machine.

8.5.4.5.3 The tensile testing machine shall be set in operation but stopped when the exhaust valve either breaks through the material or when the material breaks along the specimen mounting ring.

8.5.4.5.4 The flat plate pushing device shall have a velocity of 305 mm/min (12 in./min) under load conditions and shall be uniform at all times.

8.5.4.5.5 The maximum force registered by the indicating device of the tensile testing machine shall be recorded for each determination.

8.5.4.6 Report.

8.5.4.6.1 The mounting strength of each specimen shall be recorded and reported to the nearest 1 N (¼ lbf).

8.5.4.6.2 The average mounting strength shall be calculated and reported to the nearest 1 N (¼ lbf).

8.5.4.7 Interpretation. The average mounting strength shall be used to determine pass or fail performance.

8.5.5 Fitting Pull-Out Strength Test.

8.5.5.1 Application. This test method shall apply to each type of external fitting mounted on ensembles.

8.5.5.2 Samples.

8.5.5.2.1 Samples for conditioning shall be external fitting assemblies mounted into the ensemble material using the means of mounting and the fabrication methods used to install the external fitting into the actual ensemble.

8.5.5.2.2 Samples shall be conditioned as specified in 8.1.2.

8.5.5.3 Specimens.

8.5.5.3.1 Specimens shall be external fitting assemblies mounted into the ensemble material using the means of mounting and the fabrication methods used to install the external fitting into the actual ensemble.

8.5.5.3.2 At least three specimens shall be tested.

8.5.5.4 Apparatus.

8.5.5.4.1 A specimen mounting ring shall be used for clamping the specimen.

8.5.5.4.1.1 The mounting ring shall have an inner diameter of 150 mm (6 in.).

8.5.5.4.1.2 The mounting ring shall have a means for tightly clamping the specimen along the circumference of the ring

and shall hold the specimen perpendicular to the motion of the pushing force.

8.5.5.4.1.3 The mounting ring shall be designed such that a means is provided for affixing it to the fixed (bottom) arm of a tensile testing machine.

8.5.5.4.2 A set of tensile machine jaws shall be used to pull the external fitting perpendicular to the surface of the garment material in which the external fitting is mounted.

8.5.5.4.3 The tensile testing machine shall meet the following criteria:

(1) The machine shall be capable of holding the specimen mounting ring securely in the fixed lower arm.
(2) The machine shall be capable of holding the flat plate pushing device securely in the movable upper arm.
(3) The machine shall have a calibrated dial, scale, or chart to indicate the applied load and elongation.
(4) The error of the machine shall not exceed 2 percent of any reading within its load range.
(5) The machine shall be outfitted with a compression cell.
(6) The machine shall be configured with the compression cell on either the lower or upper arm.

8.5.5.5 Procedure.

8.5.5.5.1 Specimens shall be clamped into the specimen mounting ring and attached to the fixed arm of a tensile testing machine.

8.5.5.5.2 The jaws of the movable arm of the tensile testing machine shall be clamped onto the body of the external fitting.

8.5.5.5.3 The tensile testing machine shall be set in operation but stopped when the external fitting assembly either breaks through the material or when the material breaks along the specimen mounting ring.

8.5.5.5.4 The tensile testing machine jaws shall have a velocity of 508 mm/min (20 in./min) under load conditions and shall be uniform at all times.

8.5.5.5.5 The maximum force registered by the indicating device of the tensile testing machine shall be recorded for each determination.

8.5.5.6 Report.

8.5.5.6.1 The pull-out strength of each specimen shall be recorded and reported to the nearest 1 N (¼ lbf).

8.5.5.6.2 The average pull-out strength shall be calculated, recorded, and reported to the nearest 1 N (¼ lbf).

8.5.5.7 Interpretation. The average pull-out strength shall be used to determine pass or fail performance.

8.5.6 Ultimate Tensile Strength Test.

8.5.6.1 Application. This test method shall apply to elastomeric interface materials.

8.5.6.2 Samples.

8.5.6.2.1 Samples for conditioning shall be the same size as the test specimens taken from either elastomeric interface sheet material or formed interfaces that are representative of the interface material nominal thickness and composition.

8.5.6.2.2 Samples shall be conditioned as specified in 8.1.2.

8.5.6.3 Specimens.

8.5.6.3.1 Specimens shall be the size required by ASTM D412, *Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers — Tension.*

8.5.6.3.2 At least 10 specimens shall be tested.

8.5.6.4 Procedure. Specimens shall be tested in accordance with Method A of ASTM D412, *Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers — Tension.*

8.5.6.5 Report.

8.5.6.5.1 The ultimate tensile strength shall be recorded and reported for each specimen to the nearest 10 kPa (2 psi).

8.5.6.5.2 The average ultimate tensile strength shall be calculated and reported for all specimens tested.

8.5.6.5.3 The average elongation at rupture shall be individually used to qualify the elastomeric character of the interface material.

8.5.6.6 Interpretation.

8.5.6.6.1 The average ultimate tensile strength shall be individually used to determine pass or fail performance.

8.5.6.6.2 An elongation at rupture of less than 125 percent shall qualify an interface material for consideration as a garment material.

8.5.7 Cut Resistance Test.

8.5.7.1 Application.

8.5.7.1.1 This test method shall apply to glove, footwear upper, and elastomeric interface materials.

8.5.7.1.2 Modifications to this test method for evaluation of glove materials shall be as specified in 8.5.7.7.

8.5.7.1.3 Modifications to this test method for evaluation of footwear upper materials shall be as specified in 8.5.7.8.

8.5.7.1.4 Modifications to this test method for evaluation of elastomeric interface materials shall be as specified in 8.5.7.9.

8.5.7.2 Samples.

8.5.7.2.1 Samples shall be whole gloves, footwear uppers, or elastomeric interface materials consisting of all layers.

8.5.7.2.2 Samples shall be conditioned as specified in 8.1.2 after the conditioning specified in the modifications.

8.5.7.3 Specimens.

8.5.7.3.1 Specimens shall be the size specified in ASTM F1790, *Standard Test Method for Measuring Cut Resistance of Materials Used in Protective Clothing.*

8.5.7.3.2 At least three specimens of glove, footwear upper, or elastomeric material shall be tested.

8.5.7.4 Procedure. Specimens shall be evaluated in accordance with ASTM F1790, *Standard Test Method for Measuring Cut Resistance of Materials Used in Protective Clothing*, with the specimens tested at a specific load in grams (ounces) for the measurement of the distance of blade travel.

8.5.7.5 Report.

8.5.7.5.1 The distance of blade travel shall be recorded and reported to the nearest 1 mm (1/32 in.) for each sample specimen.

8.5.7.5.2 The average distance of blade travel in mm (in.) shall be recorded and reported for all specimens tested.

8.5.7.6 Interpretation. The average distance of blade travel shall be used to determine pass or fail performance.

8.5.7.7 Specific Requirements for Testing Glove Materials.

8.5.7.7.1 Specimens shall be taken from the glove and shall not include seams.

8.5.7.7.1.1 Specimens shall consist of each composite of the glove used in the actual garment glove configuration, with layers arranged in the proper order.

8.5.7.7.1.2 Where a composite is identical to another composite except for an additional reinforcement layer(s), the composite with no reinforcement layer(s) shall be tested.

8.5.7.7.2 Cut resistance testing shall be performed as directed in Table 8.5.7.7.2.

8.5.7.8 Specific Requirements for Testing Footwear Upper Materials.

8.5.7.8.1 Specimens shall be taken from the parts of the footwear upper that provide uniform thickness and shall not include seams.

8.5.7.8.2 Specimens shall consist of each composite of the footwear upper used in the actual ensemble footwear configuration, excluding the tongue and gusset, with layers arranged in the proper order.

8.5.7.8.3 Where a composite is identical to another composite except for an additional reinforcement layer(s), the composite with no reinforcement layer(s) shall be tested.

8.5.7.8.4 Cut resistance testing shall be performed under a load of 350 g (12.5 oz).

8.5.7.9 Specific Requirements for Testing Elastomeric Interface Materials.

8.5.7.9.1 Specimens shall be taken from elastomeric interface sheet material or formed elastomeric interface items that are representative of the elastomeric interface material nominal thickness.

8.5.7.9.2 Cut resistance testing shall be performed under a load of 50 g (1.75 oz).

Table 8.5.7.7.2 Test Loads for Glove Material Cut Resistance

Level	Applicability	Test Load
High	NFPA 1991; NFPA 1994 Class 1, Class 2, Class 2R, Class 3R, and Class 4R	150 g (5.3 oz)
Moderate	1994 Class 3 and Class 4	75 g (2.65 oz)
Low	NFPA 1992	50 g (1.76 oz)

8.5.8 Puncture Resistance Tests.

8.5.8.1 Puncture Resistance Test One.

8.5.8.1.1 Application.

8.5.8.1.1.1 This test shall be applied to glove, footwear upper, and elastomeric interface materials.

8.5.8.1.1.2 Modifications to this test method for testing glove materials shall be as specified in 8.5.8.1.7.

8.5.8.1.1.3 Modifications to this test method for testing footwear upper materials shall be as specified in 8.5.8.1.8.

8.5.8.1.1.4 Modifications to this test method for evaluation of elastomeric interface materials shall be as specified in 8.5.8.1.9.

8.5.8.1.2 Samples.

8.5.8.1.2.1 Samples shall be complete gloves, footwear uppers, or elastomeric materials consisting of all layers.

8.5.8.1.2.2 Samples shall be conditioned as specified in 8.1.2 after the conditioning specified in the modifications.

8.5.8.1.3 Specimens.

8.5.8.1.3.1 Specimens shall be at least 150 mm (6 in.) squares.

8.5.8.1.3.2 At least three specimens of glove, footwear upper, or elastomeric material shall be tested.

8.5.8.1.4 Procedure. Specimens shall be tested in accordance with Test Method A of ASTM F1342/F1342M, *Standard Test Method for Protective Clothing Material Resistance to Puncture*, conducting three punctures per specimen with the modifications listed in 8.5.8.1.3.1 and 8.5.8.1.3.2.

8.5.8.1.5 Report.

8.5.8.1.5.1 The puncture force shall be recorded and reported for each specimen to the nearest 0.5 N (0.125 lbf) of force.

8.5.8.1.5.2 The average puncture force shall be recorded and reported for all specimens tested.

8.5.8.1.6 Interpretation.

8.5.8.1.6.1 The average puncture force shall be used to determine pass or fail performance.

8.5.8.1.6.2 If an individual result from any test set varies more than ± 20 percent from the average result, the results from the test set shall be discarded and another set of specimens shall be tested.

8.5.8.1.6.3 If the individual results are at least 20 percent greater than the requirement, 8.5.8.1.8 does not apply.

8.5.8.1.7 Specific Requirements for Testing Glove Materials. Specimens shall be taken from the glove and shall not include seams.

8.5.8.1.7.1 Specimens shall consist of each composite of the glove used in actual garment glove configuration, with the layers arranged in the proper order.

8.5.8.1.7.2 When a composite is identical to another composite except for an additional reinforcement layer(s), the composite with no reinforcement layer(s) shall be tested.

8.5.8.1.8 Specific Requirements for Testing Footwear Upper Materials. Specimens shall be taken from the footwear upper and shall not include seams.

8.5.8.1.8.1 Specimens shall consist of each composite of the footwear upper used in the actual garment footwear configuration, excluding the tongue and gusset, with layers arranged in proper order.

8.5.8.1.8.2 Where a composite is identical to another composite except for additional an reinforcement layer(s), the composite with no reinforcement layer(s) shall be tested.

8.5.8.1.9 Specific Requirements for Testing Exposed Elastomeric Interface Materials. Specimens shall be taken from interface sheet material or formed interfaces that are representative of the interface material nominal thickness and composition.

8.5.9 Abrasion Resistance Tests.

8.5.9.1 Abrasion Resistance Test One.

8.5.9.1.1 Application. This test method shall apply to footwear soles with heels.

8.5.9.1.2 Samples.

8.5.9.1.2.1 Samples for conditioning shall be uniform cylinders of footwear soles and heel material.

8.5.9.1.2.2 Samples shall be conditioned as specified in 8.1.2.

8.5.9.1.3 Specimens. A minimum of three specimens of the footwear soles and heel materials shall be tested.

8.5.9.1.4 Procedure. Abrasion resistance tests shall be performed in accordance with Method A of ISO 4649, *Rubber, vulcanized or thermoplastic — Determination of abrasion resistance using a rotating cylindrical drum device*, with a vertical force of 10 N (2.25 lbf) over an abrasion distance of 40 m.

8.5.9.1.5 Report. The relative volume loss of each specimen shall be recorded and reported.

8.5.9.1.6 Interpretation. One or more footwear specimens failing this test shall constitute failing performance.

8.5.9.2 Abrasion Resistance Test Two.

8.5.9.2.1 Application. This test method shall apply to footwear covers where the barrier layer is configured as an exterior layer.

8.5.9.2.2 Samples.

8.5.9.2.2.1 Samples for conditioning shall be at least 500 mm (½ yd) squares of material.

8.5.9.2.2.2 Samples shall be conditioned as specified in 8.1.3.

8.5.9.2.3 Specimens.

8.5.9.2.3.1 Specimens shall be the size specified in ASTM D3884, *Standard Guide for Abrasion Resistance of Textile Fabrics (Rotary Platform, Double-Head Method)*.

8.5.9.2.3.2 A minimum of five specimens shall be tested.

8.5.9.2.4 Procedure. Specimens shall be tested in accordance with ASTM D3884, *Standard Guide for Abrasion Resistance of Textile Fabrics (Rotary Platform, Double-Head Method)*, with the following modification: the abrasion shall be continued until a hole, wear-through, or rupture in the film portion of the material is observed.

8.5.9.2.5 Report. The number of cycles required for the formation of a hole, wear-through, or rupture in the film portion of the material shall be recorded and reported.

8.5.9.2.6 Interpretation. The number of cycles required for the formation of a hole, wear-through, or rupture in the film portion of the material shall be used to determine pass or fail performance.

8.5.10 Visor High-Mass Impact Resistance Test.

8.5.10.1 Application.

8.5.10.1.1 This test shall apply to visor materials.

8.5.10.1.2 If the visor is constructed of several layers, then all layers, assembled in the order in which they appear in the garment, shall be tested as a composite.

8.5.10.2 Sample Preparation.

8.5.10.2.1 Samples shall be at least 305 mm (12 in.) squares of visor material.

8.5.10.2.2 Samples shall be conditioned as specified in 8.1.2.

8.5.10.3 Specimens.

8.5.10.3.1 Specimens shall be 450 mm × 305 mm (17.72 in. × 12 in.).

8.5.10.3.2 A minimum of five specimens shall be tested.

8.5.10.4 Procedure. Specimens shall be tested in accordance with Section 9.11 of ANSI/ISEA Z87.1, *American National Standard for Occupational and Educational Personal Eye and Face Protection Devices*, with the following modifications:

(1) Visor material shall be securely mounted to the test fixture.
(2) The sample number shall be indicated.
(3) The impact location shall be in the center apex of the visor between the frame members.
(4) Testing shall be performed on samples conditioned for a minimum of 4 hours at –25°C ± 2 °C (–13°F ± 4 °F).
(5) Testing shall commence between 60 and 90 seconds.
(6) The sample shall not be allowed to move more than 6 mm (0.25 in.).

8.5.10.5 Report. Visible penetration or full-thickness cracks shall be recorded and reported.

8.5.10.6 Interpretation. Penetration or full-thickness cracking on any single impact shall be used to determine compliance.

8.5.11 Cold Temperature Performance Tests.

8.5.11.1 Cold Temperature Bend Test One.

8.5.11.1.1 Application. This test method shall apply to garment, hood, elastomeric interface, and glove materials.

8.5.11.1.2 Sample Preparation.

8.5.11.1.2.1 Samples for conditioning shall be at least 1 m (1 yd) squares of material.

8.5.11.1.2.2 Samples shall be conditioned as specified in 8.1.2.

8.5.11.1.3 Specimens.

8.5.11.1.3.1 Specimens shall be the size specified in ASTM D747, *Standard Test Method for Apparent Bending Modulus of Plastics by Means of a Cantilever Beam.*

8.5.11.1.3.2 A minimum of five specimens consisting of all layers in each of the warp directions, machine or coarse, and the filling directions, cross-machine or wale, shall be tested.

8.5.11.1.3.3 Where the material is isotropic, 10 specimens shall be tested.

8.5.11.1.4 Specimens shall be tested in accordance with ASTM D747, *Standard Test Method for Apparent Bending Modulus of Plastics by Means of a Cantilever Beam*, with the following modifications:

(1) Specimens shall be conditioned for a minimum of 4 hours at –25°C ± 2°C (–13°F ± 4°F)
(2) The test temperature shall be –25°C (–13°F).
(3) The bending moment shall be that applied when the specimen is bent to a 60-degree angular deflection and shall be calculated in inch-pounds as follows:

[8.5.11.1.4]

$$\text{Bending moment} = \frac{\text{load scale reading} \times \text{moment weight}}{100}$$

(4) Values shall be permitted to be obtained for materials that are too flexible to measure with this apparatus by laminating to a stiffening material that yields a valid test value and subtracting out the stiffening material's bending moment when tested alone. Permitted lamination techniques shall include fastening of one or both ends of the specimens.

8.5.11.1.5 Report. Cold temperature performance results shall be recorded and reported as the average for each material direction.

8.5.11.1.6 Interpretation. Failure of the material in any direction shall constitute failing performance.

8.5.11.2 Cold Temperature Bend Test Two.

8.5.11.2.1 Application. This test method shall apply to visor component materials.

8.5.11.2.2 Sample Preparation.

8.5.11.2.2.1 Samples shall be at least 1 m (1 yd) squares of material consisting of all layers.

8.5.11.2.2.2 Samples shall be conditioned as specified in 8.1.2.

8.5.11.2.3 Specimens.

8.5.11.2.3.1 Specimens shall be the size specified in ASTM D2136, *Standard Test Method for Coated Fabrics — Low-Temperature Bend Test.*

8.5.11.2.3.2 At least five specimens consisting of all layers shall be tested.

8.5.11.2.4 Procedure.

8.5.11.2.4.1 Specimens shall be tested in accordance with ASTM D2136, with the following modifications:

(1) Specimens shall be conditioned for a minimum of 4 hours at –25°C ± 2°C (–13°F ± 4°F).
(2) The test shall be performed at a temperature of –25°C ± 2°C (–13°F ± 4°F).

8.5.11.2.4.2 Following this testing, specimens shall be examined for evidence of damage, including any breakage, cracks, tears, or separation, but not including discoloration along the folded area.

8.5.11.2.5 Report. Observations of visible damage shall be recorded and reported for each specimen.

8.5.11.2.6 Interpretation.

8.5.11.2.6.1 Damage of any one specimen shall constitute failing performance.

8.5.11.2.6.2 Rigid visors that do not bend but show no evidence of damage shall still be considered to have passed the test.

8.6 Ensemble/Component Functional Performance Tests.

8.6.1 Overall Garment Function and Integrity Test.

8.6.1.1 Application.

8.6.1.1.1 This test method shall apply to garments, hoods, nonencapsulating ensembles, and encapsulating ensembles.

8.6.1.1.2 Modifications for testing separate hood items shall be as specified in 8.6.1.8.

8.6.1.2 Samples.

8.6.1.2.1 Samples shall be complete garments or ensembles, including all outerwear and other items required to be compliant.

8.6.1.2.2 Samples for Class Type R shall be conditioned as specified in 8.1.9.

8.6.1.2.3 Samples shall be conditioned as specified in 8.1.2.

8.6.1.3 Specimens.

8.6.1.3.1 Specimens shall be complete garments or ensembles with gloves, footwear, hoods, and, if applicable, respirators.

8.6.1.3.2 At least three specimens shall be tested.

8.6.1.3.3 The specimen shall include all outerwear and other items required for the ensemble to be compliant with this standard.

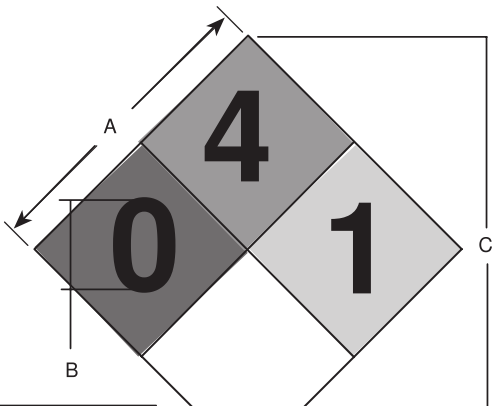
8.6.1.3.4 Where the ensemble offers multiple types of external fittings, each type of external fitting shall be installed in the ensemble prior to testing.

8.6.1.3.5 Where the ensemble uses the respirator facepiece as the ensemble visor, each style of the ensemble shall be tested with each style of the respirator specified by the manufacturer.

8.6.1.3.6 Where socks are used as part of the protective ensemble, it is permitted that testing be performed on only one representative outer boot style for the evaluation of the ensemble.

8.6.1.4 Apparatus. The equipment and supplies specified in ASTM F1154, *Standard Practices for Evaluating the Comfort, Fit, Function, and Durability of Protective Ensembles, Ensemble Elements, and Other Components*, shall be used along with the following additional items:

(1) A Snellen eye chart for a 6 m (20 ft) distance



	Length	
Measurement	mm	in.
A	64	2.5
B	25	1
C	90	3.5

FIGURE 8.6.1.4 NFPA 704 Placard.

(2) A stopwatch or other timing device
(3) A protractor or other device to measure the angle of the placard relative to the test subject
(4) An NFPA 704–based placard as seen in Figure 8.6.1.4.

8.6.1.5 Procedure.

8.6.1.5.1 Overall function and integrity shall be measured in accordance with ASTM F1154, *Standard Practices for Evaluating the Comfort, Fit, Function, and Durability of Protective Ensembles, Ensemble Elements, and Other Components*, with the following parameters:

(1) Both Procedures A and B specified in ASTM F1154 shall be used. Testing of ensembles immediately following testing as specified in Section 18.2 shall be permitted.
(2) Specimens to be tested shall meet the sizing range of the test subjects as determined in Chapter 5.
(3) Specimens shall be donned in accordance with the manufacturer's instructions.
(4) Testing shall be conducted at 25°C ± 6°C (77°F ± 10°F) and relative humidity of 50 percent ± 20 percent.
(5) Following the exercise procedures, NFPA 1992– and NFPA 1994-compliant garments and ensembles shall be measured for liquidtight integrity as specified in 8.2.3.1.
(6) Following the exercise procedures, NFPA 1991-compliant garments and ensembles shall be measured for gastight integrity as specified in 8.2.1.
(7) Where hoods are provided, a determination shall be made that the ensemble is designed to accommodate at least head protection meeting the dimensional requirements for Type 1, Class G helmets as specified in ANSI/ISEA Z89.1, *American National Standard for Industrial Head Protection*. Nonencapsulating ensemble hoods shall be permitted to accommodate head protection worn either inside or outside the ensemble.
(8) Where hoods with visors or facepieces are provided, the test subject shall have a minimum visual acuity of 20/20 in each eye, uncorrected or corrected with contact lenses or glasses, as determined in a visual acuity test or doctor's examination.
(9) Test subjects shall wear underclothing in accordance with the manufacturer's recommendation or, in lieu of a detailed recommendation, a full-body coverall.
(10) Where encapsulating ensembles are evaluated or the respirator is not otherwise specified, test subjects shall wear respirators that are certified as compliant with NFPA 1981 or NFPA 1986.
(11) Where nonencapsulating ensembles are evaluated or hoods integrate with the facepiece of the respirator, test subjects shall wear the respirators specified by the manufacturer.
(12) Where protective flaps cover the closure system, the protective flaps shall be inspected upon completion of the exercise procedures and before the specimen is doffed to determine if any portion of the protective flaps has become disengaged.
(13) The closures shall be inspected upon completion of the exercise procedures and before the garment is doffed to determine if any portion of the closures has become disengaged.

8.6.1.5.2 Where hoods with visors or facepieces are provided, visual acuity testing within the ensemble shall be conducted using a standard 6.1 m (20 ft) eye chart with a normal lighting range of 100 to 150 foot-candles at the chart and with the test subject positioned at a distance of 6.1 m (20 ft) from the chart.

8.6.1.5.2.1 The test subject shall have a minimum visual acuity of 20/20 in each eye, uncorrected or corrected, as determined in a visual acuity test or doctor's examination.

8.6.1.5.3 Where hoods with visors or facepieces are provided, the test subject shall then read the standard eye chart through the lens of the respirator facepiece, if present, and ensemble visor or facepiece to determine the test subject's visual acuity.

8.6.1.5.4 The field of vision for the test subject shall be assessed for the up, down, left, and right orientation angles used in the NFPA 704–based placard with random numbers between 0 and 4 in each of the quadrants. The placard shall be 2 m +0/–0.1 m (6 ft +0/–2 in.) away from the eye of the test subject and perpendicular to the field of view line of sight being measured.

8.6.1.5.5 Where encapsulating ensembles are evaluated, the test subject shall at the end of testing be instructed to remove his or her hands from each of the gloves while still wearing the ensemble, touch the bypass value of the SCBA, and then reinsert his or her hands into the gloves.

8.6.1.5.5.1 The test subject shall perform this action a total of five sequential times and in accordance with the manufacturer's instructions.

8.6.1.5.5.2 The time for completing this action shall be timed using a stopwatch or other suitable timing device.

8.6.1.5.6 Where a protective flap is used over the closure system, the flap shall be observed to determine whether the flap remains over the closure during Exercise Procedures A and B.

8.6.1.5.6.1 Where closures are covered by a protective flap, the flap shall be inspected upon completion of the exercise procedures and before the specimen is doffed to determine if any portion of the flap has become disengaged.

8.6.1.5.6.2 The closures shall be inspected upon completion of the exercise procedures and before the specimen is doffed to determine if any portion of the closures has become disengaged.

8.6.1.6 Report.

8.6.1.6.1 The average time required for the all test subjects to complete all portions of the exercises shall be calculated and reported.

8.6.1.6.2 Where gastight integrity testing is performed, the ending garment pressure shall be recorded and reported.

8.6.1.6.3 Where liquidtight integrity testing is performed, a diagram shall be prepared for each test that identifies the locations of any liquid leakage as detected on the liquid-absorptive garment inside the specimen or on the interior surface of the specimen.

8.6.1.6.4 The length of time it takes for the test subjects to satisfactorily complete both exercise procedures shall be recorded and reported.

8.6.1.6.5 Where hoods are provided, the ensemble accommodation of head protection meeting the dimensional requirements for Type 1, Class G helmets of ANSI/ISEA Z89.1, *American National Standard for Industrial Head Protection*, shall be recorded and reported.

8.6.1.6.6 Where hoods with visors or facepieces are provided, the visual acuity of the test subject in and out of the ensemble shall be recorded and reported.

8.6.1.6.7 Where ensembles with visors are provided, the angular degree for the up, down, left, and right defining the field of vision shall be measured and reported. The average angular degree for each direction for all test subjects shall be calculated and reported.

8.6.1.6.8 Where encapsulating ensembles are evaluated, the time for each test subject to completely remove his or her hands from the gloves and reinsert his or her hands in the gloves five times sequentially shall be recorded and reported. The average time for all test subjects shall be calculated and reported.

8.6.1.6.9 Where closures are covered by a protective flap, any disengagement of the protective flap observed during the exercise procedures shall be recorded and reported.

8.6.1.6.10 Any disengagement of the closures observed after the exercise procedures shall be recorded and reported.

8.6.1.7 Interpretation.

8.6.1.7.1 For NFPA 1991-compliant ensembles, an ending garment pressure after inflation testing in accordance with 8.2.1 shall be used to determine pass or fail performance following the test subject exercises.

8.6.1.7.2 For NFPA 1992– and NFPA 1994-compliant garments and ensembles, evidence of liquid on the liquid-absorptive garment inside the specimen or on the interior surface of the ensemble shall constitute failure.

8.6.1.7.2.1 For glove and footwear parts of the ensembles that consist of multiple separate layers, accumulation of liquid between any layers shall constitute failure.

8.6.1.7.3 The average time required by the test subject to satisfactorily complete all exercises shall be used for determining pass or fail performance.

8.6.1.7.4 Where hoods are provided, the non-accommodation of head protection meeting the dimension requirements for Type 1, Class G helmets of ANSI/ISEA Z89.1, *American National Standard for Industrial Head Protection*, shall constitute failing performance. For nonencapsulating ensembles, the hood shall be permitted to accommodate head protection worn either inside or outside the ensemble.

8.6.1.7.5 Where hoods with visors or facepieces are provided, the visual acuity of each test subject inside the garment shall be used for determining pass or fail performance.

8.6.1.7.6 Where ensembles with visors are provided, the average angular field of vision in each direction shall be used to determine pass or fail performance.

8.6.1.7.7 Where encapsulating ensembles are evaluated, the average time for all test subjects to completely remove their hands from the gloves and reinsert their hands in the gloves five times sequentially shall be used to determine pass or fail performance.

8.6.1.7.8 Where closures are covered by a protective flap, any disengagement of the closure of the protective flap after the exercise sequences shall constitute failure.

8.6.1.7.9 Any disengagement of the closures after the exercise sequences shall constitute failure.

8.6.1.8 Specific Requirements for Testing Hoods.

8.6.1.8.1 Where hoods are evaluated as separate items and do not include a visor, the hoods shall only be evaluated for liquidtight integrity and their accommodation of head protection meeting the dimensional requirements of Type 1, Class G helmets of ANSI/ISEA Z89.1, *American National Standard for Industrial Head Protection*, without being worn as part of the Exercise Procedures A and B, as specified in 13.3.5.1.

8.6.1.8.2 Where hoods are evaluated as separate items and include a visor, the hoods shall be evaluated for the following assessments without being worn as part of the Exercise Procedures A and B as specified in 13.3.5:

(1) Liquidtight integrity
(2) Accommodation of head protection meeting the dimensional requirements of Type 1, Class G helmets of ANSI/ISEA Z89.1, *American National Standard for Industrial Head Protection*
(3) Visual acuity
(4) Field of vision

8.6.2 Maximum Ensemble Ventilation Rate Test.

8.6.2.1 Application. This test method shall apply to NFPA 1991– and NFPA 1994-compliant encapsulating Class 1 ensembles.

8.6.2.2 Sample Preparation.

8.6.2.2.1 Samples shall be complete NFPA 1991– or NFPA 1994-compliant Class 1 ensembles.

8.6.2.2.2 Samples shall be conditioned as specified in 8.1.2.