NFPA 1994

Standard on Protective Ensembles for First Responders to CBRN Terrorism Incidents

2007 Edition

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An International Codes and Standards Organization

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NFPA 1994

Standard on

Protective Ensembles for First Responders to CBRN Terrorism Incidents

2007 Edition

This edition of NFPA 1994, *Standard on Protective Ensembles for First Responders to CBRN Terrorist Incidents*, was prepared by the Technical Committee on Hazardous Materials Protective Clothing and Equipment, released by the Technical Correlating Committee on Fire and Emergency Services Protective Clothing and Equipment, and acted on by NFPA at its June Association Technical Meeting held June 4–8, 2006, in Orlando, FL. It was issued by the Standards Council on July 28, 2006, with an effective date of August 17, 2006, and supersedes all previous editions.

This edition of NFPA 1994 was approved as an American National Standard on August 17, 2006.

Origin and Development of NFPA 1994

The Technical Committee on Hazardous Materials Protective Clothing and Equipment began work on this document in 1998 to answer the need for personal protective equipment (PPE) for fire and emergency services personnel operating at domestic terrorism incidents involving dual-use industrial chemicals, chemical terrorism agents, or biological terrorism agents.

The committee developed this new standard, NFPA 1994, *Standard on Protective Ensembles for Chemical/Biological Terrorism Incidents*, to provide three levels of protective ensembles — Class 1, Class 2, and Class 3 ensembles — that could be selected for protection of fire and emergency services personnel based on what the incident risk analysis indicates is necessary protection for the intended operations.

The goal of this standard is to establish personal protection requirements for ensembles that would be available in quantity, pristine condition, designed for single exposure use, and easily donned and used by fire and emergency services personnel to reduce the safety risks and health risks to personnel during assessment, extrication, rescue, triage, and treatment operations at or involving chemical or biological terrorism incidents.

The jurisdiction of this committee does not include respiratory protection that will be necessary for these operations; the appropriate respiratory protection will need to be addressed by the emergency responder organizations.

The first edition was acted on by the NFPA membership at the Annual Meeting in Anaheim, CA, on May 16, 2001.

This 2007 edition (2nd edition) is a complete revision of NFPA 1994. The title of the document has changed to *Protective Ensembles for First Responders to CBRN Terrorism Incidents*. The former requirements for Class 1 CBRN ensembles, for protection from chemical, biological, and radiological terrorism agents, have been incorporated into NFPA 1991, *Standard on Vapor-Protective Ensembles for Hazardous Materials Emergencies,* 2005 edition, and are now incorporated into the base requirements for all vapor-protective ensembles. NFPA 1994 no longer specifies a Class 1 ensemble, but has left the designation "Class 1" vacant. A new Class 4 ensemble has been added to provide particulate protection for emergency responders to incidents where no chemical or biological agent is identified, but a particulate threat is present (including "white powder" incidents). These changes maintain the status of NFPA 1994 as the document providing CBRN protection for the "emergency first responders," leaving the highest level of protection to the specialized teams who will provide the back-up to the first responders for incidents and exposures that require operations or technician-level response.

The CBRN protection requirements of NFPA 1994 were developed to apply to all emergency first responders at CBRN incidents. Individual agencies (law enforcement, emergency medical, medical first receivers, fire, hazardous materials) need to define the operations for which their personnel are trained and develop detailed purchase specifications to ensure their ensembles best support their operational needs while providing CBRN protection.

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The Committee has included in Chapter 4 new requirements for manufacturers' quality assurance programs and for situations where hazards involving compliant products are believed to exist, including the appropriate actions in addressing these situations if there is a previously unknown threat to the users. These new requirements apply to all emergency services product standards that are the responsibility of this project. All labeling, design, performance, and testing requirements have been reviewed and refined as necessary.

This second edition of NFPA 1994, the 2007 edition, was presented to the Association membership at the 2006 Association meeting in Orlando, Florida on 7 June 2006, and issued by the Standards Council with an effective date of 17 August 2006.

In Memoriam, 11 September 2001

We pay tribute to the 343 members of FDNY who gave their lives to save civilian victims on September 11, 2001, at the World Trade Center. They are true American heroes in death, but they were also American heroes in life. We will keep them in our memory and in our hearts. They are the embodiment of courage, bravery, and dedication. May they rest in peace.

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Steven D. Corrado, Underwriters Laboratories Incorporated, NC [RT]
Nicholas J. Curtis, Lion Apparel, Incorporated, OH [M]
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Cy Long, Texas Commission on Fire Protection, TX [E]
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David Trivette, Tyco/Scott Health and Safety, NC [M]
Rep. International Safety Equipment Association
Robert D. Tutterow, Jr., Charlotte Fire Department, NC [U]
Rep. Fire Industry Equipment Research Organization
Harry P. Winer, U.S. Department of the Navy, MA [RT]

Alternates

Jason L. Allen, Intertek, NY [RT]
(Alt. to A. Gbur)
Eric J. Beck, Mine Safety Appliances Company, PA [M]
(Alt. to W. M. Lambert)
Janice C. Bradley, International Safety Equipment Association, VA [M]
(Alt. to D. Trivette)
Patricia A. Freeman, Globe Manufacturing Company, Incorporated, NH [M]
(Alt. to R. A. Freese)
Patricia A. Gleason, Safety Equipment Institute (SEI), VA [RT]
(Alt. to S. R. Sanders)
Mary I. Grilliot, TFG/Morning Pride Manufacturing LLC, OH [M]
(Alt. to B. Grilliot)
William E. Haskell III, U.S. Department of Health and Human Services, MA [E]
(Alt. to L. Boord)
Steven B. Lumry, Oklahoma City Fire Department, OK [C]
(Alt. to J. Minx)
Andrew P. Perrella, E. I. DuPont Company, DE [M]
(Alt. to K. M. Henry)
Frank P. Taylor, Lion Apparel, Incorporated, VA [M]
(Alt. to N. J. Curtis)

Nonvoting

Donna P. Brehm, Virginia Beach Fire Department, VA [U]
Rep. TC on Emergency Medical Services PC&E
Dean W. Cox, Fairfax County Fire and Rescue Department, VA [U]
Rep. TC on Special Operations PC&E
Glenn P. Jirka, Miami Township Fire and EMS Division, OH [E]
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Kirk Owen, Plano Fire Department, TX [U]
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Ray F. Reed, Dallas Fire Rescue, TX [U]
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Bruce H. Varner, Santa Rosa Fire Department, CA [E]
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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 the design, performance, testing, and certification of protective clothing and protective equipment manufactured for fire and emergency services organizations and personnel, to protect against exposures encountered during emergency incident operations. This Committee shall also have the primary responsibility for documents on the selection, care, and maintenance of such protective clothing and protective equipment by fire and emergency services organizations and personnel.

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Miami Township Fire & EMS Division, OH [E]
Rep. The InterAgency Board

Patricia A. Gleason, *Secretary*
Safety Equipment Institute (SEI), VA [RT]

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Steven D. Corrado, Underwriters Laboratories Inc., NC [RT]
Steven M. De Lisi, Virginia Air National Guard, VA [U]
Wade G. DeHate, Hillsborough County Fire Rescue, FL [E]
Daniel Gohlke, W. L. Gore & Associates, MD [M]
A. Ira Harkness, U.S. Department of the Navy, FL [RT]
Karen Lehtonen, Lion Apparel, Inc., OH [M]
Trudy J. Lewis, Battelle Memorial Institute, OH [RT]
John W. North, Alexandria Fire Department, VA [U]
Ulf Nystrom, Trelleborg Protective Products AB, Sweden [M]
Louis V. Ott, Gentex Corporation, PA [M]
Rep. International Safety Equipment Association
Kenneth A. Pever, Guardian Manufacturing Company, OH [M]
Timothy F. Regan, New York City Fire Department, NY [U]
Mel Seng, TFG/Norcross Safety Products, IL [M]
Jeffrey O. Stull, International Personnel Protection, Inc., TX [SE]
Jonathan V. Szalajda, U.S. Department of Health and Human Services, PA [E]
Donald B. Thompson, North Carolina State University, NC [SE]
Brian Wackowicz, Intertek, NY [RT]
Robert West, Texas Instruments, TX [U]
John E. Wisner, Jr., United Steam Fire Engine Company No. 3, MD [U]
James P. Zeigler, DuPont Personal Protection, VA [M]
Michael Ziskin, Field Safety Corporation, CT [RT]

Alternates

Dale Gregory Beggs, Texas Instruments, TX [U]
(Alt. to R. West)
Nicholas J. Curtis, Lion Apparel, Inc., OH [M]
(Alt. to K. Lehtonen)
Andy Gbur, Intertek, OH [RT]
(Alt. to B. Wackowicz)
Russell R. Greene, Battelle Memorial Institute, OH [RT]
(Alt. to T. J. Lewis)
William E. Haskell III, U.S. Department of Health and Human Services, MA [E]
(Alt. to J. V. Szalajda)
So Yon Musser, U.S. Department of the Navy, FL [RT]
(Alt. to A. I. Harkness)
Thomas M. Pease, Gentex Corporation, PA [M]
(Alt. to L. V. Ott)
John Reilly, Total Fire Group, OH [M]
(Alt. to M. Seng)

Bruce W. Teele, NFPA Staff Liaison

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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 1994

Standard on

Protective Ensembles for First Responders to CBRN Terrorism Incidents

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

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

Chapter 1 Administration

1.1 Scope.

1.1.1 This standard shall establish the minimum requirements for the design, performance, testing, documentation, and certification of protective ensembles and ensemble elements for protection from chemicals, biological agents, and radiological particulates (CBRN) terrorism agents.

1.1.2* This standard shall establish requirements for protective ensembles and ensemble elements that are worn for a single exposure at incidents involving CBRN terrorism agents.

1.1.3 This standard shall establish requirements for *new* CBRN protective ensembles and ensemble elements.

1.1.4* This standard shall not establish requirements for respiratory protection for incidents involving CBRN terrorism agents. Appropriate respiratory protection for the incidents involving specific CBRN terrorism agent exposure is a critical part of overall protection and shall be specified and provided by the authority having jurisdiction.

1.1.5 This standard shall not establish requirements for any fire-fighting applications.

1.1.6* This standard shall not establish requirements for protection at incidents involving ionizing radiation, liquefied gas, cryogenic liquid hazards, explosives, or explosive atmospheres.

1.1.7* CBRN protective ensembles and ensemble elements that are certified as compliant with NFPA 1994 shall be permitted also to be certified to NFPA 1991, *Standard on Vapor-Protective Ensembles for Hazardous Materials Emergencies*, NFPA 1992, *Standard on Liquid Splash-Protective Ensembles and Clothing for Hazardous Materials Emergencies*, and the single-use requirements of NFPA 1999, *Standard on Protective Clothing for Emergency Medical Operations*.

1.1.8 This standard shall not apply to any accessories that could be attached to the certified product, before or after purchase, but 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 of the safety concerns associated with the use of compliant CBRN protective ensembles and ensemble elements. It shall be the responsibility of the persons and organizations that use compliant CBRN protective ensembles and ensemble elements to establish safety and health practices and determine the applicability of regulatory limitations prior to use.

1.1.10 This standard shall not be construed as addressing all of 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 CBRN protective ensembles and ensemble elements to establish safety and health practices and determine the applicability of regulatory limitations prior to using this standard for any designing, manufacturing, and testing.

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 minimum levels of protection for emergency first responder personnel assigned to incidents involving CBRN terrorism agents.

1.2.1.1 To achieve this purpose, this standard shall establish minimum requirements for CBRN protective ensembles and ensemble elements for emergency first responder personnel responding to incidents involving CBRN terrorism agents, and for emergency first responder personnel exposed to victims or materials during assessment, extrication, rescue, triage, decontamination, treatment, site security, crowd management, and force protection operations at incidents involving CBRN terrorism agents.

1.2.1.2 This standard shall provide emergency first responder personnel with three levels of CBRN protective ensembles and ensemble elements that could be selected for 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 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.

1.2.3 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.

1.3 Application.

1.3.1* This standard shall not apply to Class 1 CBRN protective ensembles and ensemble elements as such requirements are now covered in NFPA 1991, *Standard on Vapor-Protective Ensembles for Hazardous Materials Emergencies*.

1.3.2 The requirements for Class 2 CBRN protective ensembles and ensemble elements shall apply to ensembles designed to provide limited protection to emergency first responder personnel at terrorism incidents involving vapor or liquid chemical hazards where the concentrations are at or above Immediately Dangerous to Life and Health (IDLH), requiring the use of self-contained breathing apparatus (SCBA).

1.3.3 The requirements for Class 3 CBRN protective ensembles and ensemble elements shall apply to ensembles designed to provide limited protection to emergency first responder personnel at terrorism incidents involving low levels of vapor or liquid chemical hazards where the concentrations

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are below Immediately Dangerous to Life and Health (IDLH), permitting the use of air-purifying respirators (APR).

1.3.4 The requirements for Class 4 CBRN protective ensembles and ensemble elements shall apply to ensembles designed to provide limited protection to emergency first responder personnel at terrorism incidents involving biological hazards or radiological particulate hazards where the concentrations are below Immediately Dangerous to Life and Health (IDLH), permitting the use of air-purifying respirators (APR).

1.3.5 This standard shall apply to the design, manufacturing, and certification processes for *new* CBRN protective ensembles and ensemble elements for incidents involving CBRN terrorism agents.

1.3.6 This edition of NFPA 1994 shall not apply to any CBRN protective ensembles and ensemble elements manufactured to prior editions of this standard.

1.3.7 This standard shall not apply to any CBRN protective ensembles and ensemble elements for incidents involving CBRN terrorism incidents manufactured in accordance with other specifications or standards of other organizations.

1.3.8 This standard shall not apply to use requirements for CBRN protective ensembles and ensemble elements for incidents involving CBRN terrorism agents, as these requirements are specified in NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program.*

1.3.9* The requirements of this standard shall not apply to any accessories that might be attached to any ensemble or to any CBRN protective ensemble elements and ensemble elements.

1.4 Units.

1.4.1 In this standard, values for measurement are followed by an equivalent in parentheses, but only the first stated value shall be regarded as the requirement.

1.4.2 Equivalent values in parentheses shall not be considered as the requirement, as these values are approximate.

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 1500, *Standard on Fire Department Occupational Safety and Health Program,* 2007 edition.

NFPA 1981, *Standard on Open-Circuit Self-Contained Breathing Apparatus for Fire and Emergency Services,* 2002 edition.

NFPA 1991, *Standard on Vapor-Protective Ensembles for Hazardous Materials Emergencies,* 2005 edition.

NFPA 1992, *Standard on Liquid Splash-Protective Ensembles and Clothing for Hazardous Materials Emergencies,* 2005 edition.

NFPA 1999, *Standard on Protective Clothing for Emergency Medical Operations,* 2003 edition.

2.3 Other Publications.

2.3.1 ANSI Publication. American National Standards Institute, Inc., 25 West 43rd Street, 4th Floor, New York, NY 10036.

ANSI Z89.1, *Standard for Industrial Head Protection*, 2003.

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

ASTM D 747, *Standard Test Method for Apparent Bending Modulus of Plastics by Means of a Cantilever Beam*, 2002.

ASTM D 751, *Standard Test Methods for Testing Coated Fabrics*, 2000.

ASTM D 1630, *Standard Test Method for Rubber Property — Abrasion Resistance (NBS Abrader)*, 2000.

ASTM D 1776, *Standard Practice for Conditioning and Testing Textiles*, 2004.

ASTM D 2136, *Standard Test Method for Coated Fabrics — Low Temperature Bend Test*, 2002.

ASTM D 2582, *Standard Test Method for Puncture Propagation Tear Resistance of Plastic Film and Thin Sheeting*, 2003.

ASTM D 3884, *Standard Guide for Abrasion Resistance of Textile Fabrics (Rotary Platform, Double-Head Method)*, 2001.

ASTM D 4157, *Standard Test Method for Abrasion Resistance of Textile Fabrics (Oscillatory Cylinder Method)*, 2002.

ASTM D 5151, *Standard Test Method for Detection of Holes in Medical Gloves*, 1999.

ASTM F 392, *Standard Test Method for Flex Durability of Flexible Barrier Materials*, 2004.

ASTM F 489, *Standard Test Method for Static Coefficient of Friction of Shoe Sole and Heel Material as Measured by the James Machine*, 1996.

ASTM F 739, *Standard Test Method for Resistance of Protective Clothing Materials to Permeation by Liquids or Gases Under Conditions of Continuous Contact,* 1999a.

ASTM F 1154, *Standard Practice for Qualitatively Evaluating the Comfort, Fit, Function, and Integrity of Chemical Protective Suit Ensembles*, 2004.

ASTM F 1301, *Standard Practice for Labeling Chemical Protective Clothing*, 2001.

ASTM F 1342, *Standard Test Method for Resistance of Protective Clothing Materials to Puncture*, 1996.

ASTM F 1359, *Standard Test Method for Measuring the Liquid Permeation Resistance of Protective Clothing or Protective Ensembles Under a Shower Spray While on a Mannequin*, 2004.

ASTM F 1671, *Standard Test Method for Resistance of Materials Used in Protective Clothing to Penetration by Blood-Borne Pathogens Using Phi-X174 Bacteriophage as a Test System*, 2003.

ASTM F 1790, *Standard Test Methods for Measuring Cut Resistance of Materials Used in Protective Clothing*, 2004.

ASTM F 1868, *Standard Test Method for Thermal and Evaporative Resistance of Clothing Materials Using a Sweating Hot Plate,* 2002.

ASTM F 2010, *Standard Test Method for Evaluation of Glove Effects on Wearer Hand Dexterity Using a Modified Pegboard Test,* 2000.

ASTM F 2412, *Standard Test Methods for Foot Protection*, 2005.

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

FIA 1209, *Whole Shoe Flex,* 1984.

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2.3.4 ISO Publications. International Organization for Standardization, 1 rue de Varembé, Case postale 56, CH-1211 Geneve 20, Switzerland.

ISO 9001, *Quality management systems — requirements*, 2000.

ISO 17011, *General requirements for accreditation bodies accrediting conformity assessment bodies*, 2004.

ISO 17025, *General requirements for the competence of testing and calibration laboratories*, 2005.

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.

ISO Guide 62, *General requirements for bodies operating assessment and certification/registration of quality systems*, 1996.

ISO Guide 65, *General requirements for bodies operating product certification systems*, 1996.

2.3.5 U.S. Government Publications. U.S. Government Printing Office, Washington, DC 20402.

Title 29, Code of Federal Regulations, Part 1910.132, Subpart L, "Personal Protective Equipment," 1994.

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, 2002.

2.3.6 U.S. Military Publications. U.S. Army Developmental Test Command (DTC), ATTN: CSTE-DTC-TT-S, Aberdeen Proving Ground, MD 21005-5055.

Test Operations Procedure (TOP 10-2-022), Man-In-Simulant Test (MIST) — Chemical Vapor Testing of Chemical/Biological Protective Suits, September 2001.

2.3.7 Other Publications.

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, April 1997, UNCLASSIFIED.

Assessment of the US Army Chemical And Biological Defense Command Report 1: Technical Assessment of the Man-In-Simulant Test (MIST) Program," National Research Council Report, 1997.

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

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. 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. A document, the main text of which contains only mandatory provisions using the word "shall" to indicate requirements and which is in a form generally suitable for mandatory reference by another standard or code or for adoption into law. Nonmandatory provisions shall be located in an appendix or annex, footnote, or fine-print note and are not to be considered a part of the requirements of a standard.

3.3 General Definitions.

3.3.1 Agents.

3.3.1.1 ***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.

3.3.1.2 ***CBRN Terrorism Agents.*** See 3.3.8.

3.3.1.3 ***Chemical Terrorism Agents.*** See 3.3.16.

3.3.1.4* ***Chemical Warfare (CW) Agents.*** See 3.3.17.

3.3.1.5 ***Radiological Particulate Terrorism Agents.*** Radioactive particulates, including alpha and beta particulates, that are generated from a source of radioactive material or nuclear event which are intentionally used to inflict lethal or incapacitating casualties, generally on a civilian population as a result of a terrorist attack. The contaminated particles emit ionizing radiation.

3.3.2 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.

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

3.3.3 Biological Terrorism Agents. See 3.3.1.1.

3.3.4 Bootie. A sock-like extension of the garment leg worn in conjunction with other footwear components.

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3.3.5 Care. Procedures for cleaning, decontamination, and storage of protective ensembles and ensemble elements.

3.3.6 CBRN. Abbreviation for Chemical, Biological, Radiological, and Nuclear.

3.3.7 CBRN Barrier Material. The part of the composite that is intended to provide protection against CBRN terrorism agents.

3.3.8 CBRN Terrorism Agents. The term used to refer to chemical terrorism agents including both chemical warfare agents and toxic industrial chemicals, biological terrorism agents, and radiological particulate terrorism agents. *(See also 3.3.1.1, Biological Terrorism Agents, 3.3.1.3, Chemical Terrorism Agents, and 3.3.1.5, Radiological Particulate Terrorism Agents.)*

3.3.9 CBRN Terrorism Incident Protective Ensembles and Ensemble Elements. Multiple elements, categorized as Class 2, Class 3, or Class 4 CBRN protective ensembles and ensemble elements, designed to provide minimum full-body protection against exposure to chemical/biological terrorism agents occurring during chemical/biological terrorism emergencies.

3.3.9.1 ***Class 2 CBRN Protective Ensemble and Ensemble Elements.*** A CBRN protective ensemble and ensemble elements designed to protect emergency first responder personnel at terrorism incidents involving vapor or liquid chemical hazards where the concentrations are at or above Immediately Dangerous to Life and Health (IDLH) requiring the use of self-contained breathing apparatus (SCBA).

3.3.9.2 ***Class 3 CBRN Protective Ensemble and Ensemble Elements.*** A CBRN protective ensemble and ensemble element designed to protect emergency first responder personnel at terrorism incidents involving low levels of vapor or liquid chemical hazards where the concentrations are below Immediately Dangerous to Life and Health (IDLH) permitting the use of CBRN air-purifying respirators (APR), or CBRN powered air-purifying respirators (PAPR).

3.3.9.3 ***Class 4 CBRN Protective Ensemble and Ensemble Elements.*** A CBRN protective ensemble and ensemble elements designed to protect emergency first responder personnel at terrorism incidents involving biological hazards or radiological particulate hazards where the concentrations are below Immediately Dangerous to Life and Health (IDLH) permitting the use of air-purifying respirators (APR), or powered air-purifying respirators (PAPR).

3.3.10 CBRN Terrorism Incident Protective Footwear. An element of the CBRN terrorism agent protective ensemble and ensemble elements designed to provide minimum protection to the foot, ankle, and lower leg.

3.3.11 CBRN Terrorism Incident Protective Footwear Cover. An item of the CBRN terrorism agent protective ensemble and ensemble elements designed and configured to be worn over standard footwear to provide barrier and physical protection to the wearer's feet.

3.3.12 CBRN Terrorism Incident Protective Garment(s). An element of the CBRN terrorism agent protective ensemble and ensemble elements designed to provide minimum protection to the upper and lower torso, head, arms, and legs; excluding the hands and feet.

3.3.13 CBRN Terrorism Incident Protective Glove(s). An element of the CBRN terrorism agent protective ensemble and ensemble elements designed to provide minimum protection to the wearer's hands and wrists.

3.3.14* Certification Organization. An independent, third-party organization established for product testing and evaluation that administers a labeling/listing/follow-up program.

3.3.15 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 with the requirements of this standard.

3.3.16 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.

3.3.17 Chemical Warfare (CW) Agents. Liquid, solid, and gas chemical agents (most are liquids) traditionally used during warfare or armed conflict to kill or incapacitate an enemy. *(See also 3.3.1.3, Chemical Terrorism Agents, and 3.3.66, Toxic Industrial Chemicals.)*

3.3.18 Class 2 CBRN Protective Ensemble and Ensemble Elements. See 3.3.9.1.

3.3.19 Class 3 CBRN Protective Ensemble and Ensemble Elements. See 3.3.9.2.

3.3.20 Class 4 CBRN Protective Ensemble and Ensemble Elements. See 3.3.9.3.

3.3.21 Compliance/Compliant. Product that meets or exceeds all applicable requirements of this standard and is certified.

3.3.22* Component. Any material, part, or subassembly used in the construction of the compliant product.

3.3.23 Composite. Any layering of ensemble material(s), ensemble element materials, or components as they appear in the final garment construction.

3.3.24 Cryogenic Gas. See 3.3.39.1.

3.3.25 Emergency First Responder Personnel. See 3.3.30.1.

3.3.26* Encapsulating. A type of CBRN protective ensemble that provides vaportight or liquidtight protection to the upper and lower torso, head, hands, and feet and completely covers the wearer and the wearer's respirator. *(See also 3.3.55.1, CBRN Terrorism Incident Protective Ensembles and Ensemble Elements, and 3.3.47, Non-Encapsulating.)*

3.3.27 Ensemble(s). See 3.3.9, CBRN Terrorism Incident Protective Ensemble and Ensemble Elements.

3.3.28* Ensemble Elements. The parts or items that comprise the CBRN terrorism incident protective ensemble and ensemble elements.

3.3.29* External Fittings. Any fitting externally located on, and part of, the ensemble which is not part of the garment material, visor material, gloves, footwear, seams, or closure assembly.

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3.3.30 First Responder Personnel.

3.3.30.1 ***Emergency First Responder Personnel.*** Those persons, including members of fire departments, police departments, other law enforcement agencies, hazardous materials response teams, emergency medical services, and other organizations that have public safety responsibilities and who would respond to rescue and treat victims, and who would protect the public during an emergency incident.

3.3.31 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.

3.3.32 Footwear.

3.3.32.1* ***CBRN Terrorism Incident Protective Footwear.*** See 3.3.10.

3.3.32.2 ***Protective Footwear.*** An abbreviated term for CBRN Terrorism Incident Protective Footwear. *(See also 3.3.10, CBRN Terrorism Incident Protective Footwear.)*

3.3.33 Footwear Cover. See 3.3.33.1, CBRN Terrorism Incident Protective Footwear Cover.

3.3.33.1* ***CBRN Terrorism Incident Protective Footwear Cover.*** See 3.3.11.

3.3.34 Footwear Upper. That portion of the footwear element above the sole.

3.3.35 Garment(s).

3.3.35.1* ***CBRN Terrorism Incident Protective Garment(s).*** See 3.3.12.

3.3.35.2 ***Outer Garment.*** A garment worn over another garment component to meet the requirements of this standard.

3.3.35.3 ***Protective Garment(s).*** An abbreviated term for CBRN Terrorism Incident Protective Garment(s). *[See also 3.3.12, CBRN Terrorism Incident Protective Garment(s).]*

3.3.36 Garment Closure. The garment component designed and configured to allow the wearer to don (put on) and doff (take off) the CBRN terrorism incident protective ensemble and ensemble elements.

3.3.37 Garment Closure Assembly. See 3.3.2.1.

3.3.38 Garment Material. See 3.3.45.2.

3.3.39 Gas.

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

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

3.3.40 Glove(s).

3.3.40.1* ***CBRN Terrorism Incident Protective Glove(s).*** See 3.3.13.

3.3.40.2 ***Outer Glove.*** A glove worn over another glove component for the purposes of providing additional protection to the wearer and to meet the requirements of this standard.

3.3.40.3 ***Protective Glove(s).*** An abbreviated term for CBRN Terrorism Incident Protective Glove(s). *[See also 3.3.13, CBRN Terrorism Incident Protective Glove(s).]*

3.3.41 Ionizing Radiation. Extremely short-wavelength, high energy penetrating rays of gamma and x-rays emitted from radioactive elements and isotopes.

3.3.42 Liquefied Gas. See 3.3.39.2.

3.3.43 Maintenance. Procedures for inspection, repair, and removal from service of CBRN protective ensembles and ensemble elements.

3.3.44 Manufacturer. The entity that directs and controls any of the following: compliant product design, compliant product manufacturing, or compliant product quality assurance; or the entity that assumes the liability for the compliant product or provides the warranty for the compliant product.

3.3.45 Material.

3.3.45.1 ***CBRN Barrier Material.*** See 3.3.7.

3.3.45.2 ***Garment Material.*** The principal protective clothing material used in the construction of CBRN terrorism incident protective ensembles and ensemble elements.

3.3.45.3 ***Protective Clothing Material.*** Any material or composite used in CBRN protective ensemble and ensemble elements for the purpose of protecting parts of the wearer's body against chemical/biological terrorism agents, or against physical hazards.

3.3.45.4 ***Visor Material.*** The transparent chemical-protective clothing material that allows the wearer to see outside the CBRN terrorism incident protective ensemble and ensemble elements.

3.3.46 Model. The collective term used to identify a group of individual elements of the same basic design and components from a single manufacturer produced by the same manufacturing and quality assurance procedures that are covered by the same certification.

3.3.47* Non-Encapsulating. A type of CBRN protective ensemble and ensemble elements that provides liquid splash protection, but does not provide vaportight protection, or liquidtight protections, and does not cover the wearer's respirator.

3.3.48 Outer Boot. A boot worn over other footwear components to meet requirements of this standard.

3.3.49 Outer Garment. See 3.3.35.2.

3.3.50 Outer Glove. See 3.3.40.2.

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

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

3.3.53* Product Label. A label or marking affixed by the manufacturer to each compliant product or product package. Such labels contain compliance statements, certification statements, general information, care, maintenance, or similar data.

3.3.54 Protective Clothing Material. See 3.3.45.3.

3.3.55 Protective Ensemble(s) and Ensemble Elements. An abbreviated term for CBRN Terrorism Incident Protective Ensembles.

3.3.55.1* ***CBRN Terrorism Incident Protective Ensembles and Ensemble Elements.*** See 3.3.9.

3.3.56 Protective Ensembles. See 3.3.55.

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3.3.57 Protective Footwear. See 3.3.32.2.

3.3.58 Protective Garment(s). See 3.3.35.3.

3.3.59 Protective Glove(s). See 3.3.40.3.

3.3.60 Radiological and Nuclear Particulate Terrorism Agents. See 3.3.1.5.

3.3.61* Respirator. A device that provides respiratory protection for the wearer.

3.3.62 Sample. The element, item, component, or composite that is conditioned for subsequent testing. An amount of the material, product or assembly to be tested that is representative of the item as a whole. *(See also 3.3.64, Specimen.)*

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

3.3.64 Specimen. The conditioned element, item, component or composite that is tested. Specimens are taken from samples. *(See also 3.3.62, Sample.)*

3.3.65 Storage Life. The life expectancy of the CBRN protective ensemble and ensemble elements from the date of manufacture when it is only stored and inspected and has undergone proper care and maintenance in accordance with manufacturer's instructions, but not used, donned, doffed, or repaired.

3.3.66 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 3.3.16, Chemical Terrorism Agents, and 3.3.17, Chemical Warfare (CW) Agents.]*

3.3.67 Visor Material. See 3.3.45.4.

Chapter 4 Certification

4.1 General.

4.1.1 The process of certification for product as being compliant with NFPA 1994 shall meet the requirements of Section 4.1, General; Section 4.2, Certification Program; Section 4.3, Inspection and Testing; Section 4.4, Recertification; Section 4.5, Manufacturers' Quality Assurance Program; Section 4.6, Hazards Involving Compliant Product; Section 4.7, Manufacturers' Investigation of Complaints and Returns; and Section 4.8, Manufacturers' Safety Alert and Product Recall Systems.

4.1.2* All compliant products that are labeled as being compliant with this standard shall meet or exceed all 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, Certification Program, and that is accredited for personal protective equipment in accordance with ISO Guide 65, *General requirements for bodies operating product certification systems.* The accreditation shall be issued by an accreditation body operating in accordance with ISO 17011, *General requirements for accreditation bodies accrediting conformity assessment bodies.*

4.1.4 Manufacturers shall not claim compliance with portions or segments of the requirements of this standard and shall not use the NFPA name or the name or identification of this standard, NFPA 1994, in any statements about their respective products unless the products are certified as compliant to this standard.

4.1.5 All compliant products shall be labeled and listed.

4.1.5.1 Glove elements and footwear elements that are provided, sold, or distributed as part of a specific ensemble shall not be required to be separately labeled or listed, but shall be included as a part of the ensemble product label and listing.

4.1.6 All compliant products shall also have a product label that meets the requirements specified in Section 5.1, Product Labeling Requirements.

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

4.1.8 The certification organization shall not issue any new certifications to the 2001 edition of NFPA 1994, *Standard on Protective Ensemble for Chemical/Biological Terrorism Incidents*, on or after the effective date for NFPA 1994, *Standard on Protective Ensembles for First Responders to CBRN Terrorism Incidents*, 2007 edition, which is 17 August 2006.

4.1.9 The certification organization shall not permit any manufacturer to continue to label any products that are certified as compliant with the 2001 edition of NFPA 1994, *Standard on Protective Ensemble for Chemical/Biological Terrorism Incidents*, on or after 1 March 2007.

4.1.10 The certification organization shall require manufacturers to remove all certification labels and product labels indicating compliance with the 2001 edition of NFPA 1994, *Standard on Protective Ensemble for Chemical/Biological Terrorism Incidents*, from all products that are under the control of the manufacturer on 1 March 2007, and the certification organization shall verify this action is taken.

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 Guide 65, *General requirements for bodies operating product certification systems.* The accreditation shall be issued by an accreditation body operating in accordance with ISO 17011, *General requirements for accreditation bodies accrediting conformity assessment bodies.*

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

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

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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 applicable requirements of this standard.

4.2.6* The certification organization shall have laboratory facilities and equipment available 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 calibration of all instruments, and procedures shall be in use 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, Manufacturers' Quality Assurance Program.

4.2.7.1* The certification organization shall require the manufacturer to have a product recall system specified in Section 4.8, Manufacturers' Safety Alert and Product Recall Systems, 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 the compliant product to determine its continued certification to this standard.

4.2.9* The certification organization shall have a follow-up inspection program of the manufacturer's facilities of the compliant product with at least two random and unannounced visits per 12-month period to verify the product's continued compliance.

4.2.9.1 As part of the follow-up inspection program, the certification organization shall select sample compliant product at random from the manufacturer's production line, from the manufacturer'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 in order to assure that the materials, components, and manufacturing quality assurance systems are consistent with the materials, components, and manufacturing quality assurance that were inspected and tested by the certification organization during initial certification and recertification.

4.2.9.3 The certification organization shall be permitted to conduct specific testing to verify the 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 acquired in accordance with 4.2.9.1 against the applicable requirements of this standard.

4.2.10 The certification organization shall have in place a series of procedures, as specified in Section 4.6, Hazards Involving Compliant Product, 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 provide 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 compliant products, 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 recertification shall be conducted by a certification organization's testing laboratory that is accredited in accordance with the requirements of ISO 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 17025, *General requirements for the competence of testing and calibration laboratories*, 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 17011, *General requirements for accreditation bodies accrediting conformity assessment bodies.*

4.3.3 A certification organization shall be permitted to utilize conditioning and testing results conducted by a product or component manufacturer for certification or recertification 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 17025, *General requirements for the competence of testing and calibration laboratories.*

4.3.3.2 The manufacturer's testing laboratory's scope of accreditation to ISO 17025, *General requirements for the competence of testing and calibration laboratories*, 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 17011, *General requirements for accreditation bodies accrediting conformity assessment bodies.*

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 for certification or recertification 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 a reasonable and acceptable reliability at a reasonable and acceptable confidence level that products certified to this standard are compliant, unless such sampling

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levels are specified herein. This information shall be included in the manufacturer's technical data package.

4.3.5 Inspection by the certification organization shall include a review of all product labels to ensure that all required label attachments, compliance statements, certification statements, and other product information are at least as specified in Section 5.1, Product Labeling Requirements.

4.3.6 Inspection by the certification organization shall include an evaluation of any symbols and pictorial graphic representations used on product labels or in user information, as permitted in 5.1.1.6, to ensure that the symbols 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 Section 5.2, User Information, 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 requirements of Section 5.3, Technical Data Package.

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

4.3.10 Testing to determine product compliance with the 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 compliant product.

4.3.10.2 The certification organization also shall 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 product or product component.

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 test method to be reconditioned and tested for another test method unless specifically permitted in 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 Glove and footwear ensemble elements that are manufactured as separate items and are not intended to be provided, sold, or distributed as part of a complete ensemble shall be certified as ensemble elements.

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

4.3.16.2 The designation of which certified ensemble(s), that compliant ensemble elements have been certified with, shall be clearly indicated on the product label of the certified ensemble element.

4.3.17 Any change in the design, construction, or material of a compliant product shall necessitate new inspection and testing to verify compliance to all 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.

4.3.18 The manufacturer shall maintain all 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.

4.3.19* Unless otherwise noted in this standard, any combination of materials or multipiece ensemble element that is needed to meet any of the performance requirements specified in Chapter 7 shall be required to meet all the requirements for that particular part of the ensemble or ensemble element.

4.4 Recertification.

4.4.1 All products that are labeled as being compliant with this standard shall undergo recertification on an annual basis.

4.4.1.1 This recertification shall include inspection and evaluation to the design requirements and testing to the performance requirements as required by this standard on all manufacturers' compliant product models.

4.4.1.2 Any change that affects the compliant product performance under design or performance requirements of this standard shall constitute a different model.

4.4.1.3 For the purpose of this standard, models shall include each unique pattern, style, or design of the compliant products.

4.4.2 Samples of manufacturer's models and components for recertification shall be acquired from the manufacturer or component supplier during random and unannounced visits as part of the follow-up program specified in 4.2.9.

4.4.2.1 For recertification, the certification organization shall acquire at least one complete compliant product.

4.4.2.2 The certification organization shall also acquire a sufficient quantity of components to be tested for recertification as required by 4.4.3.

4.4.3 Compliant products and components shall be inspected, evaluated, and tested as specified in 4.4.3.1 and 4.4.3.2. Inspection, evaluation, and testing performed as part of the follow-up program shall be permitted to be used for recertification to avoid duplication.

4.4.3.1 One sample of each compliant product shall be inspected and evaluated to the design requirements specified in Chapter 6.

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4.4.3.2 One sample of each compliant ensemble shall be tested for overall performance as specified in the ensemble general requirements in Chapter 7.

4.4.3.3 Each compliant element and component shall be tested for overall performance as specified in the appropriate element requirements in Chapter 7.

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

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, Manufacturers' Safety Alert and Product Recall Systems.

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

4.5.3 The manufacturer shall be registered to ISO 9001, *Quality management systems — requirements*.

4.5.3.1 Registration to the requirements of ISO 9001, *Quality management systems — requirements*, shall be conducted by a registrar that is accredited for personal protective equipment in accordance with ISO Guide 62, *General requirements for bodies operating assessment and certification/registration of quality systems*. The registrar shall affix the accreditation mark on the ISO registration certificate.

4.5.3.2 The scope of the ISO registration shall include at least the design and manufacturing systems management for the type of personal protective equipment being certified.

4.5.4* Any entity that meets the definition of manufacturer specified in Section 3.3, General Definitions, and therefore is considered to be the "manufacturer" but does not manufacture or assemble the compliant product, shall meet the requirements specified in Section 4.5.

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

4.5.5.1 Component manufacturers shall be considered as subcontractors.

4.5.5.2 Subcontractors shall include but not be limited to a person or persons, or a company, firm, corporation, partnership, or other organization having an agreement with or under contract with the compliant product manufacturer to supply or assemble components of the compliant product, or to assemble portions of the compliant product.

4.5.5.3 The assembly portion of the manufacturing process shall include but not be limited to the sewing, gluing, laminating, tacking, or other means of attaching whereby materials or component parts are joined together to form a portion, a component, or a complete compliant product.

4.5.6 All subcontractors, where different from the manufacturer, shall also be registered to the requirements of ISO 9001, *Quality management systems — requirements*, for manufacturing, unless the provisions specified in 4.5.6.1 and 4.5.6.2 apply.

4.5.6.1 The manufacturer shall be permitted to include subcontractors in the manufacturer's ISO 9001 registration in lieu of requiring the subcontractor to have their own ISO registration.

4.5.6.2 Where the manufacturer applies their ISO registration to subcontractors, this action shall require the inclusion of the subcontractors' addresses and functions on the manufacturer's ISO 9001 registration certificate, and the manufacturer shall provide the certification organization with copies of the ISO 9001 registrar's reports showing acceptable inclusion of these locations for the functions they perform for the manufacturer.

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 involved with 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 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 involved with a compliant product, the certification organization shall determine the scope of the hazard including 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 compliant product is gaining widespread use in applications not foreseen when the standard was written, such applications in turn being ones for which the product was not certified, and no specific scope of application has been provided in the standard, and no limiting scope of application was 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 the manufacturer of the

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compliant product component if applicable, to assist the certification organization in the investigation and to conduct its own investigation as specified in Section 4.7, Manufacturers' Investigation of Complaints and Returns.

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 the 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 the users.
(3) Removing the mark of certification from the product.
(4) Where a hazardous condition exists and it is not practical to implement (1), (2), or (3), or the responsible parties refuse to take corrective action, the certification organization shall notify relevant governmental and regulatory agencies and issue 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 indicated, 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 shall also submit either a Public Proposal 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, *Quality management systems — requirements*, 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 can 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 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 to conduct a product recall.

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

(1) Establishment of a coordinator and responsibilities by the manufacturer for the handling of safety alerts and product recalls
(2) Method of notifying all dealers, distributors, purchasers, users, and the NFPA about the safety alert or product recall that can be initiated within a one-week period following the manufacturer's decision to issue a safety alert or to 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 the 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 for documenting the effectiveness of the product recall
(5) Plan for either repairing, or replacing, or compensating purchasers for returned product

Chapter 5 Labeling and Information

5.1 Product Labeling Requirements.

5.1.1 General.

5.1.1.1 Each protective ensemble shall have a product label permanently and conspicuously attached to, embossed on, or printed on each separable garment element of the ensemble when the ensemble is properly assembled with all layers, components, and component parts in place.

5.1.1.2 Each glove element shall have a product label permanently and conspicuously attached to, embossed on, or printed on the top outside of the gauntlet of each glove piece when the glove is properly assembled with all layers, components, and component parts in place. In place of the product label being affixed to the glove, the product label shall be permitted to be attached to, printed on, or inserted into each package containing one or more pairs of gloves.

5.1.1.3 Each footwear element shall have a product label permanently and conspicuously attached to, embossed on, or printed on the inside of each footwear piece when the footwear is properly assembled with all layers, components, and component parts in place. In place of the product label being affixed to the footwear, the product label shall be permitted to be attached to, printed on, or inserted into each package containing one or more pairs of footwear.

5.1.1.4 Multiple label pieces shall be permitted in order to carry all statements and information required to be on the product label; however, all label pieces comprising the entire product label shall be located adjacent to each other.

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5.1.1.5 All worded portions of the required product label shall at least be in English.

5.1.1.6 Symbols and other pictorial graphic representations shall be permitted to be used to supplement worded statements on the product label(s) where such symbols and other pictorial graphic representations are clearly explained in the user information.

5.1.1.7* The certification organization's label, symbol, or identifying mark shall be legibly printed on the product label. All letters shall be at least 2.5 mm (3⁄32 in.) high.

5.1.1.8 The compliance and information statements specified in 5.1.2 or 5.1.3, as applicable for the specific ensemble or ensemble element, shall be legibly printed on the product label. All letters shall be at least 2 mm (1⁄16 in.) high.

5.1.1.9 In addition to the compliance and information statements required by 5.1.1.8, at least the following information shall also be printed legibly on the product label(s) in letters at least 2 mm (1⁄16 in.) high:

(1) Manufacturer's name, identification, or designation
(2) Manufacturer's address
(3) Country of manufacture
(4) Model, style, or serial number
(5) Size
(6) Garment, glove, footwear, ensemble material(s), as applicable
(7) Visor material(s) if provided
(8) Glove element for the ensemble
(9) Footwear element for the ensemble

5.1.1.10 Where detachable components including, but not limited to, outer garments, outer gloves, or outer boots must be worn with an ensemble or ensemble element in order for the ensemble or ensemble element to be compliant with this standard, at least the following statement and information shall also be printed legibly on the product label of the ensemble or ensemble element that requires an additional component. All letters shall be at least 2.5 mm (3⁄32 in.) high. The appropriate term *ensemble* or *ensemble element* shall be inserted where indicated in the label text. The statement shall be followed by the detachable component(s) type and identification and instructions for proper wear.

"TO BE COMPLIANT WITH NFPA 1994, THE FOLLOWING ADDITIONAL COMPONENTS MUST BE WORN IN CONJUNCTION WITH THIS CBRN INCIDENT (insert the term ENSEMBLE or ENSEMBLE ELEMENT here):"
[The detachable component(s) information shall appear here.]

5.1.1.11 Detachable components specified in 5.1.1.10 shall be identified by the type of item, the manufacturer, and the style or model number.

5.1.1.12 The manufacturer shall be permitted to list the detachable components in the technical data package. Where the manufacturer chooses to list detachable components in the technical data package, the manufacturer shall provide an additional statement in the label statement required by 5.1.1.10 as follows:

"SEE TECHNICAL DATA PACKAGE FOR A LIST OF DETACHABLE COMPONENTS."

5.1.1.13 Detachable components specified in 5.1.1.10 shall meet the label requirements specified in ASTM F 1301, *Standard Practice for Labeling Chemical Protective Clothing*.

5.1.2 Ensemble Compliance Statements.

5.1.2.1 Each protective ensemble shall have at least the following compliance statement on the product label. All letters shall be at least 2.5 mm (3⁄32 in.) high. The appropriate numeral for the class of the ensemble, 2, 3, or 4, and the appropriate term for the type of ensemble, *encapsulating* or *non-encapsulating*, shall be inserted where indicated in the label text.

"THIS CLASS (insert 2, 3, or 4 here) (insert ENCAPSULATING or NON-ENCAPSULATING here) CBRN PROTECTIVE ENSEMBLE MEETS THE REQUIREMENTS OF NFPA 1994, STANDARD ON PROTECTIVE ENSEMBLES FOR FIRST RESPONDERS TO CBRN TERRORISM INCIDENTS, 2007 EDITION, FOR THE ABOVE-NOTED CLASS. DO NOT REMOVE THIS LABEL."

5.1.2.2 Following the text in 5.1.2.1, the following statement shall be made on the product label. All letters shall be at least 1.5 mm (1⁄16 in.) high.

"The technical data package contains information on CBRN agents for which this garment is certified. Consult the technical data package and manufacturer's instructions before use."

5.1.3 Glove and Footwear Elements Compliance Statements.

5.1.3.1 Each glove element and footwear element shall have at least the following compliance statement on the product label. All letters shall be at least 2.5 mm (3⁄32 in.) high. The appropriate number for the class of the ensemble, 2, 3, or 4; and the appropriate term for the type of element, *glove* or *footwear*, shall be inserted where indicated in the label text.

"THIS CLASS (insert 2, 3, or 4 here) CBRN PROTECTIVE (insert GLOVE or FOOTWEAR here) ELEMENT MEETS THE REQUIREMENTS OF NFPA 1994, STANDARD ON PROTECTIVE ENSEMBLES FOR FIRST RESPONDERS TO CBRN TERRORISM INCIDENTS, 2007 EDITION, FOR THE ABOVE-NOTED CLASS. DO NOT REMOVE THIS LABEL"

5.1.3.2 Following the text in 5.1.3.1, the following statement shall be made on the product label. All letters shall be at least 1.5 mm (1⁄16 in.) high.

"The technical data package contains information on CBRN agents for which this (insert *glove* or *footwear* here) element is certified. Consult the technical data package and manufacturer's instructions before use."

5.2 User Information.

5.2.1 The manufacturer shall provide user information including, but not limited to, warnings, information, and instructions with each individual CBRN protective ensemble and ensemble element.

5.2.2 The manufacturer shall attach the required user information, or packaging containing the user information, to CBRN protective ensembles and ensemble elements in such a manner that it is not possible to use the CBRN protective ensemble and ensemble elements without being aware of the availability of the information.

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

(1) Pre-use information, as follows:
   (a) Safety considerations
   (b) Limitations of use
   (c) Ensemble element marking recommendations and restrictions
   (d) Statement that most performance properties of the ensemble and ensemble elements cannot be tested by the user in the field
   (e) Closure lubricants, if applicable
   (f) Visor antifog agents or procedures, if applicable
   (g) Recommended undergarments
   (h) Respirator considerations for ensembles
   (i) Warranty information
(2) Recommended storage practices
(3) Inspection frequency and details
(4) Don/doff, as follows:
   (a) Donning and doffing procedures
   (b) Sizing and adjustment procedures
   (c) Ensemble interface issues
   (d) Respirator interface with ensemble
(5) Proper use in accordance with the following:
   (a) NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program*
   (b) For users in the United States, 29 CFR 1910.132, "Personal Protective Equipment"
   (c) For users in other countries, a statement to advise users to consult national or other applicable personal protective equipment regulations
(6) Maintenance and cleaning, as follows:
   (a) Cleaning instructions and precautions with a statement advising users not to use clothing or ensembles that are not thoroughly cleaned and dried
   (b) Inspection details
   (c) Maintenance criteria and repair methods, where applicable
   (d) Decontamination procedures for both chemical/biological contamination
(7) Retirement and disposal criteria and consideration

5.2.4 The manufacturer shall state the storage life for all CBRN protective ensembles and ensemble elements.

5.3 Technical Data Package.

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

5.3.2* The technical data package shall contain all documentation required by this standard and the data showing compliance with this standard. The physiological protective dosage factor (PPDF) value shall be included as part of the technical data package.

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

5.3.4* In the technical data package, the manufacturer shall describe the available sizes of the CBRN protective ensemble and ensemble elements.

5.3.4.1 Descriptions of size shall include the range in height and weight for persons fitting each particular size for garments, or sizes specific in Chapter 6 for glove and footwear elements.

5.3.4.2 Descriptions also shall provide information to the wearer as to whether these sizes apply to persons wearing self-contained breathing apparatus (SCBA) or other respirators, hard hats, communications devices, and other similar equipment.

5.3.5 Garment Material and Component Descriptions.

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

5.3.5.2 The manufacturer shall provide, in the technical data package, the list and descriptions of the following CBRN protective ensemble materials and ensemble elements, if 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 types and material(s)
(8) External fitting types and material(s)
(9) External gasket types and material(s)
(10) Outer garment, glove, or footwear material(s)
(11) Manufacturer and specific model of respirator(s) tested with the ensemble
(12) Type or style of head protection accommodated within the suit

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

5.3.5.4 Descriptions of respective suit materials and components shall include the following information, if applicable:

(1) Visor material; the availability of permanent detachable covers and films
(2) Gloves, as follows:
   (a) Type of linings or surface treatments
   (b)*Available glove sizes and dimensional data for size determination
(3) Footwear, as follows:
   (a) Type of linings or surface treatments
   (b) Type of soles or special toe reinforcements
   (c) Available footwear sizes
(4) Garment closure, 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), type and how used with ensemble

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5.3.5.5 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:

(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

Chapter 6 Design Requirements

6.1 Protective Ensemble Requirements.

6.1.1 Ensembles shall have at least the applicable design requirements specified in this section where inspected by the certification organization as specified in Section 4.3, Inspection and Testing.

6.1.2 Ensembles shall be designed to protect the wearer's upper and lower torso, head, hands, and feet.

6.1.3 Ensembles elements shall include protective garments, protective gloves, and protective footwear.

6.1.4 Ensembles shall be designed to be worn for a single exposure at incidents involving CBRN terrorism agents.

6.1.5 Ensembles shall be permitted to be designed as either encapsulating or non-encapsulating, and shall be so designated on the product label as specified in 5.1.2.1.

6.1.6 Any ensemble certified as Class 2, Class 3, or Class 4 shall be permitted to also be certified to any other or both other class ensembles covered in NFPA 1994.

6.1.7 Ensembles shall be designed to accommodate the respirators specified by the manufacturer for the specific ensemble.

6.1.8 All respirators specified by the ensemble manufacturer for inclusion in Class 2, Class 3, or Class 4 ensembles shall be certified by the National Institute for Occupational Safety and Health (NIOSH) as compliant with the *Statement of Standard for NIOSH CBRN SCBA Testing*, or with the *Statement of Standard for NIOSH CBRN APR Testing*, or with the *Statement of Standard for NIOSH CBRN PAPR Testing*. All respirators shall cover the eyes, nose, and mouth at a minimum.

6.1.8.1 All respirators specified in 6.1.8 for inclusion in Class 2 ensembles shall be CBRN self-contained breathing apparatus.

6.1.8.2 Where the respirator specified in 6.1.8 is an open-circuit SCBA, the SCBA shall also be certified as compliant with NFPA 1981, *Standard on Open-Circuit Self-Contained Breathing Apparatus for Fire and Emergency Services.*

6.2 Garment Element Requirements.

6.2.1 Garments shall have at least the applicable design requirements specified in this section where inspected by the certification organization as specified in Section 4.3, Inspection and Testing.

6.2.2 Garments shall be designed and configured to protect at least the wearer's upper and lower torso, arms, and legs and the head with the respirator.

6.2.3 Garments shall be designed for a single exposure wearing at incidents involving CBRN terrorism agents.

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

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

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

6.3 Glove Element Requirements.

6.3.1 Gloves shall have at least the applicable design requirements specified in this section where inspected by the certification organization as specified in Section 4.3, Inspection and Testing.

6.3.2 Gloves shall provide protection from the fingertips to at least 25 mm (1 in.) beyond the wrist crease.

6.3.3 Gloves shall be designed to be worn for a single exposure at incidents involving CBRN terrorism agents.

6.3.4 In order to label or otherwise represent a glove that meets the requirements of this standard, the manufacturer shall provide gloves in not less than five separate and distinct sizes.

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

6.4 Footwear Element Requirements.

6.4.1 Footwear shall have at least the applicable design requirements specified in this section where inspected by the certification organization as specified in Section 4.3. Inspection and Testing.

6.4.2 Footwear shall provide protection of not less than 200 mm (8 in.) in height when measured from the plane of the sole bottom.

6.4.3 Footwear shall be designed for a single exposure wearing at incidents involving CBRN terrorism agents.

6.4.4 Protective footwear shall be offered in at least six unique and different sizes.

6.4.5 Any metal parts of footwear shall not penetrate from the outside into the lining or insole at any point.

6.4.6 No metal parts of footwear, including but not limited to nails or screws, shall be present or utilized in the construction or attachment of the sole with heel to the puncture-resistant device, insole, or upper.

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

Chapter 7 Performance Requirements

7.1 Class 2 Ensembles.

7.1.1 Class 2 Ensemble General Requirements.

7.1.1.1* Class 2 ensembles shall be tested for overall inward leakage as specified in Section 8.2, Man-In-Simulant Test (MIST), and shall have an average local physiological protective dosage factor ($PPDF_i$) value at each PAD location for the four ensembles tested of no less than 360.0 and a systemic

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physiological protective dosage factor ($PPDF_{sys}$) value for each tested ensemble of no less than 361.0.

7.1.1.2 Class 2 ensembles shall be tested for overall function as specified in Section 8.3, Overall Ensemble Function and Integrity Test, and shall allow the test subject to complete all tasks within 20 minutes, and shall allow no liquid penetration in subsequent liquidtight integrity testing as specified in Section 8.4, Liquidtight Integrity Test 1, and the garment closure shall remain engaged during the entire garment function testing.

7.1.1.2.1 Where hoods are provided, garment shall accommodate head protection devices meeting the dimensional requirements of Type I, Class G helmets of ANSI Z89.1, *Standard on Industrial Head Protection*.

7.1.1.2.2 Where hoods with visors are provided, garments shall permit the test subject to see with a visual acuity of 20/35 or better through the combination of the hood visor and the respirator facepiece lens.

7.1.1.2.3 Where protective flaps cover the closure, the protective flaps shall remain closed for the duration of the overall garment function test.

7.1.1.3 External fittings installed in Class 2 ensembles shall be tested for pull-out strength as specified in Section 8.6, Fitting Pull-Out Strength Test, and shall not have a failure force of less than 1000 N (225 lbf).

7.1.1.4 Exhaust valves installed in Class 2 ensembles shall be tested for mounting strength as specified in Section 8.24, Exhaust Valve Mounting Strength Test, and shall have a failure force greater than 135 N (30 lbf).

7.1.1.5 Exhaust valves installed in Class 2 ensembles shall be tested for inward leakage as specified in Section 8.25, Exhaust Valve Inward Leakage Tests, and shall not exhibit a leakage rate exceeding 30 ml/min (1.83 $in.^3$/min).

7.1.2 Class 2 Garment Element Requirements.

7.1.2.1 Class 2 garment materials and seams shall be tested for permeation resistance as specified in Section 8.7, Chemical Permeation Resistance Test, and shall meet the following performance criteria:

(1) For permeation testing of chemical warfare agent Distilled Mustard (HD), the average cumulative permeation in 1 hour shall not exceed 4.0 μg/cm^2.
(2) For permeation testing of chemical warfare agent Soman (GD), the average cumulative permeation in 1 hour shall not exceed 1.25 μg/cm^2.
(3) For permeation testing of liquid and gaseous industrial chemicals, the average normalized breakthrough time shall be greater than 60 minutes.

7.1.2.2 Class 2 garment materials shall be tested for bursting strength as specified in Section 8.9, Burst Strength Test, and shall have a bursting strength of not less than 156 N (35 lbf).

7.1.2.3 Class 2 garment materials shall be tested for puncture propagation tear resistance as specified in Section 8.10, Puncture Propagation Tear Resistance Test, and shall have a puncture propagation tear resistance of not less than 31 N (7 lbf).

7.1.2.4 Class 2 garment materials shall be tested for cold weather performance as specified in Section 8.11, Cold Temperature Performance Test 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).

7.1.2.5 Class 2 garment seams shall be tested for seam strength as specified in Section 8.12, Seam/Closure Breaking Strength Test, and shall have a breaking strength of not less than 1.31 kN/m (15 lbf/2 in.).

7.1.2.6 Class 2 garment closure assemblies shall be tested for closure strength as specified in Section 8.12, Seam/Closure Breaking Strength Test, and shall have a breaking strength of not less than 1.31 kN/m (15 lbf/2 in.).

7.1.2.7 Class 2 garment materials and seams shall be tested for resistance to liquid or bloodborne pathogens as specified in Section 8.21, Viral Penetration Resistance Test, and shall allow no penetration of the Phi-X-174 bacteriophage for at least 1 hour.

7.1.2.8 Class 2 Garment Visor Requirements.

7.1.2.8.1 Class 2 garment visor materials and seams shall be tested for permeation resistance as specified in Section 8.7, Chemical Permeation Resistance Test, and shall meet the following performance criteria:

(1) For permeation testing of chemical warfare agent Distilled Mustard (HD), the average cumulative permeation in 1 hour shall not exceed 4.0 μg/cm^2.
(2) For permeation testing of chemical warfare agent Soman (GD), the average cumulative permeation in 1 hour shall not exceed 1.25 μg/cm^2.
(3) For permeation testing of liquid and gaseous industrial chemicals, the average normalized breakthrough time shall be greater than 60 minutes.

7.1.2.8.2 Class 2 garment visor materials shall be tested for bursting strength as specified in Section 8.9, Burst Strength Test, and shall have a bursting strength of not less than 156 N (35 lbf).

7.1.2.8.3 Class 2 garment visor materials shall be tested for puncture propagation tear resistance as specified in Section 8.10, Puncture Propagation Tear Resistance Test, and shall have a puncture propagation tear resistance of not less than 36 N (8 lbf).

7.1.2.8.4 Class 2 garment visor materials shall be tested for cold temperature bending at –25°C (–13°F) as specified in Section 8.13, Cold Temperature Performance Test 2, and shall not crack or show evidence of visible damage.

7.1.2.8.5 Class 2 garment visor material seams shall be tested for seam strength as specified in Section 8.12, Seam/Closure Breaking Strength Test, and shall have a breaking strength of not less than 1.31 kN/m (15 lbf/2 in.).

7.1.2.8.6 Class 2 garment visor materials shall be tested for resistance to liquid or bloodborne pathogens as specified in Section 8.21, Viral Penetration Resistance Test, and shall allow no penetration of the Phi-X-174 bacteriophage for at least 1 hour.

7.1.3 Class 2 Glove Element Requirements.

7.1.3.1 Class 2 gloves shall be tested for liquidtight integrity as specified in Section 8.22, Liquidtight Integrity Test 2, and shall show no leakage.

7.1.3.2 Class 2 glove materials and seams shall be tested for permeation resistance as specified in Section 8.7, Chemical

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Permeation Resistance Test, and shall meet the following performance criteria:

(1) For permeation testing of chemical warfare agent Distilled Mustard (HD), the average cumulative permeation in 1 hour shall not exceed 4.0 μg/cm^2.
(2) For permeation testing of chemical warfare agent Soman (GD), the average cumulative permeation in 1 hour shall not exceed 1.25 μg/cm^2.
(3) For permeation testing of liquid and gaseous industrial chemicals, the average normalized breakthrough time shall be greater than 60 minutes.

7.1.3.3 Class 2 glove materials shall be tested for cut resistance as specified in Section 8.14, Cut Resistance Test, and shall have the distance of blade travel not be less than 25 mm (1 in.).

7.1.3.4 Class 2 glove materials shall be tested for puncture resistance as specified in Section 8.15, Puncture Resistance Test 1, and shall have a puncture resistance of not less than 15 N (3.8 lbf).

7.1.3.5 Class 2 glove materials shall be tested for cold weather performance as specified in Section 8.11, Cold Temperature Performance Test 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 Class 2 gloves shall be tested for hand function as specified in Section 8.16, Glove Hand Function Test, and shall have an average percent increase over barehanded control less than 300 percent.

7.1.3.7 Class 2 glove materials and seams shall be tested for resistance to liquid or bloodborne pathogens as specified in Section 8.21, Viral Penetration Resistance Test, and shall allow no penetration of the Phi-X-174 bacteriophage for at least 1 hour.

7.1.4 Class 2 Footwear Element Requirements.

7.1.4.1 Class 2 footwear shall be tested for liquidtight integrity as specified in Section 8.22, Liquidtight Integrity Test 2, and shall show no leakage.

7.1.4.2 Class 2 footwear upper material and sole shall be tested for permeation resistance as specified in Section 8.7, Chemical Permeation Resistance Test, and shall meet the following performance criteria:

(1) For permeation testing of chemical warfare agent Distilled Mustard (HD), the average cumulative permeation in 1 hour shall not exceed 4.0 μg/cm^2.
(2) For permeation testing of chemical warfare agent Soman (GD), the average cumulative permeation in 1 hour shall not exceed 1.25 μg/cm^2.
(3) For permeation testing of liquid and gaseous industrial chemicals, the average normalized breakthrough time shall be greater than 60 minutes.

7.1.4.3 Class 2 footwear upper materials shall be tested for cut resistance as specified in Section 8.14, Cut Resistance Test, and shall have the distance of blade travel not be less than 25 mm (1 in.).

7.1.4.4 Class 2 footwear upper materials shall be tested for puncture resistance as specified in Section 8.15, Puncture Resistance Test 1, and shall have a puncture resistance of not less than 36 N (8 lbf).

7.1.4.5 Class 2 footwear soles and heels shall be tested for abrasion resistance as specified in Section 8.17, Abrasion Resistance Test 1, and have an abrasion-resistance rating of not less than 65.

7.1.4.6 Class 2 footwear soles shall be tested for slip resistance as specified in Section 8.19, Slip Resistance Test, and shall have a static coefficient of 0.75 or greater.

7.1.4.7 Class 2 footwear upper material shall be tested for resistance to liquid or bloodborne pathogens as specified in Section 8.21, Viral Penetration Resistance Test, and shall allow no penetration of the Phi-X-174 bacteriophage for at least 1 hour.

7.1.4.8 Where the manufacturer specifies the use of a footwear cover to be worn over standard footwear, Class 2 footwear covers shall meet the requirements specified in 7.1.4.1, 7.1.4.2, 7.1.4.3, 7.1.4.4, 7.1.4.6, and 7.1.4.7, excluding 7.1.4.5.

7.1.4.9 Where the manufacturer specifies the use of a footwear cover to be worn over standard footwear, Class 2 footwear covers shall be tested for abrasion resistance as specified in Section 8.23, Abrasion Resistance Test 2, and shall show no wear through 3000 cycles.

7.2 Class 3 Ensembles.

7.2.1 Class 3 Ensemble General Requirements.

7.2.1.1* Class 3 ensembles shall be tested for overall inward leakage as specified in Section 8.2, Man-In-Simulant Test (MIST), and shall have an average local physiological protective dosage factor ($PPDF_i$) value at each PAD location for the four ensembles tested of no less than 120.0 and a systemic physiological protective dosage factor ($PPDF_{sys}$) value for each tested ensemble of no less than 76.0.

7.2.1.2 Class 3 Ensembles shall be tested for overall function as specified in Section 8.3, Overall Ensemble Function and Integrity Test, and shall allow the test subject to complete all tasks within 20 minutes, and shall allow no liquid penetration in subsequent liquidtight integrity testing as specified in Section 8.4, Liquidtight Integrity Test 1, and the garment closure shall remain engaged during the entire garment function testing.

7.2.1.2.1 Where hoods are provided, garment shall accommodate head protection devices meeting the dimensional requirements of Type I, Class G helmets of ANSI Z89.1, *Standard on Industrial Head Protection.*

7.2.1.2.2 Where hoods with visors are provided, garments shall permit the test subject to see with a visual acuity of 20/35 or better through the combination of the hood visor and the respirator facepiece lens.

7.2.1.2.3 Where protective flaps cover the closure, the protective flaps shall remain closed for the duration of the overall garment function test.

7.2.1.3 External fittings installed in Class 3 ensembles shall be tested for pull-out strength as specified in Section 8.6, Fitting Pull-Out Strength Test, and shall not have a failure force of less than 1000 N (225 lbf).

7.2.1.4 Exhaust valves installed in Class 3 ensembles shall be tested for mounting strength as specified in Section 8.24, Exhaust Valve Mounting Strength Test, and shall have a failure force greater than 135 N (30 lbf).

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7.2.1.5 Exhaust valves installed in Class 3 ensembles shall be tested for inward leakage as specified in Section 8.25, Exhaust Valve Inward Leakage Tests, and shall not exhibit a leakage rating exceeding 30 ml/min (1.83 $in.^3$/min).

7.2.2 Class 3 Garment Element Requirements.

7.2.2.1 Class 3 garment materials and seams shall be tested for permeation resistance as specified in Section 8.7, Chemical Permeation Resistance Test, and shall meet the following performance criteria:

(1) For permeation testing of chemical warfare agent Distilled Mustard (HD), the average cumulative permeation in 1 hour shall not exceed 4.0 $\mu g/cm^2$.
(2) For permeation testing of chemical warfare agent Soman (GD), the average cumulative permeation in 1 hour shall not exceed 1.25 $\mu g/cm^2$.
(3) For permeation testing of liquid and gaseous industrial chemicals, the average normalized breakthrough time shall be greater than 60 minutes.

7.2.2.2 Class 3 garment materials and seams shall be tested for resistance to liquid or bloodborne pathogens as specified in Section 8.21, Viral Penetration Resistance Test, and shall allow no penetration of the Phi-X-174 bacteriophage for at least 1 hour.

7.2.2.3 Class 3 garment materials shall be tested for bursting strength as specified in Section 8.9, Burst Strength Test, and shall have a bursting strength of not less than 135 N (30 lbf).

7.2.2.4 Class 3 garment materials shall be tested for puncture propagation tear resistance as specified in Section 8.10, Puncture Propagation Tear Resistance Test, and shall have a puncture propagation tear resistance of not less than 25 N (5⅝ lbf).

7.2.2.5 Class 3 garment materials shall be tested for cold weather performance as specified in Section 8.11, Cold Temperature Performance Test 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).

7.2.2.6 Class 3 garment materials shall be tested for evaporative heat transfer as specified in Section 8.8, Total Heat Loss Test, and shall have a total heat loss of not less than 200 W/m^2.

7.2.2.7 Class 3 garment seams shall be tested for seam strength as specified in Section 8.12, Seam/Closure Breaking Strength Test, and shall have a breaking strength of not less than 1.31 kN/m (15 lbf/2 in.).

7.2.2.8 Class 3 garment closure assemblies shall be tested for closure strength as specified in Section 8.12, Seam/Closure Breaking Strength Test, and shall have a breaking strength of not less than 1.31 kN/m (15 lbf/2 in.).

7.2.2.9 Class 3 Garment Visor Requirements.

7.2.2.9.1 Class 3 garment visor materials and seams shall be tested for permeation resistance as specified in Section 8.7, Chemical Permeation Resistance Test, and shall meet the following performance criteria:

(1) For permeation testing of chemical warfare agent Distilled Mustard (HD), the average cumulative permeation in 1 hour shall not exceed 4.0 $\mu g/cm^2$.
(2) For permeation testing of chemical warfare agent Soman (GD), the average cumulative permeation in 1 hour shall not exceed 1.25 $\mu g/cm^2$.
(3) For permeation testing of liquid and gaseous industrial chemicals, the average normalized breakthrough time shall be greater than 60 minutes.

7.2.2.9.2 Class 3 garment visor materials shall be tested for bursting strength as specified in Section 8.9, Burst Strength Test, and shall have a bursting strength of not less than 135 N (30 lbf).

7.2.2.9.3 Class 3 garment visor materials shall be tested for puncture propagation tear resistance as specified in Section 8.10, Puncture Propagation Tear Resistance Test, and shall have a puncture propagation tear resistance of not less than 25 N (5⅝ lbf).

7.2.2.9.4 Class 3 garment visor materials shall be tested for cold temperature bending at –25°C (–13°F) as specified in Section 8.13, Cold Temperature Performance Test 2, and shall not crack or show evidence of visible damage.

7.2.2.9.5 Class 3 garment visor material seams shall be tested for seam strength as specified in Section 8.12, Seam/Closure Breaking Strength Test, and shall have a breaking strength of not less than 1.31 kN/m (15 lbf/2 in.).

7.2.3 Class 3 Glove Element Requirements.

7.2.3.1 Class 3 gloves shall be tested for liquidtight integrity as specified in Section 8.22, Liquidtight Integrity Test 2, and shall show no leakage.

7.2.3.2 Class 3 glove material and seams shall be tested for permeation resistance as specified in Section 8.7, Chemical Permeation Resistance Test, and shall meet the following performance criteria:

(1) For permeation testing of chemical warfare agent Distilled Mustard (HD), the average cumulative permeation in 1 hour shall not exceed 4.0 $\mu g/cm^2$.
(2) For permeation testing of chemical warfare agent Soman (GD), the average cumulative permeation in 1 hour shall not exceed 1.25 $\mu g/cm^2$.
(3) For permeation testing of liquid and gaseous industrial chemicals, the average normalized breakthrough time shall be greater than 60 minutes.

7.2.3.3 Class 3 glove materials and seams shall be tested for resistance to liquid or bloodborne pathogens as specified in Section 8.21, Viral Penetration Resistance Test, and shall allow no penetration of the Phi-X-174 bacteriophage for at least 1 hour.

7.2.3.4 Class 3 glove materials shall be tested for cut resistance as specified in Section 8.14, Cut Resistance Test, and shall have the distance of blade travel be not less than 25 mm (1 in.).

7.2.3.5 Class 3 glove materials shall be tested for puncture resistance as specified in Section 8.15, Puncture Resistance Test 1, and shall have a puncture resistance of not less than 19 N (2.5 lbf).

7.2.3.6 Class 3 glove materials shall be tested for cold weather performance as specified in Section 8.11, Cold Temperature Performance Test 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).

7.2.3.7 Class 3 gloves shall be tested for hand function as specified in Section 8.16, Glove Hand Function Test, and shall

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have an average percent increase over barehanded control less than 200 percent.

7.2.4 Class 3 Footwear Element Requirements.

7.2.4.1 Class 3 footwear shall be tested for liquidtight integrity as specified in Section 8.22, Liquidtight Integrity Test 2, and shall show no leakage.

7.2.4.2 Class 3 footwear upper material and sole shall be tested for permeation resistance as specified in Section 8.7, Chemical Permeation Resistance Test, and shall meet the following performance criteria:

(1) For permeation testing of chemical warfare agent Distilled Mustard (HD), the average cumulative permeation in 1 hour shall not exceed 4.0 $\mu g/cm^2$.
(2) For permeation testing of chemical warfare agent Soman (GD), the average cumulative permeation in 1 hour shall not exceed 1.25 $\mu g/cm^2$.
(3) For permeation testing of liquid and gaseous industrial chemicals, the average normalized breakthrough time shall be greater than 60 minutes.

7.2.4.3 Class 3 footwear upper materials and seams shall be tested for resistance to liquid or bloodborne pathogens as specified in Section 8.21, Viral Penetration Resistance Test, and shall allow no penetration of the Phi-X-174 bacteriophage for at least 1 hour.

7.2.4.4 Class 3 footwear upper materials shall be tested for cut resistance as specified in Section 8.14, Cut Resistance Test, and shall have the distance of blade travel not be less than 25 mm (1 in.).

7.2.4.5 Class 3 footwear upper materials shall be tested for puncture resistance as specified in Section 8.15, Puncture Resistance Test 1, and shall have a puncture resistance of not less than 36 N (8 lbf).

7.2.4.6 Class 3 footwear soles and heels shall be tested for abrasion resistance as specified in Section 8.17, Abrasion Resistance Test 1, and have an abrasion resistance rating of not less than 65.

7.2.4.7 Class 3 footwear soles shall be tested for slip resistance as specified in Section 8.19, Slip Resistance Test, and shall have a static coefficient of 0.75 or greater.

7.2.4.8 Where the manufacturer specifies the use of a footwear cover to be worn over standard footwear, Class 3 footwear covers shall meet the requirements specified in 7.2.4.1, 7.2.4.2, 7.2.4.3, 7.2.4.4, 7.2.4.5, and 7.2.4.7, excluding 7.2.4.6.

7.2.4.9 Where the manufacturer specifies the use of a footwear cover to be worn over standard footwear, Class 3 footwear covers shall be tested for abrasion resistance as specified in Section 8.23, Abrasion Resistance Test 2, and shall show no wear-through after 3000 cycles.

7.3 Class 4 Ensembles.

7.3.1 Class 4 Ensemble General Requirements.

7.3.1.1 Class 4 ensembles shall be tested for overall particulate inward leakage as specified in Section 8.5, Particle Inward Leakage Test, and shall allow no visual particulate inward leakage demonstrating an average total inward leakage of 5 percent or less.

7.3.1.2 Class 4 ensembles shall be tested for overall function as specified in Section 8.3, Overall Ensemble Function and Integrity Test, and shall allow the test subject to complete all tasks within 15 minutes, and the garment closure shall remain engaged during the entire garment function testing.

7.3.1.2.1 Where hoods are provided, garment shall accommodate head protection devices meeting the dimensional requirements of Type I, Class G helmets of ANSI Z89.1, *Standard on Industrial Head Protection.*

7.3.1.2.2 Where hoods with visors are provided, garments shall permit the test subject to see with a visual acuity of 20/35 or better through the combination of the hood visor and the respirator facepiece lens.

7.3.1.2.3 Where protective flaps cover the closure, the protective flaps shall remain closed for the duration of the overall garment function test.

7.3.1.3 External fittings installed in Class 4 ensembles shall be tested for pull-out strength as specified in Section 8.6, Fitting Pull-Out Strength Test, and shall not have a failure force of less than 1000 N (225 lbf).

7.3.1.4 Exhaust valves installed in Class 4 ensembles shall be tested for mounting strength as specified in Section 8.24, Exhaust Valve Mounting Strength Test, and shall have a failure force greater than 135 N (30 lbf).

7.3.1.5 Exhaust valves installed in Class 4 ensembles shall be tested for inward leakage as specified in Section 8.25, Exhaust Valve Inward Leakage Test, and shall not exhibit a leakage rating exceeding 30 ml/min (1.83 $in.^3$/min).

7.3.2 Class 4 Garment Element Requirements.

7.3.2.1 Class 4 garment materials and seams shall be tested for resistance to liquid or bloodborne pathogens as specified in Section 8.21, Viral Penetration Resistance Test, and shall allow no penetration of the Phi-X-174 bacteriophage for at least 1 hour.

7.3.2.2 Class 4 garment materials shall be tested for bursting strength as specified in Section 8.9, Burst Strength Test, and shall have a bursting strength of not less than 135 N (30 lbf).

7.3.2.3 Class 4 garment materials shall be tested for puncture propagation tear resistance as specified in Section 8.10, Puncture Propagation Tear Resistance Test, and shall have a puncture propagation tear resistance of not less than 25 N (5⅗ lbf).

7.3.2.4 Class 4 garment materials shall be tested for cold weather performance as specified in Section 8.11, Cold Temperature Performance Test 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).

7.3.2.5 Class 4 garment materials shall be tested for evaporative heat transfer as specified in Section 8.8, Total Heat Loss Test, and shall have a total heat loss of not less than 450 W/m^2.

7.3.2.6 Class 4 garment seams shall be tested for seam strength as specified in Section 8.12, Seam/Closure Breaking Strength Test, and shall have a breaking strength of not less than 1.31 kN/m (15 lbf/2 in.).

7.3.2.7 Class 4 garment closure assemblies shall be tested for closure strength as specified in Section 8.12, Seam/Closure Breaking Strength Test, and shall have a breaking strength of not less than 1.31 kN/m (15 lbf/2 in.).

7.3.2.8 Class 4 Garment Visor Requirements.

7.3.2.8.1 Class 4 garment visor materials shall be tested for resistance to liquid or bloodborne pathogens as specified in

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Section 8.21, Viral Penetration Resistance Test, and shall allow no penetration of the Phi-X-174 bacteriophage for at least 1 hour.

7.3.2.8.2 Class 4 garment visor materials shall be tested for bursting strength as specified in Section 8.9, Burst Strength Test, and shall have a bursting strength of not less than 135 N (30 lbf).

7.3.2.8.3 Class 4 garment visor materials shall be tested for puncture propagation tear resistance as specified in Section 8.10, Puncture Propagation Tear Resistance Test, and shall have a puncture propagation tear resistance of not less than 25 N (5⅗ lbf).

7.3.2.8.4 Class 4 garment visor materials shall be tested for cold temperature bending at −25°C (−13°F) as specified in Section 8.13, Cold Temperature Performance Test 2, and shall not crack or show evidence of visible damage.

7.3.2.8.5 Class 4 garment visor material seams shall be tested for seam strength as specified in Section 8.12, Seam/Closure Breaking Strength Test, and shall have a breaking strength of not less than 1.31 kN/m (15 lbf/2 in.).

7.3.3 Class 4 Glove Element Requirements.

7.3.3.1 Class 4 gloves shall be tested for liquidtight integrity as specified in Section 8.22, Liquidtight Integrity Test 2, and shall show no leakage.

7.3.3.2 Class 4 glove materials and seams shall be tested for resistance to liquid or bloodborne pathogens as specified in Section 8.21, Viral Penetration Resistance Test, and shall allow no penetration of the Phi-X-174 bacteriophage for at least 1 hour.

7.3.3.3 Class 4 glove materials shall be tested for cut resistance as specified in Section 8.14, Cut Resistance Test, and shall have the distance of blade travel be not less than 25 mm (1 in.).

7.3.3.4 Class 4 glove materials shall be tested for puncture resistance as specified in Section 8.15, Puncture Resistance Test 1, and shall have a puncture resistance of not less than 19 N (2.5 lbf).

7.3.3.5 Class 4 glove materials shall be tested for cold weather performance as specified in Section 8.11, Cold Temperature Performance Test 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).

7.3.3.6 Class 4 gloves shall be tested for hand function as specified in Section 8.16, Glove Hand Function Test, and shall have an average percent increase over barehanded control less than 200 percent.

7.3.4 Class 4 Footwear Element Requirements.

7.3.4.1 Class 4 footwear shall be tested for liquidtight integrity as specified in Section 8.22, Liquidtight Integrity Test 2, and shall show no leakage.

7.3.4.2 Class 4 footwear upper material shall be tested for resistance to liquid or bloodborne pathogens as specified in Section 8.21, Viral Penetration Resistance Test, and shall allow no penetration of the Phi-X-174 bacteriophage for at least 1 hour.

7.3.4.3 Class 4 footwear upper materials shall be tested for cut resistance as specified in Section 8.14, Cut Resistance Test, and shall have the distance of blade travel be not less than 25 mm (1 in.).

7.3.4.4 Class 4 footwear upper materials shall be tested for puncture resistance as specified in Section 8.15, Puncture Resistance Test 1, and shall have a puncture resistance of not less than 36 N (8 lbf).

7.3.4.5 Class 4 footwear soles and heels shall be tested for abrasion resistance as specified in Section 8.17, Abrasion Resistance Test 1, and have an abrasion resistance rating of not less than 65.

7.3.4.6 Class 4 footwear soles shall be tested for slip resistance as specified in Section 8.19, Slip Resistance Test, and shall have a static coefficient of 0.75 or greater.

7.3.4.7 Where the manufacturer specifies the use of a footwear cover to be worn over standard footwear, Class 4 footwear covers shall meet the requirements specified in 7.3.4.1, 7.3.4.2, 7.3.4.3, 7.3.4.4, 7.3.4.6, and 7.3.4.8, excluding 7.3.4.5.

7.3.4.8 Where the manufacturer specifies the use of a footwear cover to be worn over standard footwear, Class 4 footwear covers shall be tested for abrasion resistance as specified in Section 8.23, Abrasion Resistance Test 2, and shall show no wear-through after 3000 cycles.

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 or procedures referenced in the sample preparation section of each test method shall be applied to that test method.

8.1.2 Room Temperature Conditioning Procedure for Garments, Gloves, Footwear, Garment Materials, Visor Materials, Glove Materials, Footwear Materials, Seams, and Closures.

8.1.2.1 Specimens 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 D 1776, *Standard Practice for Conditioning and Testing Textiles*, or for at least 24 hours, whichever is shortest.

8.1.2.2 Specimens shall be tested within 5 minutes after removal from conditioning.

8.1.3 Flexural Fatigue Procedure for Garment Materials. Specimens shall be subjected to flexural fatigue in accordance with ASTM F 392, *Standard Test Method for Flex Durability of Flexible Barrier Materials*, with the following modifications:

(1) In lieu of Flexing Conditions A, B, C, D, or E, test specimens shall have a flex period of 100 cycles at 45 cycles per minute. A cycle shall be full flex and twisting action.
(2) Anisotropic materials shall be tested in both machine and transverse directions.
(3) All layers of garment material in the ensemble shall be present during flex conditioning.

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8.1.4 Abrasion Procedure for Element Materials. Specimens shall be abraded in accordance with ASTM D 4157, *Standard Test Method for Abrasion Resistance of Textile Fabrics (Oscillatory Cylinder Method)*, under the following conditions and with the following modifications:

(1) A 2.3 kg (5 lb) tension weight shall be used.
(2) A 1.6 kg (3.5 lb) head weight shall be used.
(3) Silicon carbide, ultrafine, 600 grit sandpaper shall be used as the abradant.
(4) The specimen shall be as shown in Figure 8.1.4.
(5) The specimen shall be abraded for 10 continuous cycles.
(6) All layers of the element material shall be subjected to the abrasion conditioning.

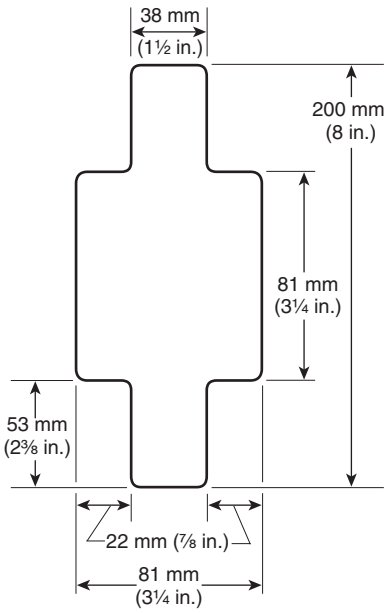

FIGURE 8.1.4 Specimen Configuration.

8.1.5 Flexural Fatigue Procedure for Gloves.

8.1.5.1 Specimen gloves shall be subjected to one full cycle of testing for hand function as specified in Section 8.16, Glove Hand Function Test.

8.1.5.2 All layers of glove material shall be present during flex conditioning.

8.1.6 Flexural Fatigue Procedure for Footwear. Specimen footwear shall be subjected to 10,000 flexes in accordance with FIA 1209, *Whole Shoe Flex*.

8.1.7 Fatigue Procedure for Suit Closure Assemblies. Specimen suit closure assemblies shall be exercised a total of 50 openings and 50 closings.

8.1.8 Elevated Humidity Conditioning Procedure for Garment, Glove, Footwear Seam, Closure, and Visor Materials. Specimens for elevated humidity shall be conditioned at 21°C ±3°C (70°F ±5°F) and a relative humidity of 80 percent ±5 percent until equilibrium is reached, as specified in ASTM D 1776, *Standard Practice for Conditioning and Testing Textiles*, or for at least 24 hours, whichever is shortest.

8.2 Man-In-Simulant Test (MIST).

8.2.1 Application. This test shall apply to Class 2 and Class 3 ensembles.

8.2.2 Samples.

8.2.2.1 Samples for conditioning shall be complete ensembles and shall include the respirator where the ensemble utilizes the respirator facepiece as the ensemble visor.

8.2.2.2 Samples shall be conditioned as specified in 8.1.2.

8.2.3 Specimens.

8.2.3.1 The specimen shall be a complete ensemble with gloves and footwear and shall include the respirator where applicable.

8.2.3.2 Where the ensemble utilizes the respirator facepiece as the ensemble visor, as specified in 6.1.8, the ensemble shall be tested with each type or model of the respirator specified by the manufacturer.

8.2.3.3 Where the respirator is completely encapsulated by the ensemble, the ensemble shall be tested with a respirator specified by the manufacturer.

8.2.3.4 A minimum of four specimens shall be tested. The specimens shall represent a minimum of two different ensemble sizes.

8.2.3.5 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.

8.2.3.6 Specimens shall be provided to fit or be adjustable to fit the selected test subjects in accordance with the manufacturer's sizing provisions that are specific to each ensemble.

8.2.3.7* None of the ensembles or components of the ensemble to be tested shall have been previously subjected to MIST testing unless it can be demonstrated that the ensemble or components are free of contamination.

8.2.3.8 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.

8.2.4 Apparatus.

8.2.4.1 The test lab chamber and procedures shall be validated against the Test Operations Procedure (TOP 10-2-022), Man-In-Simulant Test (MIST) — Chemical Vapor Testing of Chemical/Biological Protective Suits.

8.2.4.2 The test simulant shall be methyl salicylate (MS; $C_8H_8O_8$), CAS #119-36-8, more commonly known as oil of wintergreen. The MS minimum purity shall be 95 percent. Vapor doses shall be measured using passive adsorbent dosimeters (PADs).

8.2.4.3 The test facility shall include areas for dressing, 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.

8.2.4.4 The test shall be conducted in a sealed chamber with a minimum volume of sufficient dimensions to permit free movement of the test subject(s) when fully dressed in the ensemble.

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8.2.4.5 More than one test subject shall be permitted in the chamber at the same time, provided that they can complete all tasks completely in the appropriate time period and that they have an unobstructed direct path to the wind stream.

8.2.4.6 The test chamber shall have a temperature of 25°C ±3°C, relative humidity of 55 ±10 percent, and a nominal wind speed of 0.9–2.2 m/s, (2–5 mph). The average wind speed shall be 1.6 m/s, ±0.2 m/s (3.5 mph, ±0.5 mph).

8.2.4.7* The standard concentration of MS in the vapor chamber shall be 100 ±5 mg/m^3, as measured by a real-time infrared analysis of the chamber air.

8.2.4.8 Infrared readings shall be taken every 60 sec to verify compliance with the concentration requirement, and an air sample shall be taken at least every 10 min for validation of infrared readings.

8.2.4.9 Every step shall be taken to avoid generation of liquid aerosol.

8.2.4.10 For the test, a minimum of four PADs shall be placed inside the chamber at defined positions for a known duration.

8.2.4.10.1 PADs shall be the item that is placed on skin of human test subject and in different chamber locations.

8.2.4.10.2 The PADs placed inside the test chamber shall be from the same lot as the dosimeters worn by the test subject and shall be used to calibrate the PAD lot used in the analysis.

8.2.4.11 The exposure time for the chamber PADs shall be 15 min, +5 min/−0 min in length.

8.2.4.12 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.

8.2.4.13 Test subjects shall be familiar with the use of chemical protective ensembles and with the selected respirator.

8.2.4.14 The test shall be conducted using PADs that affix directly to the skin of the test subjects. The PAD used in ensemble certification shall be the same type of dosimeter that was used during the validation of the MIST test lab. The PAD shall be an adhesive-backed foil packet, measuring 25 mm × 35 mm × 0.02 mm, that contains an adsorbent material covered by a high-density polyethylene film that acts as a pseudo-skin barrier. The active surface sampling area of a PAD shall be 3.5 cm^2, ±0.6 cm^2, and its uptake rate shall be 3.5 cm/s, ±1.0 cm/s. The four chamber PADs shall be used to calibrate the lot of PADs used in the test.

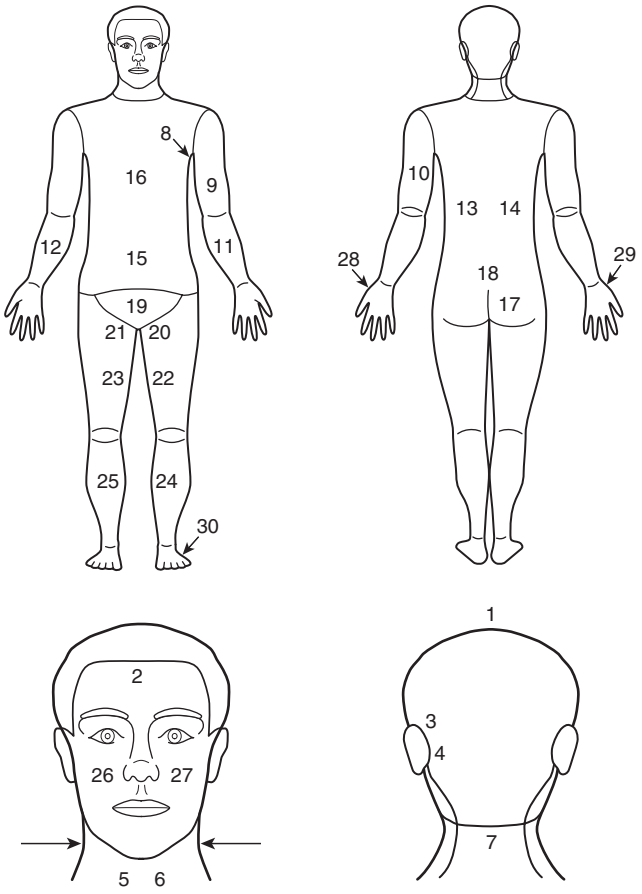
8.2.5 Procedure.

8.2.5.1 Test subjects shall have followed pre-trial procedures that include proper hydration and avoiding personal hygiene products that could contain MS.

8.2.5.2 PADs shall be placed on test subjects at the body region locations shown in Figure 8.2.5.2.

8.2.5.2.1 All PADs shall be applied in a clean dressing area, by personnel who have followed pre-trial procedures to minimize contamination. Test subjects shall also follow pre-trial procedures to minimize contamination.

8.2.5.2.2 Cheek PADs shall be located entirely within the respirator facepiece, and all other PADs shall be located entirely outside the seal of the respirator facepiece.



1: scalp (SCA)
2: forehead (F)
3: behind left ear upper (LED)
4: behind left ear (LE)
5: neck right (NED)
6: neck left (NE)
7: nape (NA)
8: left armpit (LA)
9: left inner upper arm (LIU)
10: left outer upper arm (LOU)
11: left forearm (LFA)
12: right forearm (RFA)
13: middle back (MB)
14: middle back dup. (MBD)
15: abdomen (AB)
16: chest (C)
17: right buttock (RB)
18: lower back (LB)
19: groin (GR)
20: crotch (LCR)
21: crotch (RCR)
22: left inner thigh (LIT)
23: right inner thigh (RIT)
24: left inner shin (LIS)
25: right inner shin (RIS)
26: cheek (RM)
27: cheek (LM)
28: left hand (G)
29: right hand (GD)
30: foot (B)

FIGURE 8.2.5.2 Locations of Passive Adsorption Dosimeters (PADs) on Test Subjects.

8.2.5.3 Three additional PADs shall be used to conduct background sampling and for quality control during the trial. These PADs shall be located in the dressing area, the Stage 1 undress area, and the Stage 2 undress area.

8.2.5.4 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

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are specified or required by the manufacturer as part of the certified ensemble, the test subject shall wear a short-sleeve cotton shirt and shorts or underwear.

8.2.5.5 After sealing the ensemble, the test subject shall enter the test chamber, and the test chamber shall be sealed.

8.2.5.6 The test duration will be 30 minutes in the chamber with a 5-minute decontamination period.

8.2.5.7 The start of the test, in which the test subject enters the MIST chamber, shall be initiated within 60 minutes after removal of the ensemble from the conditioning environment.

8.2.5.8 Physical Exercise Routine.

8.2.5.8.1 Once the chamber concentration has been established, the test subject(s) shall perform the following physical activity protocol. The chamber concentration shall remain within acceptable limits during the exercise protocol.

(1) Drag 70 kg (154 lbs) human dummy using both hands a distance of 10 m (33 ft) over 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) for 1 minute.
(10) Sit on stool (back to wind) for 1 minute.

8.2.5.8.2 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.

8.2.5.8.3 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.

8.2.5.8.4 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 period for that exercise has ended.

8.2.5.8.5 For activities 7 (walking in place) and 8 (crawling in place), the test subject shall rotate 90 degrees on 15-second intervals during the 1-minute period.

8.2.5.8.6 All physical activities shall be a full range of motion and performed at a moderate speed.

8.2.5.9 Decontamination and Doffing.

8.2.5.9.1 After completion of the 30-minute MIST exposure, the subjects shall move to a decontamination area, where they shall remain for at least 5 minutes. This area shall be well-ventilated to assist in off-gassing of the outside of the ensemble. At this point, all exposed ensemble surfaces, including such items as the respirator, boots, gloves, and helmets, shall be washed with a strong soap solution. If the garment is designed for wet decontamination, it shall be washed with the soap solution as well.

8.2.5.9.2 The participant shall move to the first stage undressing room where all remaining items of clothing, except for underclothes, shall be doffed. The undress process shall not exceed 5 minutes.

8.2.5.9.3 The participant shall proceed to the second stage undressing room, where the PADs shall be removed.

8.2.5.9.4* Each PAD shall be backed with aluminum foil, placed in individual sealed glass vials with a non-adsorbent lid liner, and stored in a refrigerated environment [4°C (39°F)] and shall not be removed from the environment for more than 15 minutes before processing.

8.2.6 Analysis.

8.2.6.1 The sensitivity of the analytical technique shall provide for a detection limit of 3 mg·min/m^3 (approximately 30 ng MS per PAD). The analytical technique shall be linear up to at least a dose of 2000 mg·min/m^3, with a coefficient of variation on replicate spiked dosimeter samples of less than 15 percent.

8.2.6.2 Processing of the PAD samples shall be performed within 24 hours of exposure. If liquid extraction of the PAD samples is performed, samples shall be permitted to be stored at 4°C (39°F) for up to 7 days before analysis.

8.2.6.3 Each lot of PADs used for testing shall be calibrated to determine its uptake rate. PADs shall be calibrated by placing at least four PADs from each representative lot within the chamber for 30 minutes, +5 min/–0 min during the MIST. The chamber PAD exposure time shall be set such that the PAD dosage does not exceed the linear range of the analytical technique. The average of the chamber vapor concentration and the actual time of exposure shall be used to determine the uptake rate from the following equation:

$$m = uACt$$

where:
m = the total mass measured on the PAD in mg
u = the uptake rate in cm^3/min
A = the average active area of the PAD in cm^2
Ct = the chamber vapor dosage in mg·min/cm^3

8.2.6.4 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 the

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four replicates for any particular region) shall be permitted to be lost to analysis over the course of the four test subjects.

8.2.7 Calculations.

8.2.7.1 The arithmetic mean for the calibrated uptake rate shall be used to calculate the dosage measured by each PAD $\left(Ct_{inside_i}\right)$ from the same equation based on the measured mass taken up by the PAD. Finally, the protection factor at each PAD location i inside the ensemble shall be calculated using the following equation:

$$PF_i = \frac{Ct_{outside}}{Ct_{inside_i}}$$

where:

$Ct_{outside}$ = the measured chamber vapor dosage of the individual trial over the entire exposure

Ct_{inside_i} = the average of the chamber MS concentration readings taken during the course of the test subject exposure period

8.2.7.2 All results for each PAD location shall be expressed in terms of the local physiological protective dosage factor (PPDF) value and shall be calculated according to the following equation:

$$local\ PPDF_i = \frac{OSED_i}{25} PF_i$$

8.2.7.2.1* The site-specific onset of symptoms exposure dosages (OSED) for each PAD shall be based on ECt_{10} values for mustard blistering/ulceration according to Table 8.2.7.2.1.

Table 8.2.7.2.1 Site-Specific Onset of Symptoms Exposure Dosage (OSED) by PAD Location

Body Region	PAD locations	OSED ($mg \cdot min \cdot m^{-3}$)
Head/neck	1, 1A, 2, 3, 4, 5, 6, 19, 19A	100
Torso/buttocks (excluding perineum)	11, 12, 13, 13A, 14, 14A, 15	100
Arm/hand	7, 8, 9, 10, 10A, 20, 20A	50
Leg/foot	17, 17A, 18, 18A, 21	100
Perineum	16, 16A	25

8.2.7.2.2 The average local PPDF values at each PAD location for all specimens tested shall be calculated.

8.2.7.3 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 Defence Research Establishment Suffield Report and National Research Council Report listed in 2.3.7 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 8.2.7.3:

$$PPDF_{sys} = \frac{\sum_i \frac{dz_i}{ED_{50_i}}}{\sum_i \frac{dz_i}{ED_{50_i} PF_i}}$$

8.2.7.3.1 The average systemic PPDF for all specimens tested shall be calculated and reported.

8.2.8 Report.

8.2.8.1 The average local physiological protective dosage factor ($PPDF_i$) values for each PAD location shall be recorded and reported.

8.2.8.2 The systemic physiological protective dosage factor ($PPDF_{sys}$) value for each specimen and the average $PPDF_{sys}$ value for the ensemble tested shall be recorded and reported.

Table 8.2.7.3 ED_{50_i} Values by PAD and Body Location

Body Region i for BRHA Model	PADs Mapped to This Region (average dosage from each PAD, and then calculate PF_i)	Area of Body Region (dz_i, cm^2)	ED_{50_i} for Severe Effects (VX) for Body Region (mg/individual)
Scalp	1,1A	350	0.76
Ears	2,3	50	0.46
Face, cheeks and neck	4,5,19,19A	300	0.48
Chin and neck	4,5	200	0.36
Nape	6	100	1.72
Abdomen	13A	2858	2.23
Back	11,12,14A	2540	2.65
Axillae	7	200	2.07
Upper arm medial	8	488	2.8
Upper arm lateral	9	706	6.57
Elbow fold	8,9,10,10A	50	2.09
Elbow	8,9,10,10A	50	2.25
Forearm extensor	10,10A	487	2.8
Forearm flexor	10,10A	706	6.57
Hands dorsum	20,20A	200	2.91
Hands palmar	20,20A	200	9.24
Buttocks	14	953	4.26
Groin	13,15	300	1.22
Scrotum	16,16A	200	0.11
Thigh anterior	17,17A	2845	6.57
Thigh posterior	17,17A	1422	4.26
Knee	17,17A,18,18A	200	7.14
Popliteal space (back of knees)	17,17A,18,18A	100	2.09
Shins	18,18A	1897	6.57
Calves	18,18A	948	2.8
Feet dorsum	21	500	6.6
Feet plantar	21	300	7.14

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8.2.9 Interpretation. The average $PPDF_i$ values at each PAD location and the $PPDF_{sys}$ value for each specimen shall be used to determine pass or fail performance.

8.3 Overall Ensemble Function and Integrity Test.

8.3.1 Application.

8.3.1.1 This test method shall apply to complete ensembles with gloves and footwear.

8.3.1.2 Where the ensemble utilizes the respirator facepiece as the ensemble visor, as specified in 6.1.8, each style of the ensemble shall be tested with each style of the respirator specified by the manufacturer.

8.3.2 Specimens.

8.3.2.1 The specimen shall be a minimum of a complete ensemble with gloves, footwear, and respirator if applicable.

8.3.2.2 The specimen shall include all outerwear and other items required for the ensemble to be compliant with this standard.

8.3.2.3 Where the ensemble offers multiple types of external fittings, each type of external fitting shall be installed in the ensemble prior to testing.

8.3.2.4 Each style of the respirator specified by the manufacturer for use with each style of the ensemble shall be tested.

8.3.3 Sample Preparation.

8.3.3.1 Samples for conditioning shall be complete ensembles.

8.3.3.2 Specimens shall be conditioned as specified in 8.1.2.

8.3.4 Procedure.

8.3.4.1 Ensemble overall function and integrity shall be measured in accordance with ASTM F 1154, *Standard Practice for Qualitatively Evaluating the Comfort, Fit, Function, and Integrity of Chemical Protective Suit Ensembles*, with the following parameters:

(1) Both Exercise Procedure A and Exercise Procedure B shall be used. Testing of ensembles immediately following testing as specified in Section 8.2, Man-In-Simulant Test (MIST), shall be permitted.
(2) Ensembles tested shall meet the sizing range of the test subject as determined in 5.3.4. The ensemble shall be donned in accordance with the manufacturer's instructions.
(3) Testing shall be conducted at 25°C ±7°C (77°F ±13°F) and relative humidity of 50 percent ±20 percent.
(4) For Class 2 and Class 3 ensembles, liquidtight integrity shall be measured as specified in Section 8.4, Liquidtight Integrity Test 1, after the exercise procedures are completed.
(5) Where hoods are provided, a determination shall be made that the ensemble is designed to at least accommodate head protection meeting the dimensional requirements for Type 1, Class G helmets of ANSI Z89.1, *Standard for Industrial Head Protection*. For Class 2, Class 3, and Class 4 ensembles, the hood shall be permitted to accommodate head protection worn either inside or outside the ensemble.
(6) 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 as determined in a visual acuity test or doctor's examination.
(7) Test subjects shall wear underclothing in accordance with the manufacturer's recommendation, or in lieu of a detailed recommendation, a full body coverall.
(8) 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.
(9) 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.

8.3.4.2 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 ft-candles at the chart and with the test subject positioned at a distance of 6.1 m (20 ft) from the chart.

8.3.4.3 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.

8.3.5 Report.

8.3.5.1 For Class 2 and Class 3 ensembles, 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.

8.3.5.2 The time required for the test subject to satisfactorily complete all exercises shall be recorded and reported.

8.3.5.3 Where hoods are provided, the ensemble accommodation of head protection meeting the dimensional requirements for Type 1, Class G helmets of ANSI Z89.1, *Standard for Industrial Head Protection*, shall be recorded and reported.

8.3.5.4 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.

8.3.6 Interpretation.

8.3.6.1 For Class 2 and Class 3 ensembles, evidence of liquid on the liquid-absorptive garment inside the specimen or on the interior surface of the ensemble shall constitute failing performance.

8.3.6.1.1 For glove and footwear parts of the ensembles that consist of multiple separate layers, accumulation of liquid between any layers shall constitute failure.

8.3.6.2 The time required by the test subject to satisfactorily complete all exercises shall be used for determining pass or fail.

8.3.6.3 Where hoods are provided, the non-accommodation of head protection meeting the dimension requirements for Type 1, Class G helmets of ANSI Z89.1, *Standard for Industrial Head Protection*, shall constitute failing performance. For Class 2, Class 3, and Class 4 ensembles, the hood shall be permitted to accommodate head protection worn either inside or outside the ensemble.

8.3.6.4 Where hoods with visors or facepieces are provided, the visual acuity of the test subject inside the suit shall be used for determining pass or fail.

8.4 Liquidtight Integrity Test 1.

8.4.1 Application.

8.4.1.1 This test method shall apply to Class 2 and Class 3 ensembles.

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8.4.1.2 Specific requirements for testing Class 2 ensembles shall be as specified in 8.4.8.

8.4.1.3 Specific requirements for testing Class 3 ensembles shall be as specified in 8.4.9.

8.4.2 Specimens.

8.4.2.1 A minimum of one specimen shall be tested. Specimens shall consist of the entire garment or ensemble with all layers assembled that are required for the garment or ensemble to be compliant.

8.4.2.2 The size of the garment or ensemble comprising the specimens shall be chosen to conform to the size of the mannequin in terms of chest circumference, waist circumference, and inseam height in accordance with the ensemble manufacturer's sizing system.

8.4.2.3 Each style of the respirator specified by the manufacturer for use with each style of the ensemble shall be tested.

8.4.2.4 Where the ensemble has multiple types of external fittings, each type of external fitting shall be installed in the ensemble prior to testing.

8.4.3 Preparation.

8.4.3.1 Samples for conditioning shall be complete garments or ensembles.

8.4.3.2 Specimens shall be conditioned as specified in 8.1.2.

8.4.4 Apparatus. The apparatus and supplies for testing shall be those specified in ASTM F 1359, *Standard Test Method for Measuring the Liquid Permeation Resistance of Protective Clothing or Protective Ensembles Under a Shower Spray While on a Mannequin*, using the following modifications:

(1) The surface tension of the water used in testing shall be 32 dynes/cm ±2 dynes/cm.
(2) The mannequin used in testing shall have straight arms and legs, with one arm positioned at the mannequin's side and the other arm bent at the elbow upward at a 45-degree angle.
(3) The liquid-absorptive garment shall cover all portions of the mannequin that are covered by the test specimen.

8.4.5 Procedure.

8.4.5.1 Liquidtight integrity testing of garments or ensembles shall be conducted in accordance with ASTM F 1359, *Standard Test Method for Measuring the Liquid Permeation Resistance of Protective Clothing or Protective Ensembles Under a Shower Spray While on a Mannequin*, with the following modifications:

(1) No provisions for garments or ensembles with a partial barrier layer shall be allowed.
(2) The method used for mounting of the mannequin 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.

8.4.5.2 The specimen shall be inspected within 10 minutes of the end of the liquid spray exposure period for evidence of liquid penetration.

8.4.5.3 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 the collection of liquid has occurred.

8.4.6 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.

8.4.7 Interpretation.

8.4.7.1 Evidence of liquid on the liquid-absorptive garment, inside the specimen, or on the interior surface of the ensemble, as determined by visual, tactile, or absorbent toweling, shall constitute failure of the specimen.

8.4.7.2 For glove and footwear parts of the ensembles that consist of multiple separate layers, accumulation of liquid between any layers shall constitute failure.

8.4.8 Specific Requirements for Testing Class 2 Ensembles. Testing shall be performed with the suited mannequin exposed to the liquid spray for a total of 20 minutes, 5 minutes in each of the four mannequin orientations.

8.4.9 Specific Requirements for Testing Class 3 Ensembles. Testing shall be performed with the suited mannequin exposed to the liquid spray for a total of 4 minutes, 1 minute in each of the four mannequin orientations.

8.5 Particle Inward Leakage Test.

8.5.1 Application. This test shall apply to Class 4 ensembles.

8.5.2 Samples.

8.5.2.1 Samples for conditioning shall be complete ensembles and shall include the respirator where the ensemble utilizes the respirator facepiece as the ensemble visor.

8.5.2.2 Samples shall be conditioned at 21°C ±6°C and 50 percent ±30 percent RH for at least 4 hours.

8.5.3 Specimens.

8.5.3.1 The specimen shall be a complete ensemble with gloves and footwear, and shall include the respirator where applicable.

8.5.3.2 Where the ensemble utilizes the respirator facepiece as the ensemble visor, as specified in 6.1.8, the ensemble shall be tested with each type or model of the respirator specified by the manufacturer.

8.5.3.3 A minimum of four specimens shall be tested. The specimens shall represent a minimum of two different ensemble sizes.

8.5.3.4 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.

8.5.3.5 Specimens shall be provided to 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.

8.5.3.6 None of the components to be tested shall have been previously subjected to particle inward leakage testing.

8.5.3.7 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.

8.5.4 Apparatus.

8.5.4.1 The test shall be conducted in a chamber large enough to conduct testing on at least one test subject.

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8.5.4.2 The test chamber shall have a system capable of providing a stable, uniform airflow directed at the test subject.

8.5.4.3 The test chamber shall prevent significant aerosol contact with any areas of the facility not intended as exposure areas to prevent contamination.

8.5.4.4 The test chamber shall have an aerosol generator capable of maintaining the aerosol mass concentration as specified in the procedure.

8.5.4.5 The test facility shall have separate garment storage, donning, doffing, and control room areas to prevent contamination.

8.5.4.6 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.

8.5.4.7 All test subjects shall have a medical doctor's certificate that substantiates that they are medically and physically suitable to perform these tests without danger to themselves. The medical certificate shall have been issued within 12 months prior to testing.

8.5.4.8 Test subjects shall be familiar with the use of chemical protective ensembles and with the selected respirator.

8.5.5 Procedure.

8.5.5.1 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 2.5 µm ±0.5 µm.

8.5.5.2 The test subject shall don black undergarments that cover the wearer's torso, arms, legs, and head excluding the face. The indicator garments shall provide a dark uniform appearance under black light illumination.

8.5.5.3* 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.

8.5.5.4 The 10 masked areas each shall have minimum dimensions of 25 mm × 50 mm (1 in. × 2 in.) and shall be distributed over the indicator garments.

8.5.5.5 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.

8.5.5.6 Once the test chamber has reached the conditions specified in 8.5.5.1, the test subject shall enter the chamber and be properly positioned in the wind.

8.5.5.7 The 30-minute test period shall begin when the test subject is positioned in the wind.

8.5.5.8* During the 30-minute test period, the test subject shall perform the following three series of stationary exercises. The stationary exercise shall be as specified in Procedure A of ASTM F 1154, *Standard Practice for Qualitatively Evaluating the Comfort, Fit, Function, and Integrity of Chemical Protective Suit Ensembles*, 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) for 1 minute.
(10) Rest (standing facing wind) for 1 minute.

8.5.5.9 At the conclusion of the 30-minute test period, the test subject shall exit the test chamber and enter the doffing area.

8.5.5.10 The test subject shall then be assisted in doffing the ensemble to prevent contact of the outside surface of the ensemble with the subject's skin or indicator garments.

8.5.5.11* Within 10 minutes of doffing, the masked areas shall be unmasked and the test subject shall be examined under black light for evidence of particulate inward leakage. The black light shall have a wavelength of 365 mm and an intensity of 1200 µW/cm^2 at 380 mm (15 in.).

8.5.6 Report. A diagram shall be prepared for each test that identifies the locations of any particulate inward leakage as detected on the test subject's skin or indicator garments.

8.5.7 Interpretation.

8.5.7.1 Any evidence of particulate inward leakage on any test subject's skin or indicator garments as determined by visual inspection under a black light shall constitute failure.

8.6 Fitting Pull-Out Strength Test.

8.6.1 Application. This test method shall apply to each type of external fitting mounted on Class 2, Class 3, or Class 4 ensembles.

8.6.2 Specimens.

8.6.2.1 A minimum of three specimens shall be tested.

8.6.2.2 A specimen shall consist of the entire external fitting assembly.

8.6.2.3 The means of mounting the external fitting assembly shall be representative of the construction practices used to fabricate the ensemble.

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8.6.3 Sample Preparation.

8.6.3.1 Samples for conditioning shall be external fitting assembly and garment material specimens described in 8.6.2.

8.6.3.2 Specimens shall be conditioned as specified in 8.1.2.

8.6.4 Apparatus.

8.6.4.1 A specimen mounting ring shall be used for clamping the specimen. The mounting ring shall have an inner diameter of 150 mm (6 in.). 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. 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.

8.6.4.2 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.

8.6.4.3 The tensile testing machine shall meet the following criteria:

(1) It shall be capable of holding the specimen mounting ring securely in the fixed lower arm.
(2) It shall be capable of holding the flat plate pushing device securely in the movable upper arm.
(3) It 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) It shall be outfitted with a compression cell. The testing machine shall be configured with the compression cell on either the lower or upper arm.

8.6.5 Procedure.

8.6.5.1 Specimens shall be clamped into the specimen mounting ring and attached to the fixed arm of a tensile testing machine.

8.6.5.2 The jaws of the movable arm of a tensile testing machine shall be clamped onto the body of the external fitting.

8.6.5.3 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. 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.

8.6.5.4 The maximum force registered by the indicating device of the tensile testing machine shall be recorded for each determination.

8.6.6 Report.

8.6.6.1 The pull-out strength of each specimen shall be recorded and reported to the nearest 1 N (¼ lbf).

8.6.6.2 The average pull-out strength shall be calculated, recorded, and reported to the nearest 1 N (¼ lbf).

8.6.7 Interpretation. The average pull-out strength shall be used to determine pass or fail performance.

8.7 Chemical Permeation Resistance Test.

8.7.1 Application.

8.7.1.1 This method shall apply to Class 2 and Class 3 garment, visor, glove, and footwear materials and seams.

8.7.1.2 Specific requirements for testing garment materials after flexing and abrasion shall be as specified in 8.7.7.

8.7.1.3 Specific requirements for testing visor materials shall be as specified in 8.7.8.

8.7.1.4 Specific requirements for testing glove materials after flexing shall be as specified in 8.7.9.

8.7.1.5 Specific requirements for testing footwear materials after flexing and abrasion shall be as specified in 8.7.10.

8.7.1.6 Specific requirements for testing garment, visor, and glove seams shall be as specified in 8.7.11.

8.7.2 Specimens.

8.7.2.1 A minimum of three specimens of each material shall be tested against each chemical.

8.7.2.2 For composite materials, only the CBRN barrier material shall be tested for chemical permeation resistance.

8.7.2.3 Where the flexing and abrading conditioning is required in this section, all layers shall be present during the conditioning required.

8.7.3 Preparation. Specimens shall be conditioned at least as specified in 8.1.8.

8.7.4 Procedures.

8.7.4.1 Specimens shall be tested for permeation resistance for not less than 60 minutes against the chemicals specified in 8.7.4.2 and 8.7.4.3 in accordance with ASTM F 739, *Standard Test Method for Resistance of Protective Clothing Materials to Permeation by Liquids or Gases Under Conditions of Continuous Contact*, with the following modifications:

(1) The test cells shall be designed to accommodate the introduction of liquid chemicals in a safe manner.
(2) The testing mode shall be open loop and the collection media shall be filtered air at a temperature of 32°C ±3°C (90°F ±5°F) and a relative humidity of 80 percent ±5 percent, flowed through the collection chamber of the test cell at a rate of 1 Lpm ±0.1 Lpm.
(3) Analytical methods used shall be sensitive to concentrations of at least one order of magnitude lower than the required end points.
(4) Where cumulative permeation end points are not specified in this standard, a permeation rate of 0.1 μg/cm^2/min, as defined by ASTM F 739, *Standard Test Method for Resistance of Protective Clothing Materials to Permeation by Liquids or Gases Under Conditions of Continuous Contact*, shall be used.

8.7.4.2 The following liquid chemicals shall be tested:

(1) Liquid chemical warfare agents
  (a) Distilled sulfur mustard [HD; bis (2-chloroethyl) sulfide], 505-60-2; at 32°C ±1°C (90°F ±2°F)
  (b) Soman (GD; o-pinacolyl methylphosphonofluoridate), 96-64-0; at 32°C ±1°C (90°F ±2°F)
(2) Liquid toxic industrial chemicals
  (a) Acrolein (allyl aldehyde), 107-02-8; at 32°C ±1°C (90°F ±2°F)
  (b) Acrylonitrile (VCN, cyanoethylene), 107-13-1; at 32°C ±1°C (90°F ±2°F)
  (c) Dimethyl sulfate (DMS, sulfuric acid dimethyl ester), 77-78-1; at 32°C ±1°C (90°F ±2°F)

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8.7.4.3 The following gases shall be tested:

(1) Ammonia (7664-41-7); at 32°C ±1°C (90°F ±2°F)
(2) Chlorine (Cl_2; 7782-50-5); at 32°C ±1°C (90°F ±2°F)

8.7.4.4 Class 2 Elements.

8.7.4.4.1 For Class 2 elements, the gas concentration shall be 350 ppm +35 ppm/−0 ppm.

8.7.4.4.2 For Class 2 elements, the liquid concentration density shall be 10 g/m^2 +1 g/m^2/−0 g/m^2.

8.7.4.4.3* The liquid drops shall be applied as nominal 1 µl drops uniformly distributed over the test area of the specimen surface. Where a seam, closure, or fixture is included, at least one drop shall be applied to each critical juncture, such as the seam edge.

8.7.4.4.4 The test cell shall be assembled in the closed-top configuration.

8.7.4.5 Class 3 Elements.

8.7.4.5.1 For Class 3 elements, the gas concentration shall be 40 ppm +10 ppm/−0 ppm, and the cell shall be assembled in closed-top configuration.

8.7.4.5.2 For Class 3 elements, the liquid concentration density shall be 10 g/m^2 +1 g/m^2/−0 g/m^2.

8.7.4.5.3 Drops shall be applied as nominal 1 µl drops uniformly distributed over the test area of the specimen surface. Where a seam, closure, or fixture is included, at least one drop shall be applied to each critical juncture, such as the seam edge.

8.7.4.5.4 For the liquid chemicals specified in 8.7.4.2, the test cell shall be assembled in the open-top configuration with 0.3 Lpm ±0.03 Lpm of filtered air controlled at 80 percent ±5 percent, relative humidity (RH) flowing through the top of the cell. With the open-top configuration, the test cell washer shall be allowed to be sealed by an impermeable nonreactive sealant.

8.7.5 Report.

8.7.5.1 For permeation testing of chemical warfare agents specified in 8.7.4.2(1), the cumulative permeation in 1 hour shall be recorded and reported in µg/cm^2 for each specimen. The average cumulative permeation in 1 hour for all specimens shall be calculated, recorded, and reported. The report shall include the pass or fail results for each chemical tested.

8.7.5.2 For permeation testing of liquid and gaseous industrial chemicals specified in 8.7.4.2(2) and 8.7.4.3, the normalized breakthrough time shall be recorded and reported in minutes for each specimen. The average normalized breakthrough time shall also be calculated and reported.

8.7.6 Interpretation.

8.7.6.1 For permeation testing of chemical warfare agents specified in 8.7.4.2(1), the average cumulative permeation shall be used to determine pass or fail performance.

8.7.6.2* For permeation testing of liquid and gaseous industrial chemicals specified in 8.7.4.2(2) and 8.7.4.3, the average normalized breakthrough time shall be used to determine pass or fail performance.

8.7.7 Specific Requirements for Testing Garment Materials.

8.7.7.1 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 permeation resistance testing.

8.7.7.2 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 permeation resistance testing.

8.7.7.3 It shall be permitted to precondition one sample to both flexing and abrading prior to permeation resistance testing.

8.7.8 Specific Requirements for Testing Visor Materials. Samples for conditioning shall be visor materials.

8.7.9 Specific Requirements for Testing Glove Materials After Flexing.

8.7.9.1 Samples for conditioning shall be whole gloves.

8.7.9.2 Samples shall be conditioned as specified in 8.1.5.

8.7.10 Specific Requirements for Testing Footwear Materials After Flexing and Abrading.

8.7.10.1 This test shall apply to all types of footwear configurations.

8.7.10.2 Where the footwear incorporates a sock or overboot 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.

8.7.10.3 Upper samples for conditioning shall be whole footwear items.

8.7.10.4 Upper samples shall first be conditioned by flexing as specified in 8.1.6.

8.7.10.5 Following flexing, new upper samples shall be taken in areas from the footwear upper where the greatest flexing occurred, usually at the footwear quarter or vamp, and shall be as specified in Figure 8.1.4.

8.7.10.6 Sole samples for conditioning shall be taken from the footwear or shall be permitted to be facsimile samples of sole material where the facsimile samples are the same composition and construction of the sole used in actual footwear.

8.7.10.6.1 Facsimile sole samples shall be of a maximum thickness representative of the thinnest portion of the sole, exclusive of hardware, midsoles, or inner soles.

8.7.10.6.2 Where facsimile samples are elected, the sole samples shall not be subjected to the flexing specified in 8.7.10.4.

8.7.10.6.3 Specific Requirements for Testing Thermoplastic Sole Compositions. Samples shall be compression mold samples with a consistent thickness from the thermoplastic compound used to manufacture the footwear sole or from the actual sole.

8.7.10.6.4 Specific Requirements for Testing Vulcanized Sole Compositions. Samples shall be compression mold samples with a consistent thickness from the nonvulcanized compound used to manufacture the footwear sole.

8.7.10.6.5 Specific Requirements for Testing Thermoset Sole Compositions. Samples shall be compression mold samples with a consistent thickness from the thermoset material used to manufacture the footwear sole.

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8.7.10.7 The upper samples that were taken per 8.7.10.5, and sole samples shall then be conditioned by abrading as specified in 8.1.4.

8.7.10.8 Following abrasion, only one test specimen for chemical permeation resistance testing shall be taken from each sample subjected to abrasion.

8.7.10.9 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.

8.7.11 Specific Requirements for Testing Garment, Visor, and Glove Seams.

8.7.11.1 Samples for conditioning shall be 600 mm (23½ in.) lengths of prepared seam or cut from ensembles.

8.7.11.2 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.

8.7.11.3 Permeation test specimens shall be cut such that the exact seam center divides the specimen in half.

8.7.11.4 Seam specimens shall be prepared representing each different type of seam found in the garment, or shall be taken from each different type of seam found in the garment, including as a minimum the garment-to-garment material seams and the garment-to-visor material seams.

8.7.11.5 Seam specimens shall be taken from gloves from the gauntlet portion of the glove when an external seam is used in the construction of the glove.

8.8 Total Heat Loss Test.

8.8.1 Application. This test method shall apply to the garment materials used in Class 3 and Class 4 ensembles.

8.8.2 Specimens. Total heat loss testing shall be conducted on at least three specimens. Specimens shall consist of all layers in the protective garment material arranged in the order and orientation as worn.

8.8.3 Sample Preparation.

8.8.3.1 Specimens to be tested shall be conditioned as specified in 8.1.2.

8.8.3.2 Samples for conditions shall be at least a 1 m (1 yd) square of each material.

8.8.4 Apparatus. The test apparatus shall be as specified in ASTM F 1868, *Standard Test Method for Thermal and Evaporative Resistance of Clothing Materials Using a Sweating Hot Plate.*

8.8.5 Procedure. Testing shall be conducted in accordance with ASTM F 1868, *Standard Test Method for Thermal and Evaporative Resistance of Clothing Materials Using a Sweating Hot Plate,* using Part C.

8.8.6 Report.

8.8.6.1 The average intrinsic thermal resistance (R_{cf}) of the sample shall be recorded and reported.

8.8.6.2 The average apparent intrinsic evaporative resistance (AR_{ef}) of the sample shall be recorded and reported.

8.8.6.3 The average total heat loss (Q_t) of the sample shall be determined and reported.

8.8.7 Interpretation. Pass or fail determination shall be based on the average reported total heat loss measurement of all specimens tested.

8.9 Burst Strength Test.

8.9.1 Application.

8.9.1.1 This test shall apply to garment and visor materials.

8.9.1.2 Where the garment or visor is constructed of several separable layers, then all layers, assembled in the order in which they appear in the garment or visor, shall be tested as a composite.

8.9.2 Specimens. A total of 10 specimens shall be tested.

8.9.3 Preparation.

8.9.3.1 Specimens shall be conditioned as specified in 8.1.2.

8.9.3.2 Samples for conditioning shall be at least 1 m (1 yd) square of material.

8.9.4 Procedure. Specimens shall be tested in accordance with Section 18.2, Tensile Testing Machine with Ring Clamp, of ASTM D 751, *Standard Test Methods for Testing Coated Fabrics.*

8.9.5 Report. The burst strength of each specimen shall be recorded and reported to the nearest 1 N (0.23 lbf). The average burst strength of all specimens shall be calculated, recorded, and reported.

8.9.6 Interpretation. The average burst strength shall be used to determine pass or fail performance.

8.10 Puncture Propagation Tear Resistance Test.

8.10.1 Application. This test shall apply to garment and visor materials. If the protective garment 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.

8.10.2 Specimens.

8.10.2.1 A minimum of five specimens in both the warp direction, machine or course, and the filling direction, cross-machine or wale, shall be tested.

8.10.2.2 If the material is non-anisotropic, then ten specimens shall be tested.

8.10.3 Sample Preparation.

8.10.3.1 Specimens shall be conditioned as specified in 8.1.2.

8.10.3.2 Samples for conditioning shall be at least 1 m (1 yd) square of material.

8.10.4 Procedure. Specimens shall be tested in accordance with ASTM D 2582, *Standard Test Method for Puncture Propagation Tear Resistance of Plastic Film and Thin Sheeting.*

8.10.5 Report. The puncture propagation tear resistance of each specimen shall be recorded and reported to the nearest 0.05 kg (0.1 lb) of force. An average puncture propagation tear resistance shall be calculated, recorded, and reported for warp and filling directions.

8.10.6 Interpretation. Pass or fail performance shall be based on the average puncture propagation tear resistance in the warp and filling directions. Failure in any one direction shall constitute failure for the material.

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8.11 Cold Temperature Performance Test 1.

8.11.1 Application. This test method shall apply to garment and glove materials.

8.11.2 Specimens.

8.11.2.1 A minimum of five specimens in each of the warp, machine or course direction, and the filling, cross-machine or wale direction, shall be tested.

8.11.2.2 If the material is isotropic, then ten specimens shall be tested.

8.11.3 Preparation.

8.11.3.1 Specimens shall be conditioned as specified in 8.1.2.

8.11.3.2 Samples for conditioning shall be at least 1 m (1 yd) square of material.

8.11.4 Procedure. Specimens shall be tested in accordance with ASTM D 747, *Standard Test Method for Apparent Bending Modulus of Plastics by Means of a Cantilever Beam*, with the following modifications:

(1) The test temperature shall be –25°C (–13°F).
(2) The bending moment shall be that applied with the specimen bent to a 60-degree angular deflection and shall be calculated in inch-pounds as follows:

$$\text{Bending moment} = \frac{\text{load scale reading} \times \text{moment weight}}{100}$$

where:
Bending moment (N·m) = bending moment, in·lb × 0.113

8.11.5 Report. Cold temperature performance results shall be recorded and reported as the average for each material direction.

8.11.6 Interpretation. Failure of the material in any direction shall constitute failing performance.

8.12 Seam/Closure Breaking Strength Test.

8.12.1 Application.

8.12.1.1 This test shall be applied to garment seams and the garment closure assembly used in the construction of the garment, including at least garment and garment-visor seams. If the garment consists of multiple separable layers, then the test shall be applied to the seams and closure assemblies of each separable layer.

8.12.1.2 Modifications to this test method for testing seams shall be as specified in 8.12.7.

8.12.1.3 Modifications to this test method for testing closure assemblies shall be as specified in 8.12.8.

8.12.2 Specimens.

8.12.2.1 A minimum of five seam or closure assembly specimens representative of the garment shall be tested for each seam and closure assembly type.

8.12.2.2 A straight seam shall be cut from the finished garment or shall be permitted to be prepared by joining two pieces of the garment material.

8.12.3 Preparation.

8.12.3.1 Specimens shall be conditioned as specified in 8.1.2.

8.12.3.2 Samples for conditioning shall be at least the same as the specimen size.

8.12.4 Procedure. All seams and closure assemblies shall be tested in accordance with ASTM D 751, *Standard Test Methods for Testing Coated Fabrics*.

8.12.5 Report.

8.12.5.1 The breaking strength for each seam or closure assembly specimen shall be recorded and reported. The average breaking strength for each seam or closure assembly type shall also be reported.

8.12.5.2 The type of seams and closure assemblies tested shall be recorded and reported as to whether the specimens were cut from the finished garment or prepared from fabric samples.

8.12.6 Interpretation. The average breaking strength for each seam or closure type shall be used to determine pass or fail performance.

8.12.7 Specific Procedures for Testing Seams. Samples for conditioning shall include 150 mm (6 in.) of material on either side of the seam.

8.12.8 Specific Procedures for Testing Closure Assemblies.

8.12.8.1 Samples for conditioning shall include 150 mm (6 in.) of material on either side of the closure.

8.12.8.2 Specimens shall be conditioned as specified in 8.1.7.

8.13 Cold Temperature Performance Test 2.

8.13.1 Application. This test method shall apply to visor materials.

8.13.2 Specimens. A minimum of 10 specimens shall be tested.

8.13.3 Preparation.

8.13.3.1 Specimens shall be conditioned as specified in 8.1.2.

8.13.3.2 Samples for conditioning shall be at least 1 m (1 yd) square of material.

8.13.4 Procedure.

8.13.4.1 Specimens shall be tested in accordance with ASTM D 2136, *Standard Test Method for Coated Fabrics — Low Temperature Bend Test*.

8.13.4.2 Following this testing, specimens shall be examined for evidence of damage. Damage shall include any breakage, cracks, tears, or separation, but shall not include discoloration along the folded area.

8.13.5 Report. Observations of visible damage shall be recorded and reported for each specimen.

8.13.6 Interpretation.

8.13.6.1 Damage of any one specimen shall constitute failing performance.

8.13.6.2 Rigid visors that do not bend but show no evidence of damage shall still be considered to pass the test.

8.14 Cut Resistance Test.

8.14.1 Application.

8.14.1.1 This test method shall apply to glove and footwear upper materials.

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8.14.1.2 Modifications to this test method for testing glove materials shall be as specified in 8.14.7.

8.14.1.3 Modifications to this test method for testing footwear upper materials shall be as specified in 8.14.8.

8.14.2 Specimens. A minimum of three specimens, consisting of all layers, shall be tested.

8.14.3 Preparation.

8.14.3.1 Samples for conditioning shall be whole gloves and whole footwear.

8.14.3.2 Specimens shall be conditioned as specified in 8.1.2.

8.14.4 Procedure. Specimens shall be evaluated in accordance with ASTM F 1790, *Standard Test Methods for Measuring Cut Resistance of Materials Used in Protective Clothing*, with the specimens tested at a specific load in grams for the measurement of the distance of blade travel.

8.14.5 Report. The distance of blade travel shall be recorded and reported to the nearest 1 mm (1/32 in.) for each sample specimen. The average distance of blade travel shall be recorded and reported for all specimens tested.

8.14.6 Interpretation. The average distance of blade travel shall be used to determine pass or fail performance.

8.14.7 Specific Requirements for Testing Glove Materials.

8.14.7.1 Specimens shall be taken from the back and palm of the glove and shall not include seams.

8.14.7.2 Class 2 glove specimens shall be tested at a load of 200 g (7 oz).

8.14.7.3 Class 3 and Class 4 glove specimens shall be tested at a load of 100 g (3½ oz).

8.14.8 Specific Requirements for Testing Footwear Upper Materials.

8.14.8.1 Specimens shall be taken from the parts of the footwear upper that provide uniform thickness and shall not include seams.

8.14.8.2 Class 2 footwear upper specimens shall be tested at a load of 600 g (21 oz).

8.14.8.3 Class 3 and Class 4 footwear upper specimens shall be tested at a load of 400 g (14 oz).

8.15 Puncture Resistance Test 1.

8.15.1 Application.

8.15.1.1 This test shall be applied to glove and footwear upper materials.

8.15.1.2 Modifications to this test method for testing glove materials shall be as specified in 8.15.7.

8.15.1.3 Modifications to this test method for testing footwear upper materials shall be as specified in 8.15.8.

8.15.2 Specimens. A minimum of three specimens, consisting of all layers, measuring at least 150 mm (6 in.) square shall be tested.

8.15.3 Preparation.

8.15.3.1 Samples for conditioning shall be complete gloves or footwear upper sections.

8.15.3.2 Specimens shall be tested after conditioning as specified in 8.1.2.

8.15.4 Procedure. Specimens shall be tested in accordance with ASTM F 1342, *Standard Test Method for Resistance of Protective Clothing Materials to Puncture*.

8.15.5 Report. The puncture force shall be recorded and reported for each specimen to the nearest 0.5 N (0.1 lbf). The average puncture force shall be recorded and reported for all specimens tested.

8.15.6 Interpretation. The average puncture force shall be used to determine pass or fail performance.

8.15.7 Specific Requirements for Testing Glove Materials. Specimens shall be taken from the back and palm of the glove and shall not include seams. Specimens shall consist of each composite of the palm, palm side of the fingers, and back of the glove used in actual suit glove configuration, with layers arranged in the proper order. Where the specimen composites of the palm, palm side of the fingers, and back of the glove are identical, only one representative composite shall be required to be tested.

8.15.8 Specific Requirements for Testing Footwear Upper Materials. Specimens shall be taken from the parts of the footwear upper that provide uniform thickness and shall not include seams.

8.16 Glove Hand Function Test.

8.16.1 Application. This test shall apply to gloves.

8.16.2 Specimens.

8.16.2.1 A minimum of three pairs of gloves each for small and large sizes shall be used for testing.

8.16.2.2 Each glove pair shall be tested as a complete set of gloves in new, as distributed, condition.

8.16.2.3 Glove pair specimens shall not receive special softening treatments prior to tests.

8.16.3 Sample Preparation.

8.16.3.1 Glove pair specimens shall be preconditioned as specified in 8.1.2.

8.16.3.2 Samples for conditioning shall be whole glove pairs.

8.16.4 Apparatus. The apparatus shall be as specified in ASTM F 2010, *Standard Test Method for Evaluation of Glove Effects on Wearer Hand Dexterity Using a Modified Pegboard Test*.

8.16.5 Procedures. The testing procedures shall be as specified in ASTM F 2010, *Standard Test Method for Evaluation of Glove Effects on Wearer Hand Dexterity Using a Modified Pegboard Test*.

8.16.6 Report.

8.16.6.1 The average percent increase in barehanded control shall be recorded and reported for each test subject.

8.16.6.2 The average percent increase in barehanded control for all test subjects shall be calculated, recorded, and reported.

8.16.7 Interpretation. The average percent increase in barehanded control shall be used to determine pass or fail performance.

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8.17 Abrasion Resistance Test 1.

8.17.1 Application. This test method shall apply to footwear soles.

8.17.2 Specimens. A minimum of three footwear soles shall be tested.

8.17.3 Preparation.

8.17.3.1 Samples for conditioning shall be footwear soles.

8.17.3.2 Specimens shall be conditioned as specified in 8.1.2.

8.17.4 Procedure. Abrasion resistance shall be performed in accordance with ASTM D 1630, *Standard Test Method for Rubber Property — Abrasion Resistance (NBS Abrader).*

8.17.5 Report. The abrasion-resistance rating of each specimen shall be recorded and reported.

8.17.6 Interpretation. One or more footwear specimens failing this test shall constitute failing performance.

8.18 Puncture Resistance Test 2.

8.18.1 Application. This test method shall apply to footwear soles.

8.18.2 Specimens. A minimum of three footwear soles shall be tested.

8.18.3 Sample Preparation.

8.18.3.1 Samples for conditioning shall be footwear sole sections.

8.18.3.2 Specimens shall be conditioned as specified in 8.1.2.

8.18.4 Procedure. Puncture resistance shall be performed in accordance with Section 11 of ASTM F 2412, *Standard Test Methods for Foot Protection.*

8.18.5 Report. The force required to puncture the sole reinforcement device of each specimen shall be recorded and reported.

8.18.6 Interpretation. One or more footwear specimens failing this test shall constitute failing performance.

8.19 Slip Resistance Test.

8.19.1 Application. This test method shall apply to footwear soles.

8.19.2 Specimens. A minimum of three complete footwear items shall be tested.

8.19.3 Preparation.

8.19.3.1 Samples for conditioning shall be footwear.

8.19.3.2 Specimens shall be conditioned as specified in 8.1.2.

8.19.4 Procedure. Slip resistance shall be performed in accordance with ASTM F 489, *Standard Test Method for Static Coefficient of Friction of Shoe Sole and Heel Material as Measured by the James Machine*, in a dry condition.

8.19.5 Report. The static coefficient of friction of each specimen shall be recorded and reported.

8.19.6 Interpretation. One or more footwear specimens failing this test shall constitute failing performance.

8.20 Impact and Compression Resistance Test.

8.20.1 Application. This test method shall apply to the toe section of the footwear.

8.20.2 Specimens. A minimum of three footwear items shall be tested for both impact and compression.

8.20.3 Sample Preparation.

8.20.3.1 Samples for conditioning shall be complete footwear toes.

8.20.3.2 Specimens shall be conditioned as specified in 8.1.2.

8.20.4 Procedure. Footwear specimens shall be tested in accordance with Section 5 and Section 6 of ASTM F 2412, *Standard Test Methods for Foot Protection.*

8.20.5 Report. The impact and compression forces for each specimen shall be recorded and reported.

8.20.6 Interpretation. One or more footwear specimens failing this test shall constitute failing performance.

8.21 Viral Penetration Resistance Test.

8.21.1 Application.

8.21.1.1 This test shall apply to Class 2, Class 3, and Class 4 garments, gloves, and footwear materials; garment and glove seams; and visors.

8.21.1.2 Modifications to this test method for testing garment materials after flexing and abrasion shall be as specified in 8.21.7.

8.21.1.3 Modifications to this test method for testing visor or facepiece materials shall be as specified in 8.21.8.

8.21.1.4 Modifications to this test method for testing glove materials after flexing shall be as specified in 8.21.9.

8.21.1.5 Modifications to this test method for testing footwear materials after flexing and abrasion shall be as specified in 8.21.10.

8.21.1.6 Modifications to this test method for testing garment and glove seams shall be as specified in 8.21.11.

8.21.2 Specimens. A minimum of three specimens shall be tested. Specimens shall consist of three 75 mm (3 in.) squares for each material type.

8.21.3 Sample Preparation. Specimens to be tested shall be conditioned as specified in 8.1.2.

8.21.4 Procedure.

8.21.4.1 Biopenetration resistance testing shall be conducted in accordance with ASTM F 1671, *Standard Test Method for Resistance of Materials Used in Protective Clothing to Penetration by Blood-Borne Pathogens Using Phi-X174 Bacteriophage as a Test System*, Procedure A.

8.21.4.2 The normal outer surface of the material shall be exposed to the liquid as oriented in the clothing item.

8.21.5 Report. The pass or fail result for each specimen shall be recorded and reported.

8.21.6 Interpretation. One or more failures of any specimen against any liquid shall constitute failure of the material.

8.21.7 Specific Requirements for Testing Garment Materials.

8.21.7.1 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.

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8.21.7.2 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.

8.21.7.3 It shall be permitted to precondition one sample to both flexing and abrading prior to viral penetration testing.

8.21.8 Specific Requirements for Testing Visor or Facepiece Materials.

8.21.8.1 Samples for conditioning shall be visor materials or facepiece materials.

8.21.8.2 Where the ensemble utilizes the respirator facepiece as the ensemble visor, as specified in 6.1.8, 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.

8.21.8.3 The specimen shall also include the respirator where applicable.

8.21.9 Specific Requirements for Testing Glove Materials After Flexing.

8.21.9.1 Samples for conditioning shall be whole gloves.

8.21.9.2 Samples shall be conditioned as specified in 8.1.5.

8.21.10 Specific Requirements for Testing Footwear Materials After Flexing and Abrading.

8.21.10.1 This test shall apply to all types of footwear configurations.

8.21.10.2 Where the footwear incorporates a sock or overboot 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.

8.21.10.3 Upper samples for conditioning shall be whole footwear items.

8.21.10.4 Upper samples shall first be conditioned by flexing as specified in 8.1.6.

8.21.10.5 Following flexing, new upper samples shall be taken in areas from the footwear upper where the greatest flexing occurred, usually at the footwear quarter or vamp, and shall be as specified in Figure 8.1.4.

8.21.10.6 Sole samples for conditioning shall be taken from the footwear or shall be permitted to be facsimile samples of sole material where the facsimile samples are the same composition and construction of the sole used in actual footwear.

8.21.10.6.1 Facsimile sole samples shall be of a maximum thickness representative of the thinnest portion of the sole, exclusive of hardware, midsoles, or inner soles.

8.21.10.6.2 Where facsimile samples are elected, the sole samples shall not be subjected to the flexing specified in 8.7.10.4.

8.21.10.6.3 Specific Requirements for Testing Thermoplastic Sole Compositions. Samples shall be compression mold samples with a consistent thickness from the thermoplastic compound used to manufacture the footwear sole or from the actual sole.

8.21.10.6.4 Specific Requirements for Testing Vulcanized Sole Compositions. Samples shall be compression mold samples with a consistent thickness from the nonvulcanized compound used to manufacture the footwear sole.

8.21.10.6.5 Specific Requirements for Testing Thermoset Sole Compositions. Samples shall be compression mold samples with a consistent thickness from the thermoset material used to manufacture the footwear sole.

8.21.10.7 The upper samples that were taken per 8.7.10.5, and sole samples shall then be conditioned by abrading as specified in 8.1.4.

8.21.10.8 Following abrasion, only one test specimen for chemical permeation resistance testing shall be taken from each sample subjected to abrasion.

8.21.10.9 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.

8.21.11 Specific Requirements for Testing Garment or Glove Seams.

8.21.11.1 Samples for conditioning shall be 600 mm (23½ in.) lengths of prepared seam or cut from ensembles.

8.21.11.2 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. Permeation test specimens shall be cut such that the exact seam center divides the specimen in half.

8.21.11.3 Seam specimens shall be prepared representing each different type of seam found in the garment, or shall be taken from each different type of seam found in the garment, including as a minimum the garment-to-garment material seams and the garment-to-visor material seams.

8.21.11.4 Seams specimens shall be taken from gloves from the gauntlet portion of the glove when an external seam is used in the construction of the glove.

8.22 Liquidtight Integrity Test 2.

8.22.1 Application.

8.22.1.1 This test method shall apply to Class 2, Class 3, and Class 4 gloves and footwear.

8.22.1.2 Modifications to this test method for testing gloves shall be as specified in 8.22.7.

8.22.1.3 Modifications to this test method for testing footwear shall be as specified in 8.22.8.

8.22.2 Specimens. A minimum of ten glove specimens or a minimum of three footwear specimens shall be tested. Specimens shall consist of the entire glove or footwear item with all layers assembled that are required for the item to be compliant.

8.22.3 Preparation.

8.22.3.1 Samples for conditioning shall be whole gloves or footwear.

8.22.3.2 Specimens shall be conditioned as specified in 8.1.2.

8.22.4 Procedure. Liquidtight integrity testing of gloves and footwear shall be conducted in accordance with ASTM D 5151, *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 32 dynes/cm ±2 dynes/cm.
(2) The surfactant-treated water shall remain in the specimen for a period of 1 hour +5/−0 minutes.

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(3) Observations for leakage shall be performed at the end of the test period.
(4) Blotting paper shall be permitted to be used for assisting in the determination that liquid leakage has occurred.

8.22.5 Report. Observations of water leakage shall be recorded and reported by specific area on the test specimen.

8.22.6 Interpretation. Any evidence of water leakage, as determined by visual, tactile, or absorbent blotting, shall constitute failure of the specimen.

8.22.7 Specific Requirements for Testing Gloves.

8.22.7.1 Specimens shall be conditioned as specified in 8.1.5.

8.22.7.2 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.

8.22.8 Specific Requirements for Testing Footwear.

8.22.8.1 Specimens shall be conditioned as specified in 8.1.6.

8.22.8.2 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 footwear opening.

8.23 Abrasion Resistance Test 2.

8.23.1 Application. This test method shall apply to the chemical/biological/radiological particulate barrier material, where configured as an exterior layer in protective footwear covers.

8.23.2 Sample Preparation.

8.23.2.1 Samples for conditioning shall be at least 500 mm (½ yd) squares of material.

8.23.2.2 Samples shall be conditioned as specified in 8.1.3.

8.23.3 Specimens.

8.23.3.1 Specimens shall be the size specified in ASTM D 3884, *Standard Guide for Abrasion Resistance of Textile Fabrics (Rotary Platform, Double-Head Method)*.

8.23.3.2 A minimum of five specimens shall be tested.

8.23.4 Procedure. Specimens shall be tested in accordance with ASTM D 3884, *Standard Guide for Abrasion Resistance of Textile Fabrics (Rotary Platform, Double-Head Method)*, with the following modifications:

(1) The H-18 Calibrase wheels shall be used with a 1000-g load.
(2) The abrasion shall be continued until a hole, wear-through, or rupture in the film portion of the material is observed.

8.23.5 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.

8.23.6 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.

8.24 Exhaust Valve Mounting Strength Test.

8.24.1 Application. This test method shall apply to exhaust valves mounted in Class 2, Class 3, and Class 4 ensembles.

8.24.2 Sample Preparation.

8.24.2.1 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.

8.24.2.2 Samples shall be conditioned as specified in 8.1.2.

8.24.3 Specimens.

8.24.3.1 Specimens shall be complete exhaust valve assemblies mounted into a piece of ensemble material.

8.24.3.2 At least three specimens shall be tested.

8.24.4 Apparatus.

8.24.4.1 A specimen mounting ring shall be used for clamping the sample.

8.24.4.1.1 The mounting ring shall have an inner diameter of 150 mm (6 in.).

8.24.4.1.2 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.

8.24.4.1.3 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.

8.24.4.2 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.

8.24.4.3 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. The testing machine shall be configured with the compression cell on either the lower or upper arm.

8.24.5 Procedure.

8.24.5.1 Specimens shall be clamped into the specimen mounting ring and attached to the fixed arm of a tensile testing machine.

8.24.5.2 The flat plate pushing device shall be attached to the movable arm of a tensile testing machine.

8.24.5.3 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. 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.

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8.24.5.4 The maximum force registered by the indicating device of the tensile testing machine shall be recorded for each determination.

8.24.6 Report.

8.24.6.1 The mounting strength of each specimen shall be reported to the nearest 1 N (¼ lbf).

8.24.6.2 The average mounting strength shall be calculated and reported to the nearest 1 N (¼ lbf).

8.24.7 Interpretation. The average mounting strength shall be used to determine pass/fail performance.

8.25 Exhaust Valve Inward Leakage Test.

8.25.1 Application. This test method shall apply to exhaust valves used in Class 2, Class 3, or Class 4 ensembles.

8.25.2 Sample Preparation.

8.25.2.1 Samples shall be individual exhaust valves including mounting means.

8.25.2.2 Samples shall be conditioned as specified in 8.1.2.

8.25.3 Specimens.

8.25.3.1 Specimens shall be individual exhaust valves including mounting means.

8.25.3.2 At least 10 specimens shall be tested.

8.25.3.3 Specimens shall be tested not more than 5 minutes after removal from conditioning.

8.25.4 Apparatus. The test fixture used to measure exhaust valve inward leakage shall have the following characteristics:

(1) The fixture shall allow mounting of any exhaust valve such that an airtight seal is achieved between the valve body and the fixture.
(2) The fixture shall provide for the application of suction from a vacuum pump capable of sustaining a −25 mm (−1 in.) water column gauge vacuum.
(3) The fixture shall include a pressure gauge or manometer capable of measuring pressures ranging from −25 mm to 76 mm, ±6 mm (−1 in. to 3 in., ±¼ in. water gauge) water column gauge.
(4) The fixture shall allow for the measurement of flow into the valve (valve exterior to valve interior sides) with a flow-measuring device capable of measuring flow rates from at least 0 ml/min to 100 ml/min, ±1 ml/min (0 $in.^3$/min to 6.1 $in.^3$/min, ±0.6 $in.^3$/min).

8.25.5 Procedure. The exhaust valve shall be mounted in the test fixture and a suction of −25 mm (−1 in.) water column gauge vacuum shall be applied to the side of the valve representing the suit interior for 30 seconds while the flow rate into the valve is measured.

8.25.6 Report. The inward leakage flow rate shall be reported for each specimen, and the average inward leakage of all specimens shall be calculated.

8.25.7 Interpretation. The average inward leakage shall be used to determine pass/fail in accordance with this standard.

Annex A Explanatory Material

Annex A is not a part of the requirements of this NFPA document but is included for informational purposes only. This annex contains explanatory material, numbered to correspond with the applicable text paragraphs.

A.1.1.2 Users are cautioned that exposure of ensembles to CBRN agents should require disposal, particularly if the effectiveness of decontamination cannot be assessed.

A.1.1.4 In selecting respiratory equipment, organizations should consider how the respiratory equipment interfaces with the protective ensemble. In particular, organizations should take into account how the ensemble, or portions of the ensemble, can be removed without subsequently exposing the individual wearer to respiration of residual contaminants. This is best accomplished by removal of the garments, gloves, and footwear without interrupting or terminating the respiratory protection or breaking the respirator facepiece-to-face seal.

A.1.1.6 Organizations responsible for response to specialized hazardous materials, including radiological, cryogenics, or fire fighting applications, should use protective clothing and equipment specifically designed for those activities.

A.1.1.7 This cross certification is permitted because these other standards also are premised on a single wear protocol or at most a single exposure protocol. One example of a product being certified to two standards is a hazardous materials protective ensemble, an ensemble element, or protective clothing that is certified as compliant with NFPA 1992, *Standard on Liquid Splash-Protective Ensembles and Clothing for Hazardous Materials Emergencies*, that is also being certified as a Class 3 chemical/biological protective ensemble in accordance with this standard.

Ensembles, ensemble elements, or protective clothing that is certified as compliant with any NFPA PPE standard, other than PPE for hazardous materials emergencies and PPE for emergency medical operations, cannot be also certified as compliant with NFPA 1994.

A.1.2.1 The requirements of this standard were developed taking into consideration the needs of personnel responding to incidents involving the intentional, criminal release of chemical/biological agents. This application can entail a variety of chemical, physical, biological, and other hazards.

A.1.3.1 The former Class 1 ensemble designation has been reserved to prevent industry confusion in the classification of CBRN protective ensembles as originally defined in the 2001 edition of NFPA 1994, which established three classes of protective ensembles. The protection for high vapor threats remains in NFPA 1991, *Standard on Vapor-Protective Ensembles for Hazardous Materials Emergencies.*

A.1.3.9 Emergency response organizations are cautioned that if an accessory or its means of attachment causes the structural integrity of the certified product to be compromised, the certified product might not be compliant with the standard to which it was originally certified as compliant. Additionally, if an accessory or the accessory's means of attachment is not designed and manufactured from suitable materials for the hazardous environments of emergency incidents, the failure of the accessory, or its means of attachment, could cause injury to the emergency responder. Because the aftermarket for accessories for certified product is so broad, emergency response organizations are advised to contact

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both the accessory manufacturer and the manufacturer of the certified product and verify that the accessory and its means of attachment are suitable for use in the intended emergency response environment. Emergency response organizations should seek and receive written documentation to validate the following information from the accessory manufacturer.

(1) Accessories for certified product, and the means of attachment, will not degrade the designed protection or performance of the certified product below the requirements of this standard to which it was designed, manufactured, tested, and certified.
(2) The accessory, when properly attached to the certified product, will not interfere with form, fit, or function of any of the certified product or with the form, fit, and function of any of the certified product's component parts.

A.3.2.1 Approved. The National Fire Protection Association does not approve, inspect, or certify any installations, procedures, equipment, or materials; nor does it approve or evaluate testing laboratories. In determining the acceptability of installations, procedures, equipment, or materials, the authority having jurisdiction may base acceptance on compliance with NFPA or other appropriate standards. In the absence of such standards, said authority may require evidence of proper installation, procedure, or use. The authority having jurisdiction may also refer to the listings or labeling practices of an organization that is concerned with product evaluations and is thus in a position to determine compliance with appropriate standards for the current production of listed items.

A.3.2.2 Authority Having Jurisdiction. The phrase "authority having jurisdiction," or its acronym AHJ, is used in NFPA documents in a broad manner, since jurisdictions and approval agencies vary, as do their responsibilities. Where public safety is primary, the authority having jurisdiction may be a federal, state, local, or other regional department or individual such as a fire chief; fire marshal; chief of a fire prevention bureau, labor department, or health department; building official; electrical inspector; or others having statutory authority. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the authority having jurisdiction. In many circumstances, the property owner or his or her designated agent assumes the role of the authority having jurisdiction; at government installations, the commanding officer or departmental official may be the authority having jurisdiction.

A.3.2.4 Listed. The means for identifying listed equipment may vary for each organization concerned with product evaluation; some organizations do not recognize equipment as listed unless it is also labeled. The authority having jurisdiction should utilize the system employed by the listing organization to identify a listed product.

A.3.3.1.4 Chemical Warfare (CW) Agents. Some common industrial chemicals, such as chlorine and phosgene, have also been utilized in armed conflicts.

A.3.3.14 Certification Organization. The certification organization determines compliance of a product by evaluating and testing the product in accordance with this standard, and if the product is found to be compliant, the organization indicates such compliance by labeling and listing the product.

A.3.3.22 Component. Components include items required for the design and construction of the product and are evaluated and tested individually, or are evaluated and tested as a part of the whole product.

A.3.3.26 Encapsulating. This standard does not cover requirements for vaportight protection.

A.3.3.28 Ensemble Elements. The protective ensemble elements are garments, gloves, and footwear.

A.3.3.29 External Fittings. Airline, cooling device, and communications system connections or passthroughs and glove and footwear interface materials on the chemical/biological terrorism incident protective garments are examples of external fittings.

A.3.3.32.1 CBRN Terrorism Incident Protective Footwear. Footwear consists of boots or combinations of footwear elements.

A.3.3.33.1 CBRN Terrorism Incident Protective Footwear Cover. This term applies to footwear cover; foot protection offered by combination of footwear cover and standard footwear.

A.3.3.35.1 CBRN Terrorism Incident Protective Garment(s). Garments include one-piece or multi-piece encapsulating suits or multi-piece non-encapsulating suits. In this standard, this term is also referred to in an abbreviated manner as a *protective garment(s)* and a *garment(s)*.

A.3.3.39.2 Liquefied Gas. Examples of liquefied gases include ammonia, 1,2-butadiene, chlorine, ethylene oxide, hydrogen chloride, liquefied petroleum gas, and methyl chloride. This is not an inclusive list of liquefied gases.

A.3.3.40.1 CBRN Terrorism Incident Protective Glove(s). In this standard, this term is also referred to in an abbreviated manner as a *protective glove(s)* and a *glove(s)*.

A.3.3.47 Non-Encapsulating. The non-encapsulating ensemble does not provide liquidtight, vaportight, or gastight protection.

A.3.3.51 Particulates. *Physical Classifications of Particulate Contaminants.*

Particulate Matter. There are at least seven forms of particulate matter as follows:

(1) *Aerosol.* A dispersion of solid or liquid particles of microscopic size in a gaseous medium such as smoke, fog, and mist.
(2) *Dust.* A term loosely applied to solid particles predominantly larger than colloidal and capable of temporary suspension in air or other gases. Derivation from larger masses through the application of physical force is usually implied.
(3) *Fog.* A term loosely applied to visible aerosols in which the dispersed phase is liquid. Formation by condensation is implied.
(4) *Fume.* Solid particles generated at condensation from the gaseous state, generally after volatilization from melted substances and often accompanied by a chemical reaction, such as oxidation. Popular usage sometimes loosely includes any type of contaminant.
(5) *Mist.* A term loosely applied to dispersion of liquid particles, many of which are large enough to be individually visible without visual aid.
(6) *Smog.* A term derived from the terms *smoke* and *fog* and applied to extensive atmospheric contamination by aerosols arising from a combination of natural and man-made sources.
(7) *Smoke.* Small gasborne particles resulting from incomplete combustion and consisting predominantly of carbon and other combustible materials.

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Physical Classification of Gases and Vapor Contaminants.

Gases and Vapors. Although, strictly speaking, a gas is defined as a substance above its critical temperature and a vapor is defined as the gaseous phase of a substance below its critical temperature, the term *gas* is usually applied to any material that is in the gaseous state at 25°C and 760 mm Hg pressure; the term *vapor* designates the gaseous phase of a substance that is ordinarily liquid or solid at 25°C and 760 mm Hg pressure. The distinction between the use of gas and vapor is not rigid, however. For example, hydrogen cyanide, which boils at 26°C, is always referred to as a gas, but hydrogen chloride, which boils at –83.7°C, is sometimes referred to as an acid vapor.

A.3.3.53 Product Label. The product label is not the certification organization's label, symbol, or identifying mark; however, the certification organization's label, symbol, or identifying mark can be attached to or be part of the product label. *(See also 3.2.3.)*

A.3.3.55.1 CBRN Terrorism Incident Protective Ensembles and Ensemble Elements. The elements of the protective ensemble are garments, gloves, and footwear. In this standard, this term is also referred to in an abbreviated manner as a *protective ensemble(s)* and an *ensemble(s)*.

A.3.3.61 Respirator. Respirators for CBRN terrorism incidents can include, but might not be limited to, self-contained breathing apparatus (SCBA), supplied air respirators (SAR), air-purifying respirators (APR), and powered air-purifying respirators (PAPR).

A.4.1.2 The compliance of protective ensembles in meeting this standard is determined by a battery of chemicals. Each protective ensemble, or individual element of a protective ensemble, meeting the requirements of this standard will have a list of chemicals associated with it.

Vapor-protective ensembles that are certified as compliant with the base requirements and certified with the optional CBRN terrorism protection requirements of NFPA 1991, *Standard on Vapor-Protective Ensembles for Hazardous Materials Emergencies*, also provide protection from CBRN terrorism agents.

NFPA, from time to time, has received complaints that certain items of first responder protective clothing or protective equipment might be carrying labels falsely identifying them as compliant with an NFPA standard. The requirement for placing the certification organization's mark on or next to the product label is to help ensure that the purchaser can readily determine compliance of the respective product through independent third-party certification.

NFPA advises those purchasing protective ensembles or protective ensemble elements to be aware of the following.

For protective ensembles or protective ensemble elements to meet the requirements of NFPA 1994, they must be certified by an independent third-party certification organization. In addition, the item must carry the label, symbol, or other identifying mark of that certification organization.

A protective ensemble or element that does not bear the mark of an independent third-party certification organization is NOT COMPLIANT with NFPA 1994, even if the product label states that the protective ensemble or element is compliant.

For further information about certification and product labeling, Chapter 4 and Chapter 5 of NFPA 1994 should be referenced. Also, the definitions for *certification/certified*, *labeled*, and *listed* in Chapter 3 should be reviewed.

Third-party certification is an important means of ensuring the quality of first responder protective clothing and equipment. To be certain that an item is properly certified, labeled, and listed, NFPA recommends that prospective purchasers require appropriate evidence of certification for the specific product and model from the manufacturer before purchasing. Prospective purchasers also should contact the certification organizations and request copies of the certification organization's "list" of certified products to the appropriate NFPA standard. This "listing" is a requirement of third-party certification by this standard and is a service performed by the certification organization.

All NFPA standards on fire and emergency services protective clothing and equipment require that the item be certified by an independent third-party certification organization and, as with NFPA 1994 protective ensembles or protective ensemble elements, all items of fire and emergency services protective clothing and equipment must carry the label, symbol, or other identifying mark of that certification organization.

Any item of protective clothing or protective equipment, covered by an NFPA standard, that does not bear the mark of an independent third-party certification organization is NOT COMPLIANT with the appropriate NFPA standard, even if the product label states that the item is compliant.

A.4.2.1 The certification organization should have a sufficient breadth of interest and activity so that the loss or award of a specific business contract would not be a determining factor in the financial well-being of the agency.

A.4.2.5 The contractual provisions covering a certification program should contain clauses advising the manufacturer that if requirements change, the product should be brought into compliance with the new requirements by a stated effective date through a compliance review program involving all currently listed products.

Without the clauses, certifiers would not be able to move quickly to protect their name, marks, or reputation. A product safety certification program would be deficient without these contractual provisions and the administrative means to back them up.

A.4.2.6 Investigative procedures are important elements of an effective and meaningful product safety certification program. A preliminary review should be carried out on products submitted to the agency before any major testing is undertaken.

A.4.2.7.1 For further information and guidance on recall programs, see 21 CFR 7, Subpart C.

A.4.2.9 Such inspections should include, in most instances, witnessing of production tests. With certain products the certification organization inspectors should select samples from the production line and submit them to the main laboratory for countercheck testing. With other products, it can be desirable to purchase samples in the open market for test purposes.

A.4.3.19 Manufacturers are not limited in their approaches for designing protective ensembles compliant with this standard. If the ensemble design uses combinations of materials or components to meet one part of the standard, then the same combinations must be assessed for all parts of the standard. For example, if a two-part visor is used such that the visor materials meet the chemical resistance requirement, the outer visor cannot be removed to meet the visor clarity requirement.

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The same configuration must be used for all performance requirements.

A.4.5.4 For example, this situation exists when the product is wholly manufactured and assembled by another entity, or entities, for a separate entity that puts their own name and label on the product, frequently called "private labeling," and markets and sells the product as their product.

A.4.5.5 Subcontractors should be considered to be, but not be limited to a person or persons, or a company, firm, corporation, partnership, or other organization having an agreement with or under contract with the compliant product manufacturer to supply or assemble the compliant product or portions of the compliant product.

A.4.6.1 ISO Guide 27, *Guidelines for corrective action to be taken by a certification body in the event of misuse of its mark of conformity,* is a component of accreditation of certification organizations specified in 4.1.4 and 4.2.3 of this standard. Those paragraphs contain a mandatory reference to ISO Guide 65, *General requirements for bodies operating product certification systems,* in which ISO Guide 27 is referenced.

A.4.6.2 By definition, a hazard might involve a condition that can be imminently dangerous to the end user. With this thought in mind, the investigation should be started immediately and completed in as timely a manner as is appropriate considering the particulars of the hazard being investigated.

A.4.6.11 The determination of the appropriate corrective action for the certification organization to initiate should take into consideration the severity of the product hazard and its potential consequences to the safety and health of end users. The scope of testing and evaluation should consider, among other things, testing to the requirements of the standard to which the product was listed as compliant, the age of the product, the type of use and conditions to which the compliant product has been exposed, care and maintenance that has been provided, the use of expertise on technical matters outside the certification organization's area of competence, and product hazards caused by circumstances not anticipated by the requirements of the applicable standard. As a guideline for determining which is more appropriate, a safety alert or a product recall, the following product hazard characteristics are provided, which are based on 42 CFR 84, Subpart E, §84.41:

(1) ***Critical:*** A product hazard that judgment and experience indicate is likely to result in a condition immediately hazardous to life or health (IHLH) for individuals using or depending on the compliant product. If an IHLH condition occurs, the user will sustain, or will be likely to sustain, an injury of a severity that could result in loss of life, or result in significant bodily injury or loss of bodily function, either immediately or at some point in the future.
(2) ***Major A:*** A product hazard, other than Critical, that is likely to result in failure to the degree that the compliant product does not provide any protection or reduces protection, and is not detectable to the user. The phrase *reduces protection* means the failure of specific protective design(s) or feature(s) that results in degradation of protection in advance of reasonable life expectancy to the point that continued use of the product is likely to cause physical harm to the user, or where continued degradation could lead to IHLH conditions.
(3) ***Major B:*** A product hazard, other than Critical or Major A, that is likely to result in reduced protection and is detectable to the user. The phrase *reduces protection* means the failure of specific protective design(s) or feature(s) that results in degradation of protection in advance of reasonable life expectancy to the point that continued use of the product is likely to cause physical harm to the user, or where continued degradation could lead to IHLH conditions.
(4) ***Minor:*** A product hazard, other than Critical, Major A, or Major B, that is not likely to materially reduce the usability of the compliant product for its intended purpose or a product hazard that is a departure from the established applicable standard and has little bearing on the effective use or operation of the compliant product for its intended purpose.

Where the facts are conclusive, based on characteristics of the hazard classified as indicated previously, the certification organization should consider initiating the following corrective actions with the authorized and responsible parties:

(1) Critical product hazard characteristics: product recall
(2) Major A product hazard characteristics: product recall or safety alert, depending on the nature of the specific product hazard
(3) Major B product hazard characteristics: safety alert or no action, depending on the nature of the specific product hazard
(4) Minor product hazard characteristic: no action

A.4.6.13 Reports, proposals, and proposed TIAs should be addressed to the technical committee that is responsible for the applicable standard and be sent in care of Standards Administration, NFPA, 1 Batterymarch Park, Quincy, MA 02169-7471.

A.5.1.1.7 See A.4.1.2.

A.5.3.1 Purchasers should use the technical data package to compare ensemble performance data when purchasing protective ensembles. The purchaser should determine the relative ranking of performance data to aid in this selection process.

A.5.3.2 Purchasers should request that all documentation and performance data be provided in a format that will allow easy comparison of products to aid selection.

A.5.3.4 Manufacturers should determine the size range of their ensembles by matching human dimensions with available ensemble sizes. These determinations should account for other clothing and equipment to be worn by the wearer as recommended by the manufacturer. Assessment of acceptable fit should be determined by using ASTM F 1154, *Standard Practice for Qualitatively Evaluating the Comfort, Fit, Function, and Integrity of Chemical Protective Suit Ensembles.*

A.5.3.5.4(2)(b) Hand dimensions for selection of proper glove size should consist of taking two dimensions as shown in Figure A.5.3.5.4(2)(b): the hand circumference and the length of the right hand.

Hand circumference should be measured by placing a measuring tape on a table or other flat surface with the numerals facing downward. The subject should place the right hand, palm down and fingers together, in the middle of the tape so that the tape can pass straight across the metacarpal knuckles. The circumference should be measured to the nearest 3.18 mm (⅛ in.).

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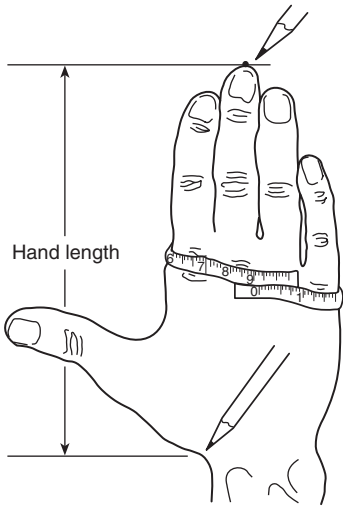

FIGURE A.5.3.5.4(2)(b) Method of Measuring Hand Dimensions.

Hand length should be measured by placing the subject's hand, palm down, on a piece of paper with the fingers together and the hand and arm in a straight line. The thumb should be fully abducted, extended away from the palm as far as possible. Mark the paper at the tip of the third, or middle, finger. A pencil mark should be placed in the notch at the base of the thumb where the thumb joins the wrist. The straight line distance between the two points should be measured to the nearest 3.18 mm (⅛ in.).

A.7.1.1.1 The minimum local physiological protective dosage factor for Class 2 ensembles is based on the NIOSH conditions used for CBRN SCBA (i.e., 300 mg/m^3 × 30 min = 9000 mg·min/m^3) in evaluating the permeation of the blister agent, distilled mustard (HD). This maximum exposure concentration is divided by the onset of symptoms exposure dosage (OSED), which is set at an exposure concentration (ECt_{10}) value that causes threshold mustard effects of blistering and ulceration in 10 percent of the population. Since blister agent effects vary with the body location, different values of the OSED are used for each body location (which vary from 25 to 100 mg·min/m^3). The reported value for local physiological protective dosage factor is normalized at each location so that each local physiological protective dosage factor is compared on the same basis. The systemic physiological protective dosage factor for Class 2 ensembles is based on NIOSH conditions used for CBRN SCBA (i.e., 2000 mg/m^3 × 30 min = 60,000 mg·min/m^3) in evaluating the permeation of the nerve agent, sarin (GB), where the soman (GD) concentration is assumed to be equivalent to the GB concentration specified in the standard. The onset of symptoms exposure dosage ($OSED_{sys}$) used to calculate the minimum systemic physiological protective dosage factor for GD is 166 mg·min/m^3 (Grotte, J. H. and L. I. Yang, "Report of the Workshop on Chemical Agent Toxicity for Acute Effects"). This value is the dosage of GD that produces threshold effects of twitching and localized sweating for 10 percent of the population (ECt_{10}).

A.7.2.1.1 The minimum local physiological protective dosage factor for Class 3 ensembles is based on the NIOSH conditions used for CBRN APR (i.e., 50 mg/m^3 × 60 min = 3000 mg·min/m^3) in evaluating the permeation of the blister agent, distilled mustard (HD). This maximum exposure concentration is divided by the onset of symptoms exposure dosage (OSED), which is set at an exposure concentration (ECt_{10}) value that causes threshold mustard effects of blistering or ulceration in 10 percent of the population. Since blister agent effects vary with the body location, different values of the OSED are used for each body location (which vary from 25 to 100 mg·min/m^3). The reported value for local physiological protective dosage factor is normalized at each location so that each local physiological protective dosage factor is compared on the same basis. The systemic physiological protective dosage factor for Class 3 ensembles is based on NIOSH conditions used for CBRN APR (i.e., 210 mg/m^3 × 60 min = 12,600 mg·min/m^3) in evaluating the permeation of the nerve agent, sarin (GB), where the soman (GD) concentration is assumed to be equivalent to the GB concentration specified in the standard. The onset of symptoms exposure dosage ($OSED_{sys}$) used to calculate the minimum systemic physiological protective dosage factor for GD is 166 mg·min/m^3 (Grotte, J. H., and L. I. Yang, "Report of the Workshop on Chemical Agent Toxicity for Acute Effects"). This value is the dosage of GD that produces threshold effects of twitching and localized sweating for 10 percent of the population (ECt_{10}).

A.8.2.3.7 SCBA and some styles of footwear might be acceptable after washing and 3 weeks in a ventilated space. Some items such as gloves and garments cannot be easily decontaminated.

A.8.2.4.7 Examples of suitable analytical techniques include gas chromatography with thermal desorption of the adsorbent in the PAD, and high performance liquid chromatography with methanol extraction of the adsorbent in the PAD.

A.8.2.5.9.4 One example of an appropriate analytical technique is NIOSH Method 6602, which uses a gas chromatograph equipped with an electron capture detector.

A.8.2.7.2.1 These values are based on an analysis of the chamber data of Gorrill and Heinen presented in AEP-52 broken down by body region and are the ECt_{10} values for severe erythema/blistering/desquamation. They include data for hot/humid exposures, where volunteers wore clothing covering almost everything but hands/neck, and clothing was not necessarily removed immediately after exposure. Clothing is assumed to provide a PF of 2.

A.8.5.5.3 Areas of the indicator garments are masked to provide an additional means of evaluating leakage. The removal of the masked areas following testing allows for uncontaminated areas for comparison purposes. Inappropriate materials for masking can affect the indicator garment by tearing, leaving residue, skewing black light visual analysis, etc.

A.8.5.5.8 Procedure A of ASTM F 1154, *Standard Practice for Qualitatively Evaluating the Comfort, Fit Function, and Integrity of Chemical Protective Suit Ensembles,* is modified by excluding the crawling and kneeling activities. The Particulate Inward Leakage Test is not intended to include mechanical action or contact as part of the test method, therefore the crawling and kneeling activities were not included and rest periods are completed in a standing position.

A.8.5.5.11 The Super-High-Intensity Lamp, Model SB-100P with Flood Bulb from Spectroline or equivalent has been found suitable for use to meet the black light specifications.

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A.8.7.4.4.3 Due to the density differences, more drops are required for GD than for DMS and HD. Dimethylsulfate density is close to that of mustard, and therefore a dot pattern similar to the mustard dot pattern is recommended (densities: HD = 1.268 g/cc; GD = 1.0887 g/cc; DMS = 1.3322 g/cc).

A.8.7.6.2 In ASTM F 739, *Standard Test Method for Resistance of Protective Clothing Materials to Permeation by Liquids or Gases Under Conditions of Continuous Contact*, normalized breakthrough time is the time at which permeation of the challenge chemical through the specimen exceeds 0.1 $\mu g/cm^2$/min. If the permeation rate does not exceed this 0.1 $\mu g/cm^2$/min, the normalized breakthrough time is reported as greater than the test duration, or, in this case, >60 minutes. However, this does not mean that breakthrough did not occur. If the permeation rate remained slightly under 0.1 $\mu g/cm^2$/min for the 60-minute duration of this procedure, a level of 6 $\mu g/cm^2$/min of chemical would have permeated.

Annex B Informational References

B.1 Referenced Publications. The documents or portions thereof listed in this annex are referenced within the informational sections of this standard and are not part of the requirements of this document unless also listed in Chapter 2 for other reasons.

B.1.1 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 1991, *Standard on Vapor-Protective Ensembles for Hazardous Materials Emergencies*, 2005 edition.

NFPA 1992, *Standard on Liquid Splash-Protective Ensembles and Clothing for Hazardous Materials Emergencies*, 2005 edition.

B.1.2 Other Publications.

B.1.2.1 ASTM Publications. ASTM International, 100 Barr Harbor Drive, P.O. Box C 700, West Conshohocken, PA 19428-2959.

ASTM F 739, *Standard Test Method for Resistance of Protective Clothing Materials to Permeation by Liquids or Gases Under Conditions of Continuous Contact*, 1999.

ASTM F 1154, *Standard Practice for Qualitatively Evaluating the Comfort, Fit, Function, and Integrity of Chemical Protective Suit Ensembles*, 1999.

B.1.2.2 ISO Publications. International Organization for Standardization, 1 rue de Varembé, Case postale 56, CH-1211, Geneve 20, 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.

ISO Guide 65, *General requirements for bodies operating product certification systems*, 1996.

B.1.2.3 U.S. Government Publications. U.S. Government Printing Office, Washington, DC 20402.

Title 21, Code of Federal Regulations, Part 7, Subpart C.

Title 42, Code of Federal Regulations, Part 84, Subpart E.

B.1.2.4 Other Publications.

Grotte, J. H., and L. I. Yang, "Report of the Workshop on Chemical Agent Toxicity for Acute Effects," IDA Document D-2176, Institute for Defense Analysis, Alexandria, VA, May 1998.

NATO Document No. 1268015. AEP-52, "Assessment of the Effect Levels of Classical Chemical Warfare Agents Applied to the Skin to be Used in the Design of Protective Equipment."

B.2 Informational References. (Reserved)

B.3 References for Extracts in Informational Sections. (Reserved)

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3.3.78 Effective Ground-Fault Current Path. An intentionally constructed, permanent, low impedance electrically conductive path designed and intended to carry ~~underground~~ electric fault current ~~conditions~~ from the point of a ground fault on a wiring system to the electrical supply source.

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