NFPA®

1994

Standard on Protective Ensembles for First Responders to Hazardous Materials Emergencies and CBRN Terrorism Incidents

2018

NFPA®

DESIGNATED SAFETY ACT www.safetyact.gov

IMPORTANT NOTICES AND DISCLAIMERS CONCERNING NFPA® STANDARDS

NOTICE AND DISCLAIMER OF LIABILITY CONCERNING THE USE OF NFPA STANDARDS

NFPA® codes, standards, recommended practices, and guides ("NFPA Standards"), of which the document contained herein is one, are developed through a consensus standards development process approved by the American National Standards Institute. This process brings together volunteers representing varied viewpoints and interests to achieve consensus on fire and other safety issues. While the NFPA administers the process and establishes rules to promote fairness in the development of consensus, it does not independently test, evaluate, or verify the accuracy of any information or the soundness of any judgments contained in NFPA Standards.

The NFPA disclaims liability for any personal injury, property, or other damages of any nature whatsoever, whether special, indirect, consequential or compensatory, directly or indirectly resulting from the publication, use of, or reliance on NFPA Standards. The NFPA also makes no guaranty or warranty as to the accuracy or completeness of any information published herein.

In issuing and making NFPA Standards available, the NFPA is not undertaking to render professional or other services for or on behalf of any person or entity. Nor is the NFPA undertaking to perform any duty owed by any person or entity to someone else. Anyone using this document should rely on his or her own independent judgment or, as appropriate, seek the advice of a competent professional in determining the exercise of reasonable care in any given circumstances.

The NFPA has no power, nor does it undertake, to police or enforce compliance with the contents of NFPA Standards. Nor does the NFPA list, certify, test, or inspect products, designs, or installations for compliance with this document. Any certification or other statement of compliance with the requirements of this document shall not be attributable to the NFPA and is solely the responsibility of the certifier or maker of the statement.

REVISION SYMBOLS IDENTIFYING CHANGES FROM THE PREVIOUS EDITION

Text revisions are shaded. A Δ before a section number indicates that words within that section were deleted and a Δ to the left of a table or figure number indicates a revision to an existing table or figure. When a chapter was heavily revised, the entire chapter is marked throughout with the Δ symbol. Where one or more sections were deleted, a • is placed between the remaining sections. Chapters, annexes, sections, figures, and tables that are new are indicated with an *N*.

Note that these indicators are a guide. Rearrangement of sections may not be captured in the markup, but users can view complete revision details in the First and Second Draft Reports located in the archived revision information section of each code at www.nfpa.org/docinfo. Any subsequent changes from the NFPA Technical Meeting, Tentative Interim Amendments, and Errata are also located there.

ALERT: THIS STANDARD HAS BEEN MODIFIED BY A TIA OR ERRATA

Users of NFPA codes, standards, recommended practices, and guides ("NFPA Standards") should be aware that NFPA Standards may be amended from time to time through the issuance of a Tentative Interim Amendment (TIA) or corrected by Errata. An official NFPA Standard at any point in time consists of the current edition of the document together with any TIAs and Errata then in effect.

To determine whether an NFPA Standard has been amended through the issuance of TIAs or corrected by Errata, go to www.nfpa.org/docinfo to choose from the list of NFPA Standards or use the search feature to select the NFPA Standard number (e.g., NFPA 13). The document information page provides up-to-date document-specific information as well as postings of all existing TIAs and Errata. It also includes the option to register for an "Alert" feature to receive an automatic email notification when new updates and other information are posted regarding the document.

ISBN: 978-145591731-0 (Print)
ISBN: 978-145591732-7 (PDF)
ISBN: 978-145591774-7 (eBook)

IMPORTANT NOTICES AND DISCLAIMERS CONCERNING NFPA® STANDARDS

ADDITIONAL NOTICES AND DISCLAIMERS

Updating of NFPA Standards

Users of NFPA codes, standards, recommended practices, and guides ("NFPA Standards") should be aware that these documents may be superseded at any time by the issuance of new editions or may be amended from time to time through the issuance of Tentative Interim Amendments or corrected by Errata. An official NFPA Standard at any point in time consists of the current edition of the document together with any Tentative Interim Amendments and any Errata then in effect. In order to determine whether a given document is the current edition and whether it has been amended through the issuance of Tentative Interim Amendments or corrected through the issuance of Errata, consult appropriate NFPA publications such as the National Fire Codes® Subscription Service, visit the NFPA website at www.nfpa.org, or contact the NFPA at the address listed below.

Interpretations of NFPA Standards

A statement, written or oral, that is not processed in accordance with Section 6 of the Regulations Governing the Development of NFPA Standards shall not be considered the official position of NFPA or any of its Committees and shall not be considered to be, nor be relied upon as, a Formal Interpretation.

Patents

The NFPA does not take any position with respect to the validity of any patent rights referenced in, related to, or asserted in connection with an NFPA Standard. The users of NFPA Standards bear the sole responsibility for determining the validity of any such patent rights, as well as the risk of infringement of such rights, and the NFPA disclaims liability for the infringement of any patent resulting from the use of or reliance on NFPA Standards.

NFPA adheres to the policy of the American National Standards Institute (ANSI) regarding the inclusion of patents in American National Standards ("the ANSI Patent Policy"), and hereby gives the following notice pursuant to that policy:

NOTICE: The user's attention is called to the possibility that compliance with an NFPA Standard may require use of an invention covered by patent rights. NFPA takes no position as to the validity of any such patent rights or as to whether such patent rights constitute or include essential patent claims under the ANSI Patent Policy. If, in connection with the ANSI Patent Policy, a patent holder has filed a statement of willingness to grant licenses under these rights on reasonable and nondiscriminatory terms and conditions to applicants desiring to obtain such a license, copies of such filed statements can be obtained, on request, from NFPA. For further information, contact the NFPA at the address listed below.

Law and Regulations

Users of NFPA Standards should consult applicable federal, state, and local laws and regulations. NFPA does not, by the publication of its codes, standards, recommended practices, and guides, intend to urge action that is not in compliance with applicable laws, and these documents may not be construed as doing so.

Copyrights

NFPA Standards are copyrighted. They are made available for a wide variety of both public and private uses. These include both use, by reference, in laws and regulations, and use in private self-regulation, standardization, and the promotion of safe practices and methods. By making these documents available for use and adoption by public authorities and private users, the NFPA does not waive any rights in copyright to these documents.

Use of NFPA Standards for regulatory purposes should be accomplished through adoption by reference. The term "adoption by reference" means the citing of title, edition, and publishing information only. Any deletions, additions, and changes desired by the adopting authority should be noted separately in the adopting instrument. In order to assist NFPA in following the uses made of its documents, adopting authorities are requested to notify the NFPA (Attention: Secretary, Standards Council) in writing of such use. For technical assistance and questions concerning adoption of NFPA Standards, contact NFPA at the address below.

For Further Information

All questions or other communications relating to NFPA Standards and all requests for information on NFPA procedures governing its codes and standards development process, including information on the procedures for requesting Formal Interpretations, for proposing Tentative Interim Amendments, and for proposing revisions to NFPA standards during regular revision cycles, should be sent to NFPA headquarters, addressed to the attention of the Secretary, Standards Council, NFPA, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101; email: stds_admin@nfpa.org.

For more information about NFPA, visit the NFPA website at www.nfpa.org. All NFPA codes and standards can be viewed at no cost at www.nfpa.org/docinfo.

NFPA® 1994

Standard on

Protective Ensembles for First Responders to Hazardous Materials Emergencies and CBRN Terrorism Incidents

2018 Edition

This edition of NFPA 1994, *Standard on Protective Ensembles for First Responders to Hazardous Materials Emergencies and CBRN Terrorism Incidents*, was prepared by the Technical Committee on Hazardous Materials Protective Clothing and Equipment and released by the Correlating Committee on Fire and Emergency Services Protective Clothing and Equipment. It was issued by the Standards Council on August 1, 2017, with an effective date of August 21, 2017, and supersedes all previous editions.

This document has been amended by one or more Tentative Interim Amendments (TIAs) and/or Errata. See "Codes & Standards" at www.nfpa.org for more information.

This edition of NFPA 1994 was approved as an American National Standard on August 21, 2017.

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 indicated 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 is necessary for these operations; the appropriate respiratory protection needs to be addressed by the emergency responder organizations.

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

The 2007 edition was a complete revision. The title of the document was 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, were incorporated into NFPA 1991, *Standard on Vapor-Protective Ensembles for Hazardous Materials Emergencies*, 2005 edition, and were then incorporated into the base requirements for all vapor-protective ensembles. For the 2007 and 2012 editions, NFPA 1994 no longer specified a Class 1 ensemble but left the designation "Class 1" vacant. A new Class 4 ensemble was added to provide particulate protection for emergency responders to incidents where no chemical agent is identified but a particulate threat is present (including "white powder" incidents).

The CBRN protection requirements were developed to apply to all emergency first responders at hazardous materials and CBRN incidents. Individual agencies (law enforcement, emergency medical, medical first receivers, fire, and 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.

In the 2007 edition, the committee also included new requirements in Chapter 4 for manufacturers' quality assurance programs and for situations in which 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 requirements apply to all emergency services product standards that are the responsibility of this project. All labeling, design, performance, and testing requirements were reviewed and refined as necessary.

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

The 2012 edition was extensively revised and included an updated permeation resistance test method with associated criteria for toxic industrial chemicals based on the cumulative permeation mass in one hour rather than breakthrough time; several new definitions; updates to several ANSI, ISO/IEC, and ASTM standards; and editorial, numbering, and formatting changes. The slip resistance test was revised based on new information that was proposed during the revision process related to the requirements necessary for evaluating the entire footwear sole. Additionally, the section on a Manufacturers' Quality Assurance Program was revised, and the Puncture Resistance Test 2 and the Impact and Compression Resistance Test were deleted from the standard and replaced with a design requirement that the footwear meet an ASTM specification for puncture and impact-resistant footwear.

The 2018 edition modifies the scope and title of the standard to include both hazardous materials and CBRN to minimize confusion as to the applicability of the standard for incidents that are not terrorism in nature. In addition, Class 1 ensemble requirements have been re-established within the standard, thereby reversing the decision to remove them in 2007. The Class 1 criteria parallel those in the 2016 edition of NFPA 1991 but provide practical criteria for both material barrier performance and overall design that result in a more form-fitting and tactical-based product. Ruggedized categories of certification (Type R) have been added for Classes 2, 3, and 4 to address the increasing use of the garments in harsher environments, such as urban search and rescue and law enforcement applications. These criteria involve more rigorous preconditioning of ensemble material prior to material barrier testing and ensemble integrity evaluations and higher levels of material physical property performance. Based upon recent research published by the U.S. Department of Defense, the chemical challenges have been modified to represent the vast diversity of chemicals found in the global chemical industry and to cover the breadth of fundamental chemical reactivity principles. Material breathability as measured by evaporative resistance and total heat loss has been addressed by reporting results for Class 2 and Class 2R ensembles and applying specific requirements for Class 3/3R and Class 4/4R ensembles. Footwear options have been broadened to allow for more flexibility when a chemical protective sock is used in coordination with the boot. Specific criteria have been developed to address separate hoods and elastomeric gasket materials. Optional criteria have been added for flash fire protection for all ensemble levels with a minimum level of flame resistance established for Class 1 ensembles. Finally, new stealth optional indicators for audible signatures and color have been added to address tactical operator concerns. Many other test methods have been modified for consistency following interlaboratory and intralaboratory validation efforts.

Correlating Committee on Fire and Emergency Services Protective Clothing and Equipment

William E. Haskell, III, *Chair*
National Institute for Occupational Safety & Health, MA [E]
Rep. National Institute for Occupational Safety & Health

Jason L. Allen, Intertek Testing Services, NY [RT]

James B. Area, Chimera Enterprises International, MD [SE]

Joseph Arrington, San Antonio Fire Department, TX [U]

Roger L. Barker, North Carolina State University, NC [SE]

James E. Brinkley, International Association of Fire Fighters, DC [L]
Rep. International Association of Fire Fighters

Steven D. Corrado, UL LLC, NC [RT]

Cristine Z. Fargo, International Safety Equipment Association, VA [M]

Edmund Farley, Pittsburgh Bureau Of Fire, PA [E]

Robert A. Freese, Globe Manufacturing Company, NH [M]

Patricia A. Gleason, ASTM/Safety Equipment Institute (SEI), VA [RT]

David V. Haston, U.S. Department of Agriculture, ID [E]

Diane B. Hess, PBI Performance Products, Inc., NC [M]

Thomas M. Hosea, U.S. Department of the Navy, FL [RT]

James S. Johnson, Lawrence Livermore National Laboratory, CA [RT]

Jeff Legendre, Northborough Fire Department, MA [U]

Karen E. Lehtonen, Lion Group, Inc., OH [M]

Gregory J. Mackin, Boston Fire Department, MA [E]

David G. Matthews, Fire & Industrial (PPE) Ltd., United Kingdom [SE]
Rep. International Standards Organization

Benjamin Mauti, Mine Safety Appliances Company, PA [M]
Rep. Compressed Gas Association

Michael F. McKenna, Michael McKenna & Associates, LLC, CA [SE]

John H. Morris, TYCO/Scott Safety, GA [M]

Jack E. Reall, Columbus (OH) Division of Fire, OH [L]
Rep. Columbus Firefighters Union

Jeffrey O. Stull, International Personnel Protection, Inc., TX [M]

Tim W. Tomlinson, Addison Fire Department, TX [C]

Robert D. Tutterow, Jr., Fire Industry Equipment Research Organization (FIERO), NC [U]
Rep. NFPA Fire Service Section

William A. Van Lent, Veridian Ltd., Inc., IA [M]
Rep. Fire & Emergency Manufacturers & Services Association

Bruce H. Varner, BHVarner & Associates, AZ [M]
Rep. International Fire Service Training Association

Steven H. Weinstein, Honeywell Safety Products, CA [M]

Richard Weise, Los Angeles County Fire Department, CA [U]

Harry P. Winer, HIP Consulting LLC, MA [SE]

Alternates

Louis Carpentier, Innotex Inc., Canada [M]
(Alt. to William A. Van Lent)

Patricia A. Freeman, Globe Manufacturing Company, LLC, NH [M]
(Alt. to Robert A. Freese)

Tim J. Gardner, 3M Company, MN [M]
(Alt. to Cristine Z. Fargo)

Pamela A. Kavalesky, Intertek Testing Services, NY [RT]
(Alt. to Jason L. Allen)

Judge W. Morgan, Tyco/Scott Safety, NC [M]
(Alt. to John H. Morris)

Gary L. Neilson, Sparks, NV [U]
(Alt. to Robert D. Tutterow, Jr.)

Amanda H. Newsom, UL LLC, NC [RT]
(Alt. to Steven D. Corrado)

Anthony Petrilli, U.S. Department of Agriculture, MT [E]
(Alt. to David V. Haston)

Stephen R. Sanders, ASTM/Safety Equipment Institute (SEI), VA [RT]
(Alt. to Patricia A. Gleason)

Russell Shephard, Australasian Fire & Emergency Service Authorities Council, Australia [SE]
(Alt. to David G. Matthews)

David P. Stoddard, Michael McKenna & Associates, LLC, CA [SE]
(Alt. to Michael F. McKenna)

Grace G. Stull, International Personnel Protection, Inc., TX [M]
(Alt. to Jeffrey O. Stull)

Jonathan V. Szalajda, National Institute for Occupational Safety & Health, PA [E]
(Alt. to William E. Haskell, III)

Donald B. Thompson, North Carolina State University, NC [SE]
(Alt. to Roger L. Barker)

W. Jason Traynor, MSA Safety, PA [M]
(Alt. to Benjamin Mauti)

Jian Xiang, The DuPont Company, Inc., VA [M]
(Alt. to Diane B. Hess)

Nonvoting

Robert J. Athanas, FDNY/SAFE-IR, Incorporated, NY [U]
Rep. TC on Electronic Safety Equipment

Christina M. Baxter, U.S. Department of Defense, VA [E]
Rep. TC on Hazardous Materials PC&E

Tricia L. Hock, ASTM/Safety Equipment Institute (SEI), VA [RT]
Rep. TC on Emergency Medical Services PC&E

Stephen J. King, Babylon, NY [SE]
Rep. TC on Structural and Proximity Fire Fighting PC&E

Jeremy Metz, West Metro Fire Rescue, CO [U]
Rep. TC on Special Operations PC&E

Brian Montgomery, U.S. Department of Justice, DC [E]

Daniel N. Rossos, Oregon Department of Public Safety Standards & Training, OR [E]
Rep. TC on Respiratory Protection Equipment

Rick L. Swan, IAFF Local 2881/CDF Fire Fighters, VA [L]
Rep. TC on Wildland Fire Fighting PC&E

Chris Farrell, NFPA Staff Liaison

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

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

Committee Scope: This Committee shall have primary responsibility for documents on 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.

Technical Committee on Hazardous Materials Protective Clothing and Equipment

Christina M. Baxter, *Chair*
U.S. Department of Defense, VA [E]

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

Jason L. Allen, Intertek Testing Services, NY [RT]
Ted S. Buck, Orr Safety Corporation, KY [M]
Brian J. Clifford, U.S. Federal Bureau of Investigation, VA [U]
Steven D. Corrado, UL LLC, NC [RT]
Richard P. Daly, Jr., St. Charles Fire Department, MO [U]
Nicholas Del Re, Fire Department City of New York, NY [L]
Rep. International Association of Fire Fighters
Dustin Green, Citrus County Sheriffs Office, FL [C]
Russell R. Greene, Battelle Memorial Institute, OH [RT]
Todd W. Haines, Dallas/Fort Worth International Airport, TX [U]
A. Ira Harkness, U.S. Department of the Navy, FL [RT]
William E. Haskell, III, National Institute for Occupational Safety & Health, MA [E]
Rep. National Institute for Occupational Safety & Health
Ryan C. Hirschey, Saint-Gobain Performance Plastics, NH [M]
Kyle Kerbow, Lakeland Industries, TX [M]
Rep. International Safety Equipment Association
Michael P. Kienzle, W. L. Gore & Associates, Inc., MD [M]
Andra Kirsteins, U.S. Department of the Army, MA [RT]
Karen E. Lehtonen, Lion Group, Inc., OH [M]
Susan L. Lovasic, The DuPont Company, Inc., VA [M]
Philip C. Mann, Kappler, Inc., AL [M]
John W. North, Alexandria Fire Department, VA [U]
Ulf Nystrom, Ansell Protective Solutions, Sweden [M]
Paul G. Rogers, Fire Department City of New York, NY [U]
Rep. Fire Department City of New York
Robert E. Shelton, City of Cincinnati Fire Department, OH [C]
Jeffrey O. Stull, International Personnel Protection, Inc., TX [M]
Donald B. Thompson, North Carolina State University, NC [SE]
Robert West, Texas Instruments, Inc., TX [U]
John E. Wisner, Jr., United Steam Fire Engine Company No. 3, AZ [U]
James P. Zeigler, J. P. Zeigler, LLC, VA [SE]
Michael Ziskin, Field Safety Corporation, CT [RT]

Alternates

Dale Gregory Beggs, Texas Instruments, Inc., TX [U]
(Alt. to Robert West)
D. Mark Bledsoe, U.S. Federal Bureau of Investigations, VA [U]
(Alt. to Brian J. Clifford)
Ronald L. Bove, W. L. Gore & Associates, Inc., MD [M]
(Alt. to Michael P. Kienzle)
Ted J. Cooper, U.S. Department of the Navy, FL [RT]
(Alt. to A. Ira Harkness)
Paul Vincent Dulisse, New York City Fire Department, NY [U]
(Alt. to Paul G. Rogers)
William A. Fithian, ASTM/Safety Equipment Institute (SEI), VA [RT]
(Alt. to Patricia A. Gleason)
Pamela A. Kavalesky, Intertek Testing Services, NY [RT]
(Alt. to Jason L. Allen)
Jeffrey Kennedy, Austin Fire Department, TX [U]
(Alt. to Todd W. Haines)
Devang Khariwala, Saint-Gobain Performance Plastics, NH [M]
(Alt. to Ryan C. Hirschey)
Paul S. Lakomiak, Ansell/Onguard Industries/Dunlop, MD [M]
(Alt. to Ulf Nystrom)
Beth C. Lancaster, U.S. Department of Defense, VA [E]
(Alt. to Christina M. Baxter)
Amanda H. Newsom, UL LLC, NC [RT]
(Alt. to Steven D. Corrado)
R. Bryan Ormond, North Carolina State University, NC [SE]
(Alt. to Donald B. Thompson)
Louis V. Ott, Gentex Corporation, PA [M]
(Alt. to Kyle Kerbow)
Enrique Eduardo Perea, Miami Dade Fire Rescue, FL [L]
(Alt. to Nicholas Del Re)
Diane Redden, Lion Group, Inc., OH [M]
(Alt. to Karen E. Lehtonen)
Richard C. Shoaf, St. Charles Fire Department, MO [U]
(Alt. to Richard P. Daly, Jr.)
Grace G. Stull, International Personnel Protection, Inc., TX [M]
(Alt. to Jeffrey O. Stull)
Quoc T Truong, U.S. Department of the Army, MA [RT]
(Alt. to Andra Kirsteins)
Kristin Williamson, The DuPont Company, Inc., VA [M]
(Alt. to Susan L. Lovasic)

Thomas McGowan, NFPA Staff Liaison

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

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

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

Contents

NFPA 1994

Standard on

Protective Ensembles for First Responders to Hazardous Materials Emergencies and CBRN Terrorism Incidents

2018 Edition

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

A reference in brackets [ ] following a section or paragraph indicates material that has been extracted from another NFPA document. As an aid to the user, the complete title and edition of the source documents for extracts in the recommendations sections of this document are given in Chapter 2 and those for extracts in the informational sections are given in Annex B. Extracted text may be edited for consistency and style and may include the revision of internal paragraph references and other references as appropriate. Requests for interpretations or revisions of extracted text should be sent to the technical committee responsible for the source document.

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 used during hazardous materials and chemical, biological, radiological, or nuclear (CBRN) terrorism incidents.

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

N **1.1.2.1*** This standard shall also establish requirements for ruggedized ensembles that can be used multiple times where there is no exposure to hazardous materials and CBRN terrorism agents and that provide a greater level of physical hazard resistance and increased durability.

N **1.1.2.2** This standard shall also establish additional optional requirements for hazardous materials and CBRN protective ensembles for escape protection only from chemical flash fires encountered during hazardous materials and CBRN incidents.

N **1.1.2.3** This standard shall also establish additional optional requirements for hazardous materials and CBRN protective ensembles addressing stealth characteristics of ensembles.

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

1.1.4* This standard shall not establish requirements for respiratory protection for incidents involving hazardous materials or CBRN terrorism agents. Appropriate respiratory protection for the incidents involving specific hazardous materials or 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 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.

1.1.8 This standard shall not be construed as addressing all of the safety concerns associated with the use of compliant hazardous materials and CBRN protective ensembles and ensemble elements. It shall be the responsibility of the persons and organizations that use compliant hazardous materials and CBRN protective ensembles and ensemble elements to establish safety and health practices and to determine the applicability of regulatory limitations prior to use.

1.1.9 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 hazardous materials and CBRN protective ensembles and ensemble elements to establish safety and health practices and to determine the applicability of regulatory limitations prior to using this standard for any designing, manufacturing, and testing.

1.1.10 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 hazardous materials and CBRN terrorism agents.

1.2.1.1 To achieve this purpose, this standard shall establish minimum requirements for hazardous materials and CBRN protective ensembles and ensemble elements for emergency first responder personnel responding to incidents involving hazardous materials and 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 hazardous materials and CBRN terrorism agents.

1.2.1.2 This standard shall provide emergency first responder personnel with four levels of hazardous materials and 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.

N **1.2.1.3** This standard shall establish a level of physical hazard resistance for three of the four levels of CBRN ensembles and ensemble elements that could be selected for those operations where ensembles are used multiple times without exposure to hazardous materials and CBRN terrorism agents and for operations requiring increased durability.

N **1.2.1.4** This standard shall establish a minimum level of limited chemical flash fire protection for escape only in the event of a chemical flash fire, as an option for compliant CBRN protective ensembles and ensemble elements.

N **1.2.1.5** This standard shall establish a minimum level of stealth characteristics, as an option for compliant CBRN ensembles.

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* The requirements for Class 1 hazardous materials and CBRN protective ensembles and ensemble elements shall apply to ensembles designed to provide protection to emergency first responder personnel at 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).

1.3.2 The requirements for Class 2 hazardous materials and CBRN protective ensembles and ensemble elements shall apply to ensembles designed to provide limited protection to emergency first responder personnel at hazardous materials or 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 hazardous materials and CBRN protective ensembles and ensemble elements shall apply to ensembles designed to provide limited protection to emergency first responder personnel at hazardous materials or 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 air-purifying respirators (APR).

1.3.4 The requirements for Class 4 hazardous materials and CBRN protective ensembles and ensemble elements shall apply to ensembles designed to provide limited protection to emergency first responder personnel at terrorism incidents involving particulate hazards, including 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* hazardous materials and 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 hazardous materials or CBRN protective ensembles and ensemble elements for incidents involving hazardous materials or CBRN terrorism incidents, which are manufactured in accordance with other specifications or the standards of other organizations.

Δ **1.3.8** This standard shall not apply to use requirements for hazardous materials and CBRN protective ensembles and ensemble elements for incidents involving hazardous materials or CBRN terrorism agents, as these requirements are specified in NFPA 1500.

1.3.9* The requirements of this standard shall not apply to any accessories that might be attached to any CBRN protective ensemble 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 704, *Standard System for the Identification of the Hazards of Materials for Emergency Response,* 2017 edition.

NFPA 1500, *Standard on Fire Department Occupational Safety, Health, and Wellness Program,* 2018 edition.

NFPA 1951, *Standard on Protective Ensembles for Technical Rescue Incidents,* 2013 edition.

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

NFPA 1981, *Standard on Open-Circuit Self-Contained Breathing Apparatus (SCBA) for Emergency Services,* 2013 edition.

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

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

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

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

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

2.3 Other Publications.

N **2.3.1 AAFA Publications.** American Apparel and Footwear Association, 1601 No. Kent Street, Suite 1200, Arlington, VA 22209.

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

N **2.3.2 AATCC Publications.** American Association of Textile Chemists and Colorists, P. O. Box 12215, Research Triangle Park, NC 27709.

AATCC Evaluation Procedure 6, *Instrumental Color Measurement*, 2008.

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

ANSI/ISEA Z87.1, *American National Standard for Occupational and Educational Eye and Face Protective Devices*, 2015.

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

Δ **2.3.4 ASTM Publications.** ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959.

ASTM D412, *Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers — Tension*, 2015a.

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

ASTM D751, *Standard Test Methods for Testing Coated Fabrics*, 2011.

ASTM D1776/D1776M, *Standard Practice for Conditioning and Testing Textiles*, 2016.

ASTM D2582, *Standard Test Method for Puncture Propagation Tear Resistance of Plastic Film and Thin Sheeting*, 2009.

ASTM D3884, *Standard Guide for Abrasion Resistance of Textile Fabrics (Rotary Platform, Double-Head Method)*, 2013 e1.

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

ASTM D5151, *Standard Test Method for Detection of Holes in Medical Gloves*, 2015.

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

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

ASTM F1154, *Standard Practices for Qualitatively Evaluating the Comfort, Fit, Function, and Durability of Protective Ensembles and Ensemble Components*, 2011.

ASTM F1301, *Standard Practice for Labeling Chemical Protective Clothing*, 2011 e1.

ASTM F1342/F1342M, *Standard Test Method for Resistance of Protective Clothing Materials to Puncture*, 2013.

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

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

ASTM F1671/F1671M, *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*, 2013.

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

ASTM F1868, *Standard Test Method for Thermal and Evaporative Resistance of Clothing Materials Using a Sweating Hot Plate,* 2014.

ASTM F2010/F2010M, *Standard Test Method for Evaluation of Glove Effects on Wearer Hand Dexterity Using a Modified Pegboard Test*, 2010.

ASTM F2412, *Standard Test Methods for Foot Protection*, 2011.

ASTM F2413, *Standard Specification for Performance Requirements for Protective (Safety) Toe Cap Footwear*, 2011.

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

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

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

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

ISO 4649, *Rubber, vulcanized or thermoplastic — Determination of abrasion resistance using a rotating cylindrical drum device*, 2010.

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

ISO 13287, *Personal protective equipment — Footwear — Test method for slip resistance*, 2012.

ISO 9001, *Quality management systems — Requirements,* 2008.

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

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/IEC 17011, *Conformity assessment — General requirements for accreditation bodies accrediting conformity assessment bodies*, 2004.

ISO/IEC 17021, *Conformity assessment — Requirements for bodies providing audit and certification of management systems — Part 1: requirements*, 2015.

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

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

•

2.3.7 NIOSH Publications. National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention, 1600 Clifton Road, Atlanta, GA 30333.

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.

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

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

2.3.9 Other Publications.

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

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

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

3.2.5 Shall. Indicates a mandatory requirement.

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

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

3.3 General Definitions.

3.3.1 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 3.3.7.

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

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

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

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

3.3.7 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.)*

3.3.8 CBRN Terrorism Incident Protective Ensembles and Ensemble Elements. Multiple elements, categorized as Class 1, 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.

N **3.3.8.1** ***Class 1 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).

3.3.8.2 ***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).

Δ **3.3.8.3** ***Class 3 CBRN Protective Ensemble and Ensemble Elements.*** A CBRN protective ensemble and ensemble elements 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).

Δ **3.3.8.4** ***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).

3.3.9 CBRN Terrorism Incident Protective Footwear. The element of the protective ensemble that provides protection to the foot, ankle, and lower leg.

3.3.10 CBRN Terrorism Incident Protective Footwear Cover. The item of the protective ensemble to be worn over standard footwear to provide barrier and physical protection to the wearer's feet.

3.3.11 CBRN Terrorism Incident Protective Garment(s). The element of the protective ensemble that provides protection to the upper and lower torso, head, arms, and legs; excluding the hands and feet.

3.3.12 CBRN Terrorism Incident Protective Glove(s). The element of the protective ensemble that provides protection to the wearer's hands and wrists.

N **3.3.13 CBRN Terrorism Incident Protective Hood.** The element of the protective ensemble that provides protection to the wearer's head and neck.

3.3.14 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.

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

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 3.3.75, Toxic Industrial Chemicals.)*

N **3.3.18 Class 1 CBRN Protective Ensemble and Ensemble Elements.** See 3.3.8.1.

3.3.19 Class 2 CBRN Protective Ensemble and Ensemble Elements. See 3.3.8.2.

3.3.20 Class 3 CBRN Protective Ensemble and Ensemble Elements. See 3.3.8.3.

3.3.21 Class 4 CBRN Protective Ensemble and Ensemble Elements. See 3.3.8.4.

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

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

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

3.3.25 Cryogenic Gas. See 3.3.43.1.

N **3.3.26 Elastomer.** A polymeric material that returns to its original length and shape after stretching.

N **3.3.27* Elastomeric Interface Material.** An exposed elastomeric material that is not otherwise used as garment material, which provides an interface between components of the ensemble and ensemble elements, other than seams, and if applicable, the interface between the respirator facepiece and the ensemble or ensemble elements.

3.3.28 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.

3.3.29* 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 3.3.61.1, CBRN Terrorism Incident Protective Ensembles and Ensemble Elements, and 3.3.53, Nonencapsulating Ensemble.)*

N **3.3.30 Encapsulating Ensemble.** A type of ensemble that completely covers the wearer and the wearer's respirator.

3.3.31 Ensemble(s). See 3.3.8, CBRN Terrorism Incident Protective Ensemble and Ensemble Elements.

3.3.32 Ensemble Elements. Multiple elements, including garments, gloves, footwear, and hoods.

3.3.33* 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.

3.3.34 First Responder Personnel. See 3.3.28, Emergency First Responder Personnel.

3.3.35 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.

3.3.36 Footwear.

3.3.36.1* ***CBRN Terrorism Incident Protective Footwear.*** See 3.3.9.

3.3.36.2 ***Protective Footwear.*** An abbreviated term for CBRN Terrorism Incident Protective Footwear. *(See also 3.3.9, CBRN Terrorism Incident Protective Footwear.)*

3.3.36.3 ***Standard Footwear.*** Footwear approved by the authority having jurisdiction (AHJ) for wear with protective garments as defined in 3.3.11 and, where required, worn with a CBRN terrorism incident protective footwear cover. *(See 3.3.10.)*

3.3.37 Footwear Cover. See 3.3.37.1, CBRN Terrorism Incident Protective Footwear Cover.

3.3.37.1* ***CBRN Terrorism Incident Protective Footwear Cover.*** See 3.3.10.

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

3.3.39 Garment(s).

3.3.39.1* ***CBRN Terrorism Incident Protective Garment(s).*** See 3.3.11.

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

3.3.39.3 ***Protective Garment(s).*** An abbreviated term for CBRN Terrorism Incident Protective Garment(s). *[See 3.3.11, CBRN Terrorism Incident Protective Garment(s).]*

3.3.40 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.

3.3.41 Garment Closure Assembly. See 3.3.2.1.

3.3.42 Garment Material. See 3.3.51.2.

3.3.43 Gas.

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

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

3.3.44 Glove(s).

3.3.44.1* ***CBRN Terrorism Incident Protective Glove(s).*** See 3.3.12.

3.3.44.2 ***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.

3.3.44.3 ***Protective Glove(s).*** An abbreviated term for CBRN Terrorism Incident Protective Glove(s). *[See 3.3.12, CBRN Terrorism Incident Protective Glove(s).]*

N **3.3.45 Hood(s).**

N **3.3.45.1** ***CBRN Terrorism Incident Protective Hood(s).*** See 3.3.13.

N **3.3.45.2** ***Protective Hood(s).*** An abbreviated term for CBRN Terrorism Incident Protective Hood(s). [See 3.3.13, CBRN Terrorism Incident Protective Hood(s)]

3.3.46 Integrity Footwear Cover. A component of the protective footwear element designed and configured to be worn over an outerboot to provide footwear with liquid–splash protection when integrated with the protective ensemble.

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

3.3.48 Liquefied Gas. See 3.3.43.2.

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

3.3.50 Manufacturer. The entity that directs and controls 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.

3.3.51 Material.

3.3.51.1 ***CBRN Barrier Material.*** See 3.3.6.

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

3.3.51.3 ***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.

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

3.3.52 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.

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

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

3.3.55 Outer Garment. See 3.3.39.2.

3.3.56 Outer Glove. See 3.3.44.2.

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

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

3.3.59* 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.

3.3.60 Protective Clothing Material. See 3.3.51.3.

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

3.3.61.1* *CBRN Terrorism Incident Protective Ensembles and Ensemble Elements.* See 3.3.8.

3.3.62 Protective Ensembles. See 3.3.61.

3.3.63 Protective Footwear. See 3.3.36.2.

3.3.64 Protective Garment(s). See 3.3.39.3.

3.3.65 Protective Glove(s). See 3.3.44.3.

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

3.3.67 Radiological and Nuclear Particulate Terrorism Agents. See 3.3.1.5.

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

3.3.69 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 3.3.72, Specimen.)*

3.3.70 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.

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

3.3.72 Specimen. The conditioned element, item, component or composite that is tested. Specimens are taken from samples. *(See also 3.3.69, Sample.)*

3.3.73 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.

N **3.3.74* Tethered Applications.** Applications in which a hose or line is attached to the garment or hood portion of an ensemble via an external fitting mounted on the garment material that is further connected to a fixed location external to the suit.

3.3.75 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.]*

3.3.76 Visor Material. See 3.3.51.4.

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.

Δ **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/IEC 17065, *Conformity assessment — Requirements for bodies certifying products, processes, and services*. The accreditation shall be issued by an accreditation body operating in accordance with ISO/IEC 17011, *Conformity assessment — 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, footwear elements, and hood 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.

4.1.5.2 Glove elements, footwear elements, and hood elements that are provided, sold, or distributed as individual elements shall be required to be separately labeled and listed. The individual element product listing shall include the ensemble with which the element is certified.

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 2012 edition of NFPA 1994 on or after the effective date for NFPA 1994, 2017 edition, which is August 21, 2017.

4.1.9 The certification organization shall not permit any manufacturer to continue to label any products that are certified as compliant with the 2012 edition of NFPA 1994, on or after August 21, 2018.

Δ **4.1.10** The certification organization shall require manufacturers to remove all certification labels and product labels indicating compliance with the 2012 edition of NFPA 1994, from all products that are under the control of the manufacturer on August 21, 2018 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.

Δ **4.2.3** The certification organization shall be accredited for personal protective equipment in accordance with ISO/IEC 17065, *Conformity assessment — Requirements for bodies certifying products, processes and services*. The accreditation shall be issued by an accreditation body operating in accordance with ISO/IEC 17011, *Conformity assessment — 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.

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.

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

4.2.6.1 The certification organization laboratory facilities shall have a program in place and functioning for 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/IEC 17025, *General requirements for the competence of testing and calibration laboratories*.

4.3.2.1 The certification organization's testing laboratory's scope of accreditation to ISO/IEC 17025, *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/IEC 17011, *Conformity assessment — 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/IEC 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/IEC 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/IEC 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 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 the certified ensemble(s) with which compliant ensemble elements have been certified 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 Annual Verification of Product Compliance.

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.

4.4.3.2 One specimen of each compliant ensemble shall be permitted to be tested for each overall ensemble performance test 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, with the following modifications:

(1) Chemical permeation resistance testing specified for Class 1 ensembles shall be limited to the following chemicals:
   (a) Ammonia
   (b) Acrolein
   (c) Acrylonitrile
   (d) Chlorine
   (e) Dimethyl sulfate
(2) Chemical permeation resistance testing specified for Class 2, Class 2R, Class 3, and Class 3R ensembles shall be limited to the following chemicals:
   (a) Acrylonitrile
   (b) Ammonia
   (c) Dimethyl sulfate

4.4.3.3.1 With the exception of chemical permeation testing, a total of two specimens shall be permitted for ensemble material and component testing requirements. If the testing is specified for both directions of a material, a total of two specimens per material direction shall be permitted for testing requirements.

4.4.4 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, on 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/DIS 9001, *Quality management systems — Requirements*.

4.5.3.1 Registration to the requirements of ISO/DIS 9001, *Quality management systems — Requirements*, shall be conducted by a registrar that is accredited for personal protective equipment in accordance with ISO/IEC 17021, *Conformity assessment — Requirements for bodies providing audit and certification of management systems*.

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

4.5.3.3 The registrar shall affix the accreditation mark on the ISO registration certificate.

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/DIS 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/DIS 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/DIS 9001 registration certificate, and the manufacturer shall provide the certification organization with copies of the ISO/DIS 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 or unfit for use. 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 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 item (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 hazard-

ous 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/DIS 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 1-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.

Δ **5.1.1.1** Each protective ensemble shall have a product label permanently and conspicuously attached to, embossed on, or printed on each separable 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.

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 6 mm (¼ 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 2.5 mm (3⁄32 in.) high.

Δ **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) and shall be at least 1.6 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)
(7) Visor material(s) if provided
(8) Glove element for the ensemble
(9) Footwear element for the ensemble
(10) Hood element for the ensemble
(11) "Breathable (see manufacturer's Technical Data Package)" as required by 6.2.7

Δ **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 1.6 mm (1/16 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 HAZARDOUS MATERIALS AND CBRN PROTECTIVE [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 F1301, *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, 1, 2, 3, or 4, and the appropriate term for the type of ensemble, *encapsulating* or *nonencapsulating*, shall be inserted where indicated in the label text.

"THIS CLASS [insert 1, 2, 2R, 3, 3R, 4, or 4R here] [insert ENCAPSULATING or NONENCAPSULATING here] HAZARDOUS MATERIALS AND CBRN PROTECTIVE ENSEMBLE MEETS THE REQUIREMENTS OF NFPA 1994, *STANDARD ON PROTECTIVE ENSEMBLES FOR FIRST RESPONDERS TO HAZARDOUS MATERIALS EMERGENCIES AND CBRN TERRORISM INCIDENTS*, 2018 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 1.6 mm (1/16 in.) high.

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

N **5.1.2.3** Where the manufacturer specifies outer footwear element options as permitted in 6.1.3.1, the following additional language shall be provided as part of the product label:

"OUTER BOOT FOOTWEAR OPTIONS WORN WITH THIS ENSEMBLE MUST MEASURE AT LEAST 200 MM (8 IN.) HIGH AND BE CERTIFIED TO NFPA 1951, 1971, 1991, 1992, 1994, or 1999."

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 1, 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 1, 2, 2R, 3, 3R, 4, or 4R here] HAZARDOUS MATERIALS AND CBRN PROTECTIVE [insert GLOVE or FOOTWEAR here] ELEMENT MEETS THE REQUIREMENTS OF NFPA 1994, *STANDARD ON PROTECTIVE ENSEMBLES FOR FIRST RESPONDERS TO HAZARDOUS MATERIALS EMERGENCIES AND CBRN TERRORISM INCIDENTS*, 2018 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 1.6 mm (1/16 in.) high.

"THE TECHNICAL DATA PACKAGE CONTAINS INFORMATION ON HAZARDOUS MATERIALS AND CBRN AGENTS FOR WHICH THIS (INSERT GLOVE OR FOOTWEAR HERE) ELEMENT IS CERTIFIED. CONSULT THE TECHNICAL DATA PACKAGE AND MANUFACTURER'S INSTRUCTIONS BEFORE USE. DO NOT REMOVE THIS LABEL."

Δ **5.1.3.3** Where footwear is designed and configured according to 6.4.10, the sock, the outer boot, and the integrity cover shall have at least the following compliance statement on each component, and all letters shall be at least 2.5 mm (3/32 in.) high:

"THE [insert component], WHEN WORN WITH [insert other two components], MEETS THE HAZARDOUS MATERIALS AND CBRN FOOTWEAR REQUIREMENTS OF CLASS [insert 1, 2, 2R, 3, 3R, 4, or 4R] OF NFPA 1994, *STANDARD ON PROTECTIVE ENSEMBLES FOR FIRST RESPONDERS TO HAZARDOUS MATERIALS EMERGENCIES AND CBRN TERRORISM INCIDENTS*, 2018 EDITION, FOR THE ABOVE-NOTED CLASS. DO NOT REMOVE THIS LABEL."

N **5.1.4 Hood Elements Compliance Statements.**

N **5.1.4.1** Each Class 3, 3R, 4, or 4R hood 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 (3 or 4) shall be inserted where indicated in the label text.

"THIS CLASS [insert 3, 3R, 4, or 4R here] CBRN PROTECTIVE HOOD ELEMENT MEETS THE REQUIREMENTS OF NFPA 1994, *STANDARD ON PROTECTIVE ENSEMBLES FOR FIRST RESPONDERS TO HAZARDOUS MATERIALS EMERGENCIES AND CBRN TERRORISM INCIDENTS*, 2018 EDITION, FOR THE ABOVE-NOTED CLASS. DO NOT REMOVE THIS LABEL"

N **5.1.4.2** Following the text in 5.1.4.1, the following statement shall appear on the product label. All letters shall be at least 1.6 mm (1/16 in.) high.

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

N **5.1.5 Optional Compliance Statements.**

N **5.1.5.1** Where a protective ensemble meets the additional optional requirements for flash fire protection, the protective ensemble shall have the following additional compliance statement as part of the product label. All letters shall be at least 1.6 mm (1/16 in.) high.

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

N **5.1.5.2** Where the protective ensemble has also been evaluated to the optional stealth requirements, the protective ensemble shall have the following additional statement as part of the product label. All letters shall be at least 1.6 mm (1/16 in.) high.

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

5.2 User Information.

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

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

Δ **5.2.3** The manufacturer shall provide at least the following instructions and information with each hazardous materials and 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
   (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 hazardous materials and CBRN protective ensembles and ensemble elements.

5.3 Technical Data Package.

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

5.3.2* The technical data package shall contain all documentation required by this standard and the values obtained from the initial certification showing compliance with the requirements of Chapter 7 in the current edition of this standard, using the reporting formats provided in Table 5.3.2(a) and Table 5.3.2(b) for each ensemble, element, material, or component, as applicable.

N **5.3.2.1** The technical data package information shall indicate "Pass" for those requirements where there is no quantitative value reported and "Not applicable" for specific requirements that do not apply to the protective ensemble.

N **5.3.2.2** The manufacturer shall be permitted to make modifications in the tabular format in order to accommodate specific product features or additional materials as applicable to the certified product.

5.3.3 In the technical data package, the manufacturer shall describe the hazardous materials and CBRN protective ensemble and ensemble elements in terms of manufacturer trade name 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 hazardous materials and 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 ensembles, or sizes specific in Chapter 6 for glove, hood, and footwear elements.

N **Table 5.3.2(a) Format for Reporting Certification Test Data in Technical Data Package**

Ensemble or Element	Performance Requirement	Test Method	Requirement	Result
Class 1 Ensembles				
Nonencapsulating ensemble or encapsulating ensemble	Liquidtight integrity	Procedure A of ASTM F1359/F1359M (Section 8.4)	No liquid penetration	
	Overall inward leakage (MIST)	Section 8.2	$PPDF_i \geq 871$ $PPDF_{sys} \geq 441$	
	Overall ensemble function and integrity	Procedures A and B, in ASTM F1154 (Section 8.3)	Test subject completes task ≤20 minutes Accommodates head protection devices meeting ANSI/ISEA Z89.1 (Type 1, Class G) Protective flap remains closed over closure system Test subject has visual acuity through facepiece lens and visor 20/35 or better Test subject properly identifies 3 out of 4 numbers on NFPA 704 placard at each angle	
	Gastight integrity	ASTM F1052 (Section 8.26)	Ending suit pressure ≥80 mm (≥3 5⁄32 in.) water gauge	
Encapsulating ensemble	Overall ensemble function and integrity	ASTM F1154 (Section 8.3)	Time to remove and reinsert hands in gloves 5 times ≤2.5 minutes	
	Maximum ensemble ventilation rate	Section 8.27	Internal suit pressure ≤150 mm (≤6 in.) water gauge	
External fitting	Gastight integrity	ASTM F1052 (Section 8.26)	Ending suit pressure ≥80 mm (≥3 5⁄32 in.) water gauge	
External fittings intended for tethered applications	Pull out strength	Section 8.6	Strength ≥1000 N (≥225 lbf)	
External fittings not intended for tethered applications	Pull out strength	Section 8.6	Strength ≥135 N (≥30 lbf)	
Exhaust valves	Exhaust valve mounting strength	Section 8.24	Strength ≥135 N (≥30 lbf)	
	Exhaust valve inward leakage	Section 8.25	Leakage rate ≤30 mL/min (≤1.83 $in.^3$/min)1.8	
Class 1 Garment Elements				
Materials and seams	Chemical permeation resistance	Section 8.7		See Table 5.3.2(b).
Garment materials	Burst strength	Section 8.9	Strength ≥200 N (≥45 lbf)	
Sock materials	Burst strength	Section 8.9	Strength ≥156 N (≥35 lbf)	
Garment materials	Puncture propagation tear resistance	ASTM D2582 (Section 8.10)	Tear resistance ≥49 N (≥11 lbf)	
Sock materials	Puncture propagation tear resistance	ASTM D2582 (Section 8.10)	Tear resistance ≥31 N (≥7 lbf)	
Garment materials	Cold temperature performance	ASTM D747 (Section 8.11)	Bending moment of ≤0.057 N·m (0.5 in.·lbf) at an angular deflection of 60°at −25°C (−13°F)	
Garment materials	Flammability resistance	ASTM F1358 (Section 8.28)	Afterflame time of ≤2.0 s and does not melt and drip	
Seams and closure assemblies	Seam/closure breaking strength	ASTM D751 (Section 8.12)	Breaking strength ≥67 N/25 mm (≥15 lbf/1 in.)	
Class 1 Garment Visors				
Materials and seams	Chemical permeation resistance	Section 8.7		See Table 5.3.2(b).
Materials	Visor high-mass impact resistance	Section 9.11 of ANSI/ISEA Z87.1 (Section 8.13)	No full-thickness punctures, cracks, holes, or fractures	
Materials	Flammability resistance	ASTM F1358 (Section 8.28)	Afterflame time of ≤2.0 s and does not melt and drip	

(continues)

N **Table 5.3.2(a)** *Continued*

Ensemble or Element	Performance Requirement	Test Method	Requirement	Result
Material seams	Seam/closure breaking strength	ASTM D751 (Section 8.12)	Breaking strength ≥67 N/25 mm (≥15 lbf/1 in.)	
Elastomeric Interface Materials				
	Ultimate tensile strength	Method A of ASTM D412 (Section 8.29)	Elongation at rupture ≥125%	
	Chemical permeation resistance	Section 8.7		See Table 5.3.2(b).
	Cut resistance	ASTM F1790 (Section 8.14)	Blade travel distance of ≥20 mm (≥0.8 in.)	
	Puncture resistance	ASTM F1342/F1342M (Section 8.15)	Puncture resistance of ≥7 N (≥1.6 lbf)	
	Ultimate tensile strength	Method A of ASTM D412 (Section 8.29)	Ultimate tensile strength of ≥4 MPa (≥580 psi)	
Class 1 Glove Elements				
	Liquidtight integrity	ASTM D5151 with modifications (Section 8.22)	No liquid penetration	
	Chemical permeation resistance	Section 8.7		See Table 5.3.2(b).
	Cut resistance	ASTM F1790 (Section 8.14)	Blade travel distance of ≥20 mm (≥0.8 in.)	
	Puncture resistance	ASTM F1342/F1342M (Section 8.15)	Puncture resistance of ≥15 N (≥3.8 lbf)	
	Cold temperature performance	ASTM D747 (Section 8.11)	Bending moment of ≤0.057 N·m (≤0.5 in.·lbf) at an angular deflection of 60°at −25°C (−13°F)	
	Flammability resistance	ASTM F1358 (Section 8.28)	Afterflame time of ≤2.0 s and does not melt and drip	
	Glove hand function	ASTM F2010/F2010M (Section 8.16)	Average % increase over barehanded control <300%	
Class 1 Footwear Elements				
	Liquidtight integrity	ASTM D5151 with modifications (Section 8.22)	No liquid penetration	
	Slip resistance	ISO 13287 (Section 8.19)	Coefficient of friction ≥0.40	
	Flammability resistance	ASTM F1358 (Section 8.28)	Afterflame time of ≤2.0 s and does not melt and drip	
Upper materials	Chemical permeation resistance	Section 8.7		See Table 5.3.2(b).
	Cut resistance	ASTM F1790 (Section 8.14)	Blade travel distance of ≥20 mm (0.8 in.)	
	Puncture resistance	ASTM F1342/F1342M (Section 8.15)	Puncture resistance of ≥36 N (≥8 lbf)	
Soles and heels	Abrasion resistance	ISO 4649 (Section 8.17)	Relative volume loss not >250 mm^3 (>0.015 $in.^3$)	
Footwear covers			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	
	Abrasion resistance	ASTM D3884 (Section 8.23)	Show no wear-through after 3000 cycles	
Socks			Outer boot of the footwear element meets the minimum height requirement specified in 6.4.3 and the cut resistance performance requirement in 7.1.4.3	
Class 2 Ensembles				
	Liquidtight integrity	Procedure A of ASTM F1359/F1359M (Section 8.4)	No liquid penetration	

(continues)

N **Table 5.3.2(a)** *Continued*

Ensemble or Element	Performance Requirement	Test Method	Requirement	Result
	Overall inward leakage (MIST)	Section 8.2	$PPDF_i \geq 481$ $PPDF_{sys} \geq 328$	
	Overall ensemble function and integrity	Procedures A and B in ASTM F1154 (Section 8.3)	Test subject completes task ≤20 minutes Accommodates head protection devices meeting ANSI/ISEA Z89.1 (Type 1, Class G) Protective flap remains closed over closure system Test subject has visual acuity through facepiece lens and visor 20/35 or better	
External fittings intended for tethered applications	Fitting pull out strength	Section 8.6	Strength ≥1000 N (≥225 lbf)	
External fittings not intended for tethered applications	Fitting pull out strength	Section 8.6	Strength ≥135 N (≥30 lbf)	
Exhaust valves	Exhaust valve mounting strength	Section 8.24	Strength ≥135 N (≥30 lbf)	
	Exhaust valve inward leakage	Section 8.25	Leakage rate ≤30 mL/min (≤1.83 $in.^3$/min)	
Class 2 Garment Elements				
Materials and seams	Chemical permeation resistance	Section 8.7		See Table 5.3.2(b).
	Viral penetration resistance	ASTM F1671/F1671M (Section 8.21)	No penetration for ≥1 hr	
Garment materials	Burst strength	Section 8.9	Strength ≥156 N (≥35 lbf)	
Garment materials	Puncture propagation tear resistance	ASTM D2582 (Section 8.10)	Tear resistance ≥31 N (≥7 lbf)	
Garment materials	Cold temperature performance	ASTM D747 (Section 8.11)	Bending moment of ≤0.057 N·m (≤0.5 in.·lbf) at an angular deflection of 60°at −25°C (−13°F)	
Seams and closure assemblies	Seam/closure breaking strength	ASTM D751 (Section 8.12)	Breaking strength ≥34 N/25 mm (≥7.5 lbf/1 in.)	
Class 2 Garment Visors				
Materials and seams	Chemical permeation resistance	Section 8.7		See Table 5.3.2(b).
Materials	Viral penetration resistance	ASTM F1671/F1671M (Section 8.21)	No penetration for ≥1 hr	
	Visor high-mass impact resistance	Section 9.11 of ANSI/ISEA Z87.1 (Section 8.13)	No full-thickness punctures, cracks, holes, or fractures	
Material seams	Seam/closure breaking strength	ASTM D751 (Section 8.12)	Breaking strength ≥34 N/25 mm (≥7.5 lbf/1 in.)	
Class 2 Elastomeric Interface Materials				
	Ultimate tensile strength	Method A of ASTM D412 (Section 8.29)	Elongation at rupture ≥125%	
	Chemical permeation resistance	Section 8.7		See Table 5.3.2(b).
	Cut resistance	ASTM F1790 (Section 8.14)	Blade travel distance of ≥20 mm (≥0.8 in.)	
	Puncture resistance	ASTM F1342/F1342M (Section 8.15)	Puncture resistance of ≥7 N (≥1.6 lbf)	
	Ultimate tensile strength	Method A of ASTM D412 (Section 8.29)	Ultimate tensile strength of ≥4 MPa (≥580 psi)	

(continues)

N **Table 5.3.2(a)** *Continued*

Ensemble or Element	Performance Requirement	Test Method	Requirement	Result
Class 2 Glove Elements				
	Liquidtight integrity	ASTM D5151 with modifications (Section 8.22)	No liquid penetration	
	Chemical permeation resistance	Section 8.7		See Table 5.3.2(b).
	Cut resistance	ASTM F1790 (Section 8.14)	Blade travel distance of ≥20 mm (≥0.8 in.)	
	Puncture resistance	ASTM F1342/F1342M (Section 8.15)	Puncture resistance of ≥15 N (≥3.8 lbf)	
	Cold temperature performance	ASTM D747 (Section 8.11)	Bending moment of ≤0.057 N·m (≤0.5 in.·lbf) at an angular deflection of 60°at −25°C (−13°F)	
	Glove hand function	ASTM F2010/F2010M (Section 8.16)	Average % increase over barehanded control <300%	
Materials and seams	Viral penetration resistance	ASTM F1671 (Section 8.21)	No penetration for ≥1 hr	
Class 2 Footwear Elements				
	Liquidtight integrity	ASTM D5151 with modifications (Section 8.22)	No liquid penetration	
	Slip resistance	ISO 13287 (Section 8.19)	Coefficient of friction ≥0.40	
Upper materials	Chemical permeation resistance	Section 8.7		See Table 5.3.2(b).
	Cut resistance	ASTM F1790 (Section 8.14)	Blade travel distance of ≥20 mm (≥0.8 in.)	
	Puncture resistance	ASTM F1342/F1342M (Section 8.15)	Puncture resistance of ≥36 N (≥8 lbf)	
	Viral penetration resistance	ASTM F1671/F1671M (Section 8.21)	No penetration for ≥1 hr	
Soles and heels	Abrasion resistance	ISO 4649 (Section 8.17)	Relative volume loss will not be >250 mm^3 (>0.015 $in.^3$)	
Footwear covers			Meet the requirements specified in 7.2.4.1, 7.2.4.2, 7.2.4.3, 7.2.4.4, 7.2.4.6, and 7.2.4.7	
	Abrasion resistance	ASTM D3884 (Section 8.23)	Show no wear-through after 3000 cycles	
Socks			Outer boot of the footwear element meets the minimum height requirement specified in 6.4.3 and the cut resistance performance requirement in 7.2.4.3	
Class 2R Ensembles				
	Liquidtight integrity	Procedure A of ASTM F1359/F1359M (Section 8.4)	No liquid penetration	
	Overall inward leakage (MIST)	Section 8.2	$PPDF_i \geq 481$ $PPDF_{sys} \geq 328$	
	Overall ensemble function and integrity	Procedures A and B, in ASTM F1154 (Section 8.3)	Test subject completes task ≤20 minutes Accommodates head protection devices meeting ANSI/ISEA Z89.1 (Type 1, Class G) Protective flap remains closed over closure system Test subject has visual acuity through facepiece lens and visor 20/35 or better	
External fittings intended for tethered applications	Fitting pull out strength	Section 8.6	Strength ≥1000 N (≥225 lbf)	

(continues)

N **Table 5.3.2(a)** *Continued*

Ensemble or Element	Performance Requirement	Test Method	Requirement	Result
External fittings not intended for tethered applications	Fitting pull out strength	Section 8.6	Strength ≥135 N (≥30 lbf)	
Exhaust valves	Exhaust valve mounting strength	Section 8.24	Strength ≥135 N (≥30 lbf)	
	Exhaust valve inward leakage	Section 8.25	Leakage rate ≤30 mL/min (≤1.83 in.^{3}/min)	
Class 2R Garment Elements				
Materials and seams	Chemical permeation resistance	Section 8.7		See Table 5.3.2(b).
	Viral penetration resistance	ASTM F1671/F1671M (Section 8.21)	No penetration for ≥1 hr	
Garment materials	Burst strength	Section 8.9	Strength ≥200 N (≥45 lbf)	
Sock materials	Burst strength	Section 8.9	Strength ≥ 156 N (≥35 lbf)	
Garment materials	Puncture propagation tear resistance	ASTM D2582 (Section 8.10)	Tear resistance ≥49 N (≥11 lbf)	
Sock materials	Puncture propagation tear resistance	ASTM D2582 (Section 8.10)	Tear resistance ≥31 N (≥7 lbf)	
Garment materials	Cold temperature performance	ASTM D747 (Section 8.11)	Bending moment of ≤0.057 N·m (≤0.5 in.·lbf) at an angular deflection of 60°at −25°C (−13°F)	
Seams and closure assemblies	Seam/closure breaking strength	ASTM D751 (Section 8.12)	Breaking strength ≥67 N/25 mm (≥15 lbf/1 in.)	
Class 2R Garment Visors				
Materials and seams	Chemical permeation resistance	Section 8.7		See Table 5.3.2(b).
Materials	Viral penetration resistance	ASTM F1671/F1671M (Section 8.21)	No penetration for ≥1 hr	
	Visor high-mass impact resistance	Section 9.11 of ANSI/ISEA Z87.1 (Section 8.13)	No full-thickness punctures, cracks, holes, or fractures	
Material seams	Seam/closure breaking strength	ASTM D751 (Section 8.12)	Breaking strength ≥67 N/25 mm (≥15 lbf/1 in.)	
Class 2R Elastomeric Interface Materials				
	Ultimate tensile strength	Method A of ASTM D412 (Section 8.29)	Elongation at rupture ≥125%	
	Chemical permeation resistance	Section 8.7		See Table 5.3.2(b).
	Cut resistance	ASTM F1790 (Section 8.14)	Blade travel distance of ≥20 mm (≥0.8 in.)	
	Puncture resistance	ASTM F1342 (Section 8.15)	Puncture resistance of ≥7 N (≥1.6 lbf)	
	Ultimate tensile strength	Method A of ASTM D412 (Section 8.29)	Ultimate tensile strength of ≥4 MPa (≥580 psi)	
	Cold temperature performance	ASTM D747 (Section 8.11)	Bending moment of ≤0.057 N·m (≤0.5 in.·lbf) at an angular deflection of 60°at −25°C (−13°F)	
Class 2R Glove Elements				
	Liquidtight integrity	ASTM D5151 with modifications (Section 8.22)	No liquid penetration	
	Chemical permeation resistance	Section 8.7		See Table 5.3.2(b).
	Cut resistance	ASTM F1790 (Section 8.14)	Blade travel distance of ≥20 mm (≥0.8 in.)	
	Puncture resistance	ASTM F1342/F1342M (Section 8.15)	Puncture resistance of ≥15 N (≥3.8 lbf)	
	Cold temperature performance	ASTM D747 (Section 8.11)	Bending moment of ≤0.057 N·m (≤0.5 in.·lbf) at an angular deflection of 60°at −25°C (−13°F)	

(continues)

N **Table 5.3.2(a)** ***Continued***

Ensemble or Element	Performance Requirement	Test Method	Requirement	Result
	Glove hand function	ASTM F2010/F2010M (Section 8.16)	Average % increase over barehanded control <300%	
Materials and seams	Viral penetration resistance	ASTM F1671/F1671M (Section 8.21)	No penetration for ≥1 hr	
Class 2R Footwear Elements				
	Liquidtight integrity	ASTM D5151 with modifications (Section 8.22)	No liquid penetration	
	Slip resistance	ISO 13287 (Section 8.19) ASTM F2412	Coefficient of friction ≥0.40 Meets ASTM F2413, for impact-, compression-, and puncture-resistant footwear with the exception of flex resistance to cracking	
Upper materials	Chemical permeation resistance	Section 8.7		See Table 5.3.2(b).
	Cut resistance	ASTM F1790 (Section 8.14)	Blade travel distance of ≥20 mm (≥0.8 in.)	
	Puncture resistance	ASTM F1342/F1342M (Section 8.15)	Puncture resistance of ≥36 N (≥8 lbf)	
	Viral penetration resistance	ASTM F1671/F1671M (Section 8.21)	No penetration for ≥1 hr	
Soles and heels	Abrasion resistance	ISO 4649 (Section 8.17)	Relative volume loss not >250 mm^3 (0.015 in^3)	
Footwear covers			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 7.3.4.7, excluding 7.3.4.5	
	Abrasion resistance	ASTM D3884 (Section 8.23)	Show no wear-through after 3000 cycles	
Socks			Outer boot of the footwear element meets the minimum height requirement specified in 6.4.3 and the cut resistance performance requirement in 7.3.4.3	
Class 3 Ensembles				
	Liquidtight integrity	Procedure A of ASTM F1359/F1359M (Section 8.4)	No liquid penetration	
	Overall inward leakage (MIST)	Section 8.2	$PPDF_i \geq 160$ $PPDF_{sys} \geq 69$	
	Overall ensemble function and integrity	Procedures A and B, in ASTM F1154 (Section 8.3)	Test subject completes task ≤20 minutes Accommodates head protection devices meeting ANSI/ISEA Z89.1 (Type 1, Class G) Protective flap remains closed over closure system Test subject has visual acuity through facepiece lens and visor 20/35 or better	
External fittings intended for tethered applications	Fitting pull out strength	Section 8.6	Strength ≥1000 N (≥225 lbf)	
External fittings not intended for tethered applications	Fitting pull out strength	Section 8.6	Strength ≥135 N (≥30 lbf)	
Exhaust valves	Exhaust valve mounting strength	Section 8.24	Strength ≥135 N (≥30 lbf)	
	Exhaust valve inward leakage	Section 8.25	Leakage rate ≤30 mL/min (≤1.83 $in.^3$/min)	

(continues)

N **Table 5.3.2(a)** *Continued*

Ensemble or Element	Performance Requirement	Test Method	Requirement	Result
Class 3 Garment Elements				
Materials and seams	Chemical permeation resistance	Section 8.7		See Table 5.3.2(b).
	Viral penetration resistance	ASTM F1671/F1671M (Section 8.21)	No penetration for ≥1 hr	
Garment materials	Burst strength	Section 8.9	Strength ≥135 N (≥30 lbf)	
	Puncture propagation tear resistance	ASTM D2582 (Section 8.10)	Tear resistance ≥25 N (≤5 ⅗ lbf)	
	Cold temperature performance	ASTM D747 (Section 8.11)	Bending moment of ≤0.057 N·m (≤0.5 in.·lbf) at an angular deflection of 60°at −25°C (−13°F)	
	Total heat loss	Section 8.8	≥200 W/m^2	
	Evaporative resistance	ISO 11092 (Section 8.20)	≤30 Pa m^2/W	
Seams and closure assemblies	Seam/closure breaking strength	ASTM D751 (Section 8.12)	Breaking strength ≥34 N/25 mm (≥7.5 lbf/1 in.)	
Class 3 Garment Visors				
Materials and seams	Chemical permeation resistance	Section 8.7		See Table 5.3.2(b).
Materials	Viral penetration resistance	ASTM F1671/F1671M (Section 8.21)	No penetration for ≥1 hr	
	Visor high-mass impact resistance	Section 9.11 of ANSI/ISEA Z87.1		
		Section 8.13	No full-thickness punctures, cracks, holes, or fractures	
Material seams	Seam/closure breaking strength	ASTM D751 (Section 8.12)	Breaking strength ≥34 N/25 mm (≥7.5 lbf/1 in.)	
Class 3 Elastomeric Interface Materials				
	Ultimate tensile strength	Method A of ASTM D412 (Section 8.29)	Elongation at rupture ≥125%	
	Chemical permeation resistance	Section 8.7		See Table 5.3.2(b).
	Cut resistance	ASTM F1790 (Section 8.14)	Blade travel distance of ≥20 mm (≥0.8 in.)	
	Puncture resistance	ASTM F1342/F1342M (Section 8.15)	Puncture resistance of ≥7 N (≥1.6 lbf)	
	Ultimate tensile strength	Method A of ASTM D412 (Section 8.29)	Ultimate tensile strength of ≥4 MPa (≥580 psi)	
Class 3 Glove Elements				
	Liquidtight integrity	ASTM D5151 with modifications (Section 8.22)	No liquid penetration	
	Chemical permeation resistance	Section 8.7		See Table 5.3.2(b).
	Cut resistance	ASTM F1790 (Section 8.14)	Blade travel distance of ≥20 mm (≥0.8 in.)	
	Puncture resistance	ASTM F1342/F1342M (Section 8.15)	Puncture resistance of ≥9 N (≥2 lbf)	
	Cold temperature performance	ASTM D747 (Section 8.11)	Bending moment of ≤0.057 N·m (≤½ in. lbf) at an angular deflection of 60°at −25°C (−13°F)	
	Glove hand function	ASTM F2010/F2010M (Section 8.16)	Average % increase over barehanded control <200%	
Materials and seams	Viral penetration resistance	ASTM F1671 (Section 8.21)	No penetration for ≥1 hr	
Class 3 Footwear Elements				
	Liquidtight integrity	ASTM D5151 with modifications (Section 8.22)	No liquid penetration	
	Slip resistance	ISO 13287 (Section 8.19)	Coefficient of friction ≥0.40	

(continues)

N **Table 5.3.2(a)** ***Continued***

Ensemble or Element	Performance Requirement	Test Method	Requirement	Result
Upper materials	Chemical permeation resistance	Section 8.7		See Table 5.3.2(b).
	Cut resistance	ASTM F1790 (Section 8.14)	Blade travel distance of ≥20 mm (≥0.8 in.)	
	Puncture resistance	ASTM F1342/F1342M (Section 8.15)	Puncture resistance of ≥36 N (≥8 lbf)	
	Viral penetration resistance	ASTM F1671/F1671M (Section 8.21)	No penetration for ≥1 hr	
Soles and heels	Abrasion resistance	ISO 4649 (Section 8.17)	Relative volume loss not >250 mm^3 >250 mm^3 (>0.015 in^3)	
Footwear covers			Meet the requirements specified in 7.4.4.1, 7.4.4.2, 7.4.4.3, 7.4.4.4, 7.4.4.6, and 7.4.4.7	
	Abrasion resistance	ASTM D3884 (Section 8.23)	Show no wear-through after 3000 cycles	
Footwear designed and configured according to 6.4.10			(1) Booties sock meets the requirements specified in 7.4.4.2 and 7.4.4.3 (2) Outer boot meets the requirements specified in 7.4.4.4 and 7.4.4.5 (3) Integrity cover meets the requirements in 7.4.4.1, 7.4.4.7, and 7.4.4.9	
Socks			Outer boot of the footwear element meets the minimum height requirement specified in 6.4.3 and the cut resistance performance requirement specified in 7.4.4.3	
Class 3 Hood Elements				
			Meet all of the applicable requirements specified in 7.4.1	
Elastomeric interface material	Ultimate tensile strength	Method A of ASTM D412 (Section 8.29)	Elongation at rupture ≥125%	
	Chemical permeation resistance	Section 8.7		See Table 5.3.2(b).
	Cut resistance	ASTM F1790 (Section 8.14)	Blade travel distance of ≥20 mm (≥0.8 in.)	
	Puncture resistance	ASTM F1342/F1342M (Section 8.15)	Puncture resistance of ≥7 N (≥1.6 lbf)	
	Ultimate tensile strength	Method A of ASTM D412 (Section 8.29)	Ultimate tensile strength of ≥4 MPa (≥580 psi)	
Class 3R Ensembles				
	Liquidtight integrity	Procedure A of ASTM F1359/F1359M (Section 8.4)	No liquid penetration	
	Overall inward leakage (MIST)	Section 8.2	$PPDF_i \geq 160$ $PPDF_{sys} \geq 69$	
	Overall ensemble function and integrity	Procedures A and B, in ASTM F1154 (Section 8.3)	Test subject completes task ≤20 minutes Accommodates head protection devices meeting ANSI/ISEA Z89.1 (Type 1, Class G) Protective flap remains closed over closure system Test subject has visual acuity through facepiece lens and visor 20/35 or better	
External fittings intended for tethered applications	Fitting pull out strength	Section 8.6	Strength ≥1000 N (≥225 lbf)	

(continues)

N **Table 5.3.2(a)** *Continued*

Ensemble or Element	Performance Requirement	Test Method	Requirement	Result
External fittings not intended for tethered applications	Fitting pull out strength	Section 8.6	Strength ≥135 N (≥30 lbf)	
Exhaust valves	Exhaust valve mounting strength	Section 8.24	Strength ≥135 N (≥30 lbf)	
	Exhaust valve inward leakage	Section 8.25	Leakage rate ≤30 mL/min (≤1.83 in.^{3}/min)	
Class 3R Garment Elements				
Materials and seams	Chemical permeation resistance	Section 8.7		See Table 5.3.2(b).
	Viral penetration resistance	ASTM F1671/F1671M (Section 8.21)	No penetration for ≥1 hr	
Garment materials	Burst strength	Section 8.9	Strength ≥156 N (≥35 lbf)	
	Puncture propagation tear resistance	ASTM D2582 (Section 8.10)	Tear resistance ≥31 N (≥7 lbf)	
	Cold temperature performance	ASTM D747 (Section 8.11)	Bending moment of ≤0.057 N·m (≤0.5 in.·lbf) at an angular deflection of 60°at –25°C (–13°F)	
	Total heat loss	Section 8.8	≥200 W/m^2	
	Evaporative resistance	ISO 11092 (Section 8.20)	≤30 Pa m^2/W	
Seams and closure assemblies	Seam/closure breaking strength	ASTM D751 (Section 8.12)	Breaking strength ≥34 N/25 mm (≥7.5 lbf/1 in.)	
Class 3R Garment Visors				
Materials and seams	Chemical permeation resistance	Section 8.7		See Table 5.3.2(b).
Materials	Viral penetration resistance	ASTM F1671/F1671M (Section 8.21)	No penetration for ≥1 hr.	
	Visor high-mass impact resistance	Section 9.11 of ANSI/ISEA Z87.1 (Section 8.13)	No full-thickness punctures, cracks, holes, or fractures	
Material seams	Seam/closure breaking strength	ASTM D751 (Section 8.12)	Breaking strength ≥34 N/25 mm (≥7.5 lbf/1 in.)	
Class 3R Elastomeric Interface Materials				
	Ultimate tensile strength	Method A of ASTM D412 (Section 8.29)	Elongation at rupture ≥125%	
	Chemical permeation resistance	Section 8.7		See Table 5.3.2(b).
	Cut resistance	ASTM F1790 (Section 8.14)	Blade travel distance of ≥20 mm (≥0.8 in.)	
	Puncture resistance	ASTM F1342/F1342M (Section 8.15)	Puncture resistance of ≥7 N (≥1.6 lbf)	
	Ultimate tensile strength	Method A of ASTM D412 (Section 8.29)	Ultimate tensile strength of ≥4 MPa (≥580 psi)	
	Cold temperature performance	ASTM D747 (Section 8.11)	Bending moment of ≤0.057 N·m (≤½ in.·lbf) at an angular deflection of 60°at –25°C (–13°F)	
Class 3R Glove Elements				
	Liquidtight integrity	ASTM D5151 with modifications (Section 8.22)	No liquid penetration	
	Chemical permeation resistance	Section 8.7		See Table 5.3.2(b).
	Cut resistance	ASTM F1790 (Section 8.14)	Blade travel distance of ≥20 mm (≥0.8 in.)	
	Puncture resistance	ASTM F1342/F1342M (Section 8.15)	Puncture resistance of ≥15 N (≥3.8 lbf)	
	Cold temperature performance	ASTM D747 (Section 8.11)	Bending moment of ≤0.057 N·m (≤0.5 in.·lbf) at an angular deflection of 60°at –25°C (–13°F)	

(continues)

N **Table 5.3.2(a)** *Continued*

Ensemble or Element	Performance Requirement	Test Method	Requirement	Result
	Glove hand function	ASTM F2010/F2010M (Section 8.16)	Average % increase over barehanded control <200%	
Materials and seams	Viral penetration resistance	ASTM F1671 (Section 8.21)	No penetration for ≥1 hr	
Class 3R Footwear Elements				
	Liquidtight integrity	ASTM D5151 with modifications (Section 8.22)	No liquid penetration	
	Slip resistance	ISO 13287 (Section 8.19)	Coefficient of friction ≥0.40	
Upper materials	Chemical permeation resistance	Section 8.7		See Table 5.3.2(b).
	Cut resistance	ASTM F1790 (Section 8.14)	Blade travel distance of ≥20 mm (≥0.8 in.)	
	Puncture resistance	ASTM F1342/F1342M (Section 8.15)	Puncture resistance of ≥36 N (≥8 lbf)	
	Viral penetration resistance	ASTM F1671/F1671M (Section 8.21)	No penetration for ≥1 hr	
Soles and heels	Abrasion resistance	ISO 4649 (Section 8.17)	Relative volume loss not >250 mm^3	
Footwear covers			Meet the requirements specified in 7.5.4.1, 7.5.4.2, 7.5.4.3, 7.5.4.4, 7.5.4.5, and 7.5.4.7, excluding 7.5.4.6	
	Abrasion resistance	ASTM D3884 (Section 8.23)	Show no wear-through after 3000 cycles	
Footwear designed and configured according to 6.4.10			(1) Booties sock meets the requirements specified in 7.5.4.2 and 7.5.4.3 (2) Outer boot meets the requirements specified in 7.5.4.4 and 7.5.4.5 (3) Integrity cover meets the requirements in 7.5.4.1, 7.5.4.7, and 7.5.4.9	
Socks			Outer boot of the footwear element meets the minimum height requirement specified in 6.4.3 and the cut resistance performance requirement specified in 7.5.4.4	
Class 3R Hood Elements				
			Meet all of the applicable requirements specified in 7.5.1	
Elastomeric interface material	Ultimate tensile strength	Method A of ASTM D412 (Section 8.29)	Elongation at rupture ≥125%	
	Chemical permeation resistance	Section 8.7		See Table 5.3.2(b).
	Cut resistance	ASTM F1790 (Section 8.14)	Blade travel distance of ≥20 mm (≥0.8 in.)	
	Puncture resistance	ASTM F1342/F1342M (Section 8.15)	Puncture resistance of ≥7 N (≥1.6 lbf)	
	Ultimate tensile strength	Method A of ASTM D412 (Section 8.29)	Ultimate tensile strength of ≥4 MPa (≥580 psi)	
Class 4 Ensembles				
	Overall particulate inward leakage	Section 8.5	No visual particulate inward leakage	
	Overall ensemble function and integrity	Procedures A and B, in ASTM F1154 (Section 8.3)	Test subject completes task ≤15 min.	
			Accommodates head protection devices meeting ANSI/ISEA Z89.1 (Type 1, Class G)	
			Protective flap remains closed over closure system	

(continues)

N **Table 5.3.2(a)** *Continued*

Ensemble or Element	Performance Requirement	Test Method	Requirement	Result
			Test subject has visual acuity through facepiece lens and visor 20/35 or better	
External fittings intended for tethered applications	Fitting pull out strength	Section 8.6	Strength ≥1000 N (≥225 lbf)	
External fittings (not intended for tethered applications)	Fitting pull out strength	Section 8.6	Strength ≥135 N (≥30 lbf)	
Exhaust valves	Exhaust valve mounting strength	Section 8.24	Strength ≥135 N (≥30 lbf)	
	Exhaust valve inward leakage	Section 8.25	Leakage rate ≤30 mL/min (1.83 in^3/min)	
Class 4 Garment Elements				
	Viral penetration resistance	ASTM F1671/F1671M (Section 8.21)	No penetration for ≥1 hr	
Garment materials	Burst strength	Section 8.9	Strength ≥135 N (≥30 lbf)	
	Puncture propagation tear resistance	ASTM D2582 (Section 8.10)	Tear resistance ≥25 N (≥5 3/5 lbf)	
	Cold temperature performance	ASTM D747 (Section 8.11)	Bending moment of ≤0.057 N·m (≤0.5 in.·lbf) at an angular deflection of 60°at −25°C (−13°F)	
	Total heat loss	Section 8.8	≥450 W/m^2	
	Evaporative resistance	ISO 11092 (Section 8.20)	≤30 Pa m^2/W	
Seams and closure assemblies	Seam/closure breaking strength	ASTM D751 (Section 8.12)	Breaking strength ≥34 N/25 mm (≥7.5 lbf/1 in.)	
Class 4 Garment Visors				
Materials	Viral penetration resistance	ASTM F1671/F1671M (Section 8.21)	No penetration for ≥1 hr	
	Visor high-mass impact resistance	Section 9.11 of ANSI/ISEA Z87.1 (Section 8.13)	No full-thickness punctures, cracks, holes, or fractures	
Material seams	Seam/closure breaking strength	ASTM D751 (Section 8.12)	Breaking strength ≥34 N/25 mm (≥7.5 lbf/1 in.)	
Class 4 Elastomeric Interface Materials				
	Ultimate tensile strength	Method A of ASTM D412 (Section 8.29)	Elongation at rupture ≥125%	
	Cut resistance	ASTM F1790 (Section 8.14)	Blade travel distance of ≥20 mm (≥0.8 in.)	
	Puncture resistance	ASTM F1342/F1342M (Section 8.15)	Puncture resistance of ≥7 N (≥1.6 lbf)	
	Ultimate tensile strength	Method A of ASTM D412 (Section 8.29)	Ultimate tensile strength of ≥4 MPa (≥580 psi)	
Class 4 Glove Elements				
	Liquidtight integrity	ASTM D5151 with modifications (Section 8.22)	No liquid penetration	
	Cut resistance	ASTM F1790 (Section 8.14)	Blade travel distance of ≥20 mm (≥0.8 in.)	
	Puncture resistance	ASTM F1342/F1342M (Section 8.15)	Puncture resistance of ≥9 N (≥2 lbf)	
	Cold temperature performance	ASTM D747 (Section 8.11)	Bending moment of ≤0.057 N·m (≤0.5 in.·lbf) at an angular deflection of 60°at −25°C (−13°F)	
	Glove hand function	ASTM F2010/F2010M (Section 8.16)	Average % increase over barehanded control <200%	
Materials and seams	Viral penetration resistance	ASTM F1671/F1671M (Section 8.21)	No penetration for ≥1 hr	

(continues)

N **Table 5.3.2(a)** *Continued*

Ensemble or Element	Performance Requirement	Test Method	Requirement	Result
Class 4 Footwear Elements				
	Liquidtight integrity	ASTM D5151 with modifications (Section 8.22)	No liquid penetration	
	Slip resistance	ISO 13287 (Section 8.19)	Coefficient of friction ≥0.40	
Upper materials	Cut resistance	ASTM F1790 (Section 8.14)	Blade travel distance of ≥20 mm (≥0.8 in.)	
	Puncture resistance	ASTM F1342/F1342M (Section 8.15)	Puncture resistance of ≥36 N (≥8 lbf)	
	Viral penetration resistance	ASTM F1671/F1671M (Section 8.21)	No penetration for ≥1 hr	
Soles and heels	Abrasion resistance	ISO 4649 (Section 8.17)	Relative volume loss not >250 mm^3 (>0.015 in^3)	
Footwear covers			Meet the requirements specified in 7.6.4.1, 7.6.4.2, 7.6.4.3, 7.6.4.4, 7.6.4.6, and 7.6.4.7, excluding 7.6.4.5	
	Abrasion resistance	ASTM D3884 (Section 8.23)	Show no wear-through after 3000 cycles	
Footwear designed and configured according to 6.4.10			(1) Socks meet the requirements specified in 7.6.4.2 (2) Outer boot meets the requirements specified in 7.6.4.3 and 7.6.4.4 (3) Integrity cover meets the requirements in 7.6.4.1, 7.6.4.7, and 7.6.4.8	
Socks			Outer boot of the footwear element meets the minimum height requirement specified in 6.4.3 and the cut resistance performance requirement in 7.6.4.3	
Class 4 Hood Elements				
			Meet all the applicable requirements specified in 7.6.1	
Elastomeric interface material	Ultimate tensile strength	Method A of ASTM D412 (Section 8.29)	Elongation at rupture ≥125%	
	Cut resistance	ASTM F1790 (Section 8.14)	Blade travel distance of ≥20 mm (≥0.8 in.)	
	Puncture resistance	ASTM F1342/F1342M (Section 8.15)	Puncture resistance of ≥7 N (≥1.6 lbf)	
	Ultimate tensile strength	Method A of ASTM D412 (Section 8.29)	≥4 MPa (≥580 psi)	
Class 4R Ensembles				
	Overall particulate inward leakage	Section 8.5	No visual particulate inward leakage	
	Overall ensemble function and integrity	Procedures A and B, in ASTM F1154 (Section 8.3)	Test subject completes task ≤15 min Accommodates head protection devices meeting ANSI/ISEA Z89.1 (Type 1, Class G) Protective flap remains closed over closure system Test subject has visual acuity through facepiece lens and visor 20/35 or better	
External fittings intended for tethered applications	Fitting pull out strength	Section 8.6	Strength ≥1000 N (≥225 lbf)	

(continues)

N **Table 5.3.2(a)** *Continued*

Ensemble or Element	Performance Requirement	Test Method	Requirement	Result
External fittings (not intended for tethered applications)	Fitting pull out strength	Section 8.6	Strength ≥135 N (≥30 lbf)	
Exhaust valves	Exhaust valve mounting strength	Section 8.24	Strength ≥135 N (30 lbf)	
	Exhaust valve inward leakage	Section 8.25	Leakage rate ≤30 mL/min (≤1.83 in.^{3}/min)	
Class 4R Garment Elements				
	Viral penetration resistance	ASTM F1671/F1671M (Section 8.21)	No penetration for ≥1 hr	
Garment materials	Burst strength	Section 8.9	Strength ≥156 N (≥35 lbf)	
	Puncture propagation tear resistance	ASTM D2582 (Section 8.10)	Tear resistance ≥31 N (≥7 lbf)	
	Cold temperature performance	ASTM D747 (Section 8.11)	Bending moment of ≤0.057 N·m (≤0.5 in.·lbf) at an angular deflection of 60°at −25°C (−13°F)	
	Total heat loss	Section 8.8	≥450 W/m^2	
	Evaporative resistance	ISO 11092 (Section 8.20)	≤30 Pa m^2/W	
Seams and closure assemblies	Seam/closure breaking strength	ASTM D751 (Section 8.12)	Breaking strength ≥34 N/25 mm (≥7.5 lbf/1 in.)	
Class 4R Garment Visors				
Materials	Viral penetration resistance	ASTM F1671/F1671M (Section 8.21)	No penetration for ≥1 hr	
	Visor high-mass impact resistance	Section 9.11 of ANSI/ISEA Z87.1 (Section 8.13)	No full-thickness punctures, cracks, holes, or fractures	
Material seams	Seam/closure breaking strength	ASTM D751 (Section 8.12)	Breaking strength ≥34 N/25 mm (≥7.5 lbf/1 in.)	
Class 4R Elastomeric Interface Materials				
	Ultimate tensile strength	Method A of ASTM D412 (Section 8.29)	Elongation at rupture ≥125%	
	Cut resistance	ASTM F1790 (Section 8.14)	Blade travel distance of ≥20 mm (≥0.8 in.)	
	Puncture resistance	ASTM F1342/F1342M (Section 8.15)	Puncture resistance of ≥7 N (≥1.6 lbf)	
	Ultimate tensile strength	Method A of ASTM D412 (Section 8.29)	Ultimate tensile strength of ≥4 MPa (≥580 psi)	
	Cold temperature performance	ASTM D747 (Section 8.11)	Bending moment of ≤0.057 N·m (≤0.5 in.·lbf)at an angular deflection of 60°at −25°C (−13°F)	
Class 4R Glove Elements				
	Liquidtight integrity	ASTM D5151 with modifications (Section 8.22)	No liquid penetration	
	Cut resistance	ASTM F1790 (Section 8.14)	Blade travel distance of ≥20 mm (≥0.8 in.)	
	Puncture resistance	ASTM F1342/F1342M (Section 8.15)	Puncture resistance of ≥15 N (≥3.8 lbf)	
	Cold temperature performance	ASTM D747 (Section 8.11)	Bending moment of ≤0.057 N·m (≤0.5 in.·lbf) at an angular deflection of 60°at −25°C (−13°F)	
	Glove hand function	ASTM F2010/F2010M (Section 8.16)	Average % increase over barehanded control <200%	
Materials and seams	Viral penetration resistance	ASTM F1671/F1671M (Section 8.21)	No penetration for ≥1 hr	
Class 4R Footwear Elements				
	Liquidtight integrity	ASTM D5151 with modifications (Section 8.22)	No liquid penetration	

(continues)

N **Table 5.3.2(a)** *Continued*

Ensemble or Element	Performance Requirement	Test Method	Requirement	Result
	Slip resistance	ISO 13287 (Section 8.19)	Coefficient of friction ≥0.40	
Upper materials	Cut resistance	ASTM F1790 (Section 8.14)	Blade travel distance of ≥20 mm (≥0.8 in.)	
	Puncture resistance	ASTM F1342/F1342M (Section 8.15)	Puncture resistance of ≥36 N (≥8 lbf)	
	Viral penetration resistance	ASTM F1671/F1671M (Section 8.21)	No penetration for ≥1 hr	
Soles and heels	Abrasion resistance	ISO 4649 (Section 8.17)	Relative volume loss not >250 mm^3 (>0.015 in^3)	
Footwear covers			Meet the requirements specified in 7.7.4.1, 7.7.4.2, 7.7.4.3, 7.7.4.4, 7.7.4.6, and 7.7.4.8, excluding 7.7.4.5	
	Abrasion resistance	ASTM D3884 (Section 8.23)	Show no wear-through after 3000 cycles	
Footwear designed and configured according to 6.4.10			(1) Socks meet the requirements specified in 7.7.4.2	
			(2) Outer boot meets the requirements specified in 7.7.4.3 and 7.7.4.4	
			(3) Integrity cover meets the requirements in 7.7.4.1, 7.7.4.7, and 7.7.4.8	
Socks			Outer boot of the footwear element meets the minimum height requirement specified in 6.4.3 and the cut resistance performance requirement in 7.7.4.3	
Class 4R Hood Elements				
			Meet all the applicable requirements specified in 7.7.1	
Elastomeric interface material	Ultimate tensile strength	Method A of ASTM D412 (Section 8.29)	Elongation at rupture ≥125%	
	Cut resistance	ASTM F1790 (Section 8.14)	Blade travel distance of ≥20 mm (≥0.8 in.)	
	Puncture resistance	ASTM F1342/F1342M (Section 8.15)	Puncture resistance of ≥7 N (≥1.6 lbf)	
	Ultimate tensile strength	Method A of ASTM D412 (Section 8.29)	Ultimate tensile strength of ≥4 MPa (≥580 psi)	
Optional Chemical Flash Fire Protection				
Ensembles or elements	Overall ensemble flash	Section 8.30	Afterflame times ≤2 s No liquid penetration	
Hood with visor			Visual acuity of 20/100	
Garment materials, visor, glove, footwear, and elastomeric interface materials	Heat transfer performance	ASTM F2700 (Section 8.32)	≥12 cal/cm^2 (>4 in.)	
Garment materials, visor, glove, footwear, and elastomeric interface materials	Flammability resistance	Method A of ASTM D412 (Section 8.29)	Will not burn at a distance >100 mm (>4 in.), will not sustain burning for >2 s, and will not melt and drip	
Class 1 ensembles and elements			Meet applicable requirements in Section 7.1	
Class 2 ensembles and elements			Meet the applicable requirements in Section 7.2	
Class 2R ensembles and elements			Meet the applicable requirements in Section 7.3	
Class 3 ensembles and elements			Meet the applicable requirements in Section 7.4	
Class 3R ensembles and elements			Meet the applicable requirements in Section 7.5	

(continues)

N **Table 5.3.2(a)** *Continued*

Ensemble or Element	Performance Requirement	Test Method	Requirement	Result
Class 4 ensembles and elements			Meet the applicable requirements in Section 7.6	
Class 4R ensembles and elements			Meet the applicable requirements in Section 7.7	
Optional Stealth Requirements				
Ensembles	Audible signature	Section 8.34	Report	
Garment, glove, footwear, and hood outer materials	Color/Visibility	Section 8.33	Y brightness value <25, with an L* value <55	
Class 1 ensembles and elements			Meet the applicable requirements in Section 7.1	
Class 2 ensembles and elements			Meet the applicable requirements in Section 7.2	
Class 2R ensembles and elements			Meet the applicable requirements in Section 7.3	
Class 3 ensembles and elements			Meet the applicable requirements in Section 7.4	
Class 3R ensembles and elements			Meet the applicable requirements in Section 7.5	
Class 4 ensembles and elements			Meet the applicable requirements in Section 7.6	
Class 4R ensembles and elements			Meet the applicable requirements in Section 7.7	

N **Table 5.3.2(b) Format for Reporting Certification Permeation Test Data in Technical Data Package**

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

[a]Indicate either liquid challenge level (Class 1 — 20 g/m^2 or Class 2/3 — 10 g/m^2) or gas concentration (Class 1 — 1%, Class 2 — 350 ppm, Class 3 — 40 ppm).

[b]All values are cumulative permeation mass reported values in μg/cm^2.

[c]Chemicals for Class 1 only

5.3.4.2 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 hazardous materials and CBRN protective ensembles and ensemble elements to this standard, the manufacturer shall list these clothing items and equipment in the technical data package.

Δ **5.3.5.2** The manufacturer shall provide, in the technical data package, the list and descriptions of the following hazardous materials and CBRN protective ensemble materials and ensemble elements, if applicable:

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

Δ **5.3.5.4** Descriptions of respective 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

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, if applicable:

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

Chapter 6 Design Requirements

6.1 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 Ensemble elements shall include protective garments, protective gloves, protective hoods, and protective footwear.

N **6.1.3.1** Where socks are used as part of the protective ensemble, the manufacturer shall permit the use of any NFPA 1994 footwear element, or any outer boot of the footwear element that is certified to NFPA 1951, NFPA 1971, NFPA 1991, NFPA 1992, or NFPA 1999, that also meets the minimum height requirement specified in 6.4.3.

•

6.1.4 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.

6.1.5 Any ensemble certified as Class 1, 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.

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

6.1.7 All respirators specified by the ensemble manufacturer for inclusion in Class 1, 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*, the *Statement of Standard for NIOSH CBRN APR Testing,* or the *Statement of Standard for NIOSH CBRN PAPR Testing*. All respirators shall cover the eyes, nose, and mouth at a minimum.

6.1.7.1 All respirators specified in 6.1.7 for inclusion in Class 1 and Class 2 ensembles shall be CBRN self-contained breathing apparatus (SCBA).

6.1.7.2 Where the respirator specified in 6.1.7 is an open-circuit SCBA, the SCBA shall also be certified as compliant with NFPA 1981 or NFPA 1986.

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

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

6.2.4 Where garments incorporate integrated socks, the socks 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.

N **6.2.7*** Where the manufacturer designates the garment portion of the Class 2 ensembles as "breathable," the following shall apply:

(1) The total heat loss shall be measured as specified in Section 8.8, Total Heat Loss Test.
(2) The evaporative resistance shall be measured as specified in Section 8.19, Evaporative Resistance Test.
(3) The results for the total heat loss evaporative resistance shall be provided in the technical data package.
(4) "Breathable (see manufacturer's Technical Data Package)" shall be added to the product label as specified in 5.1.1.9(10).

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 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.

6.3.4 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.

N **6.4.1** Footwear elements shall be designed and configured to provide protection to the feet and ankles.

6.4.2 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.

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

•

6.4.4 Protective footwear shall be offered in at least six unique and different sizes. Where offered, hazardous materials and CBRN terrorism incident protective footwear covers shall accommodate the offered protective footwear 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.

6.4.8 Class 1 and Class 2 footwear elements shall have a heel breast not less than 13 mm (½ in.) nor more than 25 mm (1 in.).

6.4.9 For Class 1 and Class 2 footwear elements, the toe impact- and compression-resistant components and the sole puncture-resistant components shall be integral and nonremovable parts of the footwear.

6.4.10 Footwear shall be allowed to be designed and configured of a single component or of multiple components.

•

N **6.5 Hood Elements Requirements.**

N **6.5.1** Separate hood elements shall be permitted for Class 3 and Class 4 ensembles only.

N **6.5.2** Hoods shall be designed and configured to protect the wearer's head and neck.

N **6.5.2.1** Hoods shall be permitted to include a visor.

N **6.5.2.2** Hoods shall be permitted to have a face opening that provides an interface with a specific respirator facepiece.

N **6.5.2.2.1** Hoods that include a respirator interface shall be designed to accommodate the respirator(s) specified by the manufacturer for the specific hood.

N **6.5.2.2.2** All respirators specified by the hood manufacturer 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*, the *Statement of Standard for NIOSH CBRN APR Testing*, or the *Statement of Standard for NIOSH CBRN PAPR Testing*. All respirators shall cover the eyes, nose, and mouth at a minimum.

N **6.5.2.3** The interface and integration of the selected respirator with the protective hood shall not invalidate the NIOSH certification of the respirator.

N **6.5.3** Where loose-fitting facepiece powered air-purifying respirators (PAPR) are used as part of a nonencapsulating ensemble as specified by the manufacturer, the hood portion of the PAPR shall be considered a hood under this standard.

N **6.5.3.1** The hood portion of the PAPR shall be subject to the performance criteria specified in 7.4.5 or 7.6.5.

N **6.5.3.2** The PAPR shall be certified by NIOSH as compliant with the *Statement of Standard for NIOSH CBRN PAPR Testing*.

N **6.5.4** All external fittings shall be free of rough spots, burrs, or sharp edges that could tear primary materials.

N **6.6 Optional Chemical Flash Fire Protection Design Requirements.** Where protective ensembles or elements rely on external clothing items or multiple layers to meet the performance requirements in Section 7.8, Optional Chemical Flash Fire Escape Protection Requirements, the ensemble or elements shall be designed so that all layers or separate parts are securely attached, and the ensembles are provided as single integrated units.

N **6.7 Optional Stealth Design Requirements.** Where protective ensembles or elements are designed to meet the performance requirements in Section 7.9, Optional Stealth Requirements, the complete ensemble and all elements shall be subject to the applicable requirements.

Chapter 7 Performance Requirements

N **7.1 Class 1 Ensembles.**

N **7.1.1 Class 1 Ensemble General Requirements.**

N **7.1.1.1*** Class 1 ensembles shall be tested for overall inward leakage as specified in Section 8.2, Man-In-Simulant Test (MIST), and shall have a geometric mean local physiological protective dosage factor ($PPDF_i$) value at each passive adsorbent dosimeter (PAD) location for the four ensembles tested of no less than 871 and a geometric mean systemic physiological protective dosage factor ($PPDF_{sys}$) value for each of the four tested ensembles of no less than 441.

N **7.1.1.2** Class 1 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.

N **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*.

N **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.

N **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.

N **7.1.1.2.4** Where the ensemble is of an encapsulated design, it shall permit the test subject to remove and reinsert their hand into the glove system 5 times sequentially within a period of 2.5 minutes or less.

N **7.1.1.2.5** Where the ensemble includes a hood with a visor that covers the respirator facepiece, the garment shall permit the test subject to property identify 3 out of 4 numbers on the NFPA 704 based placard at each of the following angles: Upwards 36°, Downwards 30°, and Right and Left 60°.

N **7.1.1.3** Class 1 ensembles shall be tested for liquid tight integrity as specified in Section 8.4, Liquidtight Integrity Test, and ensembles shall allow no liquid penetration.

N **7.1.1.3.1** Where outer gloves are designed to be worn in conjunction with gloves attached to the ensemble, the outer gloves shall not collect liquid.

N **7.1.1.3.2** Where outer boots are designed to be worn in conjunction with socks, the outer boots shall not collect liquid.

N **7.1.1.4** Encapsulating Ensembles shall be tested for airflow capacity as specified in Section 8.26, Maximum Ensemble Ventilation Rate Test, and shall exhibit no internal pressures greater than 150 mm (6 in.) water gauge pressure, and shall show an ending pressure of at least 80 mm ($^{35}/_{32}$ in.) water gauge pressure after subsequent testing for gastight integrity as specified in Section 8.25, Gastight Integrity Test.

N **7.1.1.5** Ensembles on which external fittings are installed that penetrate any primary materials shall be tested for gastight integrity as specified in Section 8.25, Gastight Integrity Test, and show an ending pressure of at least 80 mm ($^{35}/_{32}$ in.) water gauge.

N **7.1.1.6** External fittings installed in Class 1 ensembles that are intended for tethered applications 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).

N **7.1.1.6.1** External fittings installed in Class 1 ensembles that are not intended for tethered applications 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 135 N (30 lbf).

N **7.1.1.7** Exhaust valves installed in Class 1 ensembles shall be tested for mounting strength as specified in Section 8.23, Exhaust Valve Mounting Strength Test, and shall have a failure force greater than 135 N (30 lbf).

N **7.1.1.8** Exhaust valves installed in Class 1 ensembles shall be tested for inward leakage as specified in Section 8.24, Exhaust Valve Inward Leakage Test, and shall not exhibit a leakage rate exceeding 30 mL/min (1.83 $in.^3$/min).

N **7.1.2 Class 1 Garment Element Requirements.**

N **7.1.2.1** Class 1 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 the liquid chemical warfare agent sulfur mustard, distilled (HD, or bis [2-chloroethyl] sulfide, CAS 505-60-2), the average cumulative permeation in 1 hour shall not exceed 4.0 $\mu g/cm^2$, and the average cumulative permeation for the first 15-minute interval shall not exceed 1.33 $\mu g/cm^2$.

(2) For permeation testing of the liquid chemical warfare agent soman (GD, or O-Pinacolyl methylphosphonofluoridate, CAS 96-64-0), the average cumulative permeation in 1 hour shall not exceed 1.25 $\mu g/cm^2$, and the average cumulative permeation for the first 15-minute interval shall not exceed 0.43 $\mu g/cm^2$.

(3) For permeation testing of the liquid industrial chemicals specified in 8.7.6 for Class 1, the average cumulative permeation in 1 hour shall not exceed 6.0 μg/cm², and the average cumulative permeation for the first 15-minute interval shall not exceed 2.0 μg/cm².
(4) For permeation testing of the gas industrial chemicals specified in 8.7.6 for Class 1, the average cumulative permeation in 1 hour shall not exceed 6.0 μg/cm², and the average cumulative permeation for the first 15-minute interval shall not exceed 2.0 μg/cm².

N **7.1.2.2** Class 1 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 200 N (45 lbf).

N **7.1.2.2.1** If used as part of a sock, Class 1 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).

N **7.1.2.3** Class 1 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 49 N (11 lbf).

N **7.1.2.3.1** If used as part of a sock, Class 1 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).

N **7.1.2.4** Class 1 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).

N **7.1.2.5** Class 1 garment materials shall be tested for resistance to flame impingement as specified in Section 8.27, and shall have an afterflame time of not greater than 2.0 seconds and shall not melt and drip.

N **7.1.2.6** Class 1 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 67 N/25 mm (15 lbf/1 in.).

N **7.1.2.7** Class 1 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 67 N/25 mm (15 lbf/1 in.).

N **7.1.2.8 Class 1 Garment Visor Requirements.**

N **7.1.2.8.1** Class 1 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 the liquid chemical warfare agent sulfur mustard, distilled (HD, or bis [2-chloroethyl] sulfide, CAS 505-60-2), the average cumulative permeation in 1 hour shall not exceed 4.0 μg/cm², and the average cumulative permeation for the first 15-minute interval shall not exceed 1.33 μg/cm².
(2) For permeation testing of the liquid chemical warfare agent soman (GD, or O-Pinacolyl methylphosphonofluoridate, CAS 96-64-0), the average cumulative permeation in 1 hour shall not exceed 1.25 μg/cm², and the average cumulative permeation for the first 15-minute interval shall not exceed 0.43 μg/cm².
(3) For permeation testing of the liquid industrial chemicals specified in 8.7.6 for Class 1, the average cumulative permeation in 1 hour shall not exceed 6.0 μg/cm², and the average cumulative permeation for the first 15-minute interval shall not exceed 2.0 μg/cm².
(4) For permeation testing of the gas industrial chemicals specified in 8.7.6 for Class 1, the average cumulative permeation in 1 hour shall not exceed 6.0 μg/cm², and the average cumulative permeation for the first 15-minute interval shall not exceed 2.0 μg/cm².

N **7.1.2.8.2** Class 1 garment visor materials shall be tested for high mass impact resistance as specified in Section 8.13, Visor High-Mass Impact Resistance Test, and shall not have a full-thickness puncture, cracks, holes, or fractures.

N **7.1.2.8.3** Class 1 garment visor materials shall be tested for resistance to flame impingement as specified in Section 8.27, and shall have an afterflame time of not greater than 2.0 seconds and shall not melt and drip.

N **7.1.2.8.4** Class 1 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 67 N/25 mm (15 lbf/1 in.).

N **7.1.2.9 Class 1 Elastomeric Interface Material Requirements.**

N **7.1.2.9.1*** Elastomeric interface materials shall have an elongation at rupture of not less than 125 percent when tested as specified in Section 8.28, Ultimate Tensile Strength Test.

N **7.1.2.9.2** Where the Class 1 garment includes elastomeric interface materials, each elastomeric interface material 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 the liquid chemical warfare agent sulfur mustard, distilled (HD, or bis [2-chloroethyl] sulfide, CAS 505-60-2), the average cumulative permeation in 1 hour shall not exceed 4.0 μg/cm², and the average cumulative permeation for the first 15-minute interval shall not exceed 1.33 μg/cm².
(2) For permeation testing of the liquid chemical warfare agent soman (GD, or O-Pinacolyl methylphosphonofluoridate, CAS 96-64-0), the average cumulative permeation in 1 hour shall not exceed 1.25 μg/cm², and the average cumulative permeation for the first 15-minute interval shall not exceed 0.43 μg/cm².
(3) For permeation testing of the liquid industrial chemicals specified in 8.7.6 for Class 1, the average cumulative permeation in 1 hour shall not exceed 6.0 μg/cm², and the average cumulative permeation for the first 15-minute interval shall not exceed 2.0 μg/cm².
(4) For permeation testing of the gas industrial chemicals specified in 8.7.6 for Class 1, the average cumulative permeation in 1 hour shall not exceed 6.0 μg/cm², and the average cumulative permeation for the first 15-minute interval shall not exceed 2.0 μg/cm².

N **7.1.2.9.3** Where the Class 1 garment includes elastomeric interface materials, each elastomeric interface material shall be tested for cut resistance as specified in Section 8.14, Cut Resistance Test, and shall have a blade travel distance of not less than 20 mm (0.8 in.).

N **7.1.2.9.4** Where the Class 1 garment includes elastomeric interface materials, each elastomeric interface material shall be tested for puncture resistance as specified in Section 8.15, Puncture Resistance Test 1, shall have a puncture resistance of not less than 7 N (1.6 lbf).

N **7.1.2.9.5** Where the Class 1 garment includes elastomeric interface materials, each elastomeric interface material shall be tested for ultimate tensile strength as specified in Section 8.28, Ultimate Tensile Strength Test, and shall have an ultimate tensile strength of not less than 4 MPa (580 psi).

N **7.1.2.9.6** Where the Class 1 garment includes elastomeric interface materials, each elastomeric interface material 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).

N **7.1.2.9.7** Where the Class 1 garment includes elastomeric interface materials, each interface material shall be tested for resistance to flame impingement as specified in Section 8.27, Flammability Resistance Test, and shall have an afterflame time of not greater than 2.0 seconds and shall not melt and drip.

N **7.1.3 Class 1 Glove Element Requirements.**

N **7.1.3.1** Class 1 gloves shall be tested for liquidtight integrity as specified in Section 8.21, Liquidtight Integrity Test 2, and shall show no leakage.

N **7.1.3.2** Class 1 glove 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 the liquid chemical warfare agent sulfur mustard, distilled (HD, or bis [2-chloroethyl] sulfide, CAS 505-60-2), the average cumulative permeation in 1 hour shall not exceed 4.0 $\mu g/cm^2$, and the average cumulative permeation for the first 15-minute interval shall not exceed 1.33 $\mu g/cm^2$.

(2) For permeation testing of the liquid chemical warfare agent soman (GD, or O-Pinacolyl methylphosphonofluoridate, CAS 96-64-0), the average cumulative permeation in 1 hour shall not exceed 1.25 $\mu g/cm^2$, and the average cumulative permeation for the first 15-minute interval shall not exceed 0.43 $\mu g/cm^2$.

(3) For permeation testing of the liquid industrial chemicals specified in 8.7.6 for Class 1, the average cumulative permeation in 1 hour shall not exceed 6.0 $\mu g/cm^2$, and the average cumulative permeation for the first 15-minute interval shall not exceed 2.0 $\mu g/cm^2$.

(4) For permeation testing of the gas industrial chemicals specified in 8.7.6 for Class 1, the average cumulative permeation in 1 hour shall not exceed 6.0 $\mu g/cm^2$, and the average cumulative permeation for the first 15-minute interval shall not exceed 2.0 $\mu g/cm^2$.

N **7.1.3.3** Class 1 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 20 mm (0.8 in.).

N **7.1.3.4** Class 1 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).

N **7.1.3.5** Class 1 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).

N **7.1.3.6** Class 1 glove materials shall be tested for resistance to flame impingement as specified in Section 8.27, and shall have an afterflame time of not greater than 2.0 seconds and shall not melt and drip.

N **7.1.3.7** Class 1 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.

N **7.1.4 Class 1 Footwear Element Requirements.**

N **7.1.4.1** Class 1 footwear shall be tested for liquidtight integrity as specified in Section 8.21, Liquidtight Integrity Test 2, and shall show no leakage.

N **7.1.4.2** Class 1 footwear upper materials 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 the liquid chemical warfare agent sulfur mustard, distilled (HD, or bis [2-chloroethyl] sulfide, CAS 505-60-2), the average cumulative permeation in 1 hour shall not exceed 4.0 $\mu g/cm^2$, and the average cumulative permeation for the first 15-minute interval shall not exceed 1.33 $\mu g/cm^2$.

(2) For permeation testing of the liquid chemical warfare agent soman (GD, or O-Pinacolyl methylphosphonofluoridate, CAS 96-64-0), the average cumulative permeation in 1 hour shall not exceed 1.25 $\mu g/cm^2$, and the average cumulative permeation for the first 15-minute interval shall not exceed 0.43 $\mu g/cm^2$.

(3) For permeation testing of the liquid industrial chemicals specified in 8.7.6 for Class 1, the average cumulative permeation in 1 hour shall not exceed 6.0 $\mu g/cm^2$, and the average cumulative permeation for the first 15-minute interval shall not exceed 2.0 $\mu g/cm^2$.

(4) For permeation testing of the gas industrial chemicals specified in 8.7.6 for Class 1, the average cumulative permeation in 1 hour shall not exceed 6.0 $\mu g/cm^2$, and the average cumulative permeation for the first 15-minute interval shall not exceed 2.0 $\mu g/cm^2$.

N **7.1.4.3** Class 1 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 20 mm (0.8 in.).

N **7.1.4.4** Class 1 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).

N **7.1.4.5** Class 1 footwear soles and heels shall be tested for abrasion resistance as specified in Section 8.17, Abrasion Resistance Test 1, and the relative volume loss shall not be greater than 250 mm^3 (0.015 $in.^3$).

N **7.1.4.6** Class 1 footwear shall be tested for slip resistance as specified in Section 8.18, Slip Resistance Test, and shall have a coefficient of friction of 0.40 or greater.

N **7.1.4.7** Class 1 footwear materials shall be tested for resistance to flame impingement as specified in Section 8.27, and shall have an afterflame time of not greater than 2.0 seconds and shall not melt and drip.

N **7.1.4.8** Where the manufacturer specifies the use of a footwear cover to be worn over standard footwear, Class 1 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.

N **7.1.4.9** Where the manufacturer specifies the use of a footwear cover to be worn over standard footwear, Class 1 footwear covers shall be tested for abrasion resistance as specified in Section 8.22, Abrasion Resistance Test 2, and shall show no wear-through after 3000 cycles.

N **7.1.4.10** Class 1 footwear shall meet the performance requirements specified in ASTM F2413, *Standard Specification for Performance Requirements for Protective (Safety) Toe Cap Footwear*, for impact-, compression-, and puncture-resistant footwear with the exception that flex resistance to cracking shall not be evaluated. Testing shall be performed as specified in ASTM F2412, *Standard Test Methods for Foot Protection*.

N **7.1.4.11** Where socks are used as part of a protective ensemble and the manufacturer permits the use of any outer boot of the footwear element that is certified to NFPA 1951, NFPA 1971, NFPA 1991, NFPA 1992, or NFPA 1999, the outer boot of the footwear element shall meet the minimum height requirement specified in 6.4.3 and the cut resistance performance requirement specified in 7.1.4.3.

7.2 Class 2 Ensembles.

7.2.1 Class 2 Ensemble General Requirements.

7.2.1.1* Class 2 ensembles shall be tested for overall inward leakage as specified in Section 8.2, Man-In-Simulant Test (MIST), and shall have a geometric mean local physiological protective dosage factor ($PPDF_i$) value at each PAD location for the four ensembles tested of no less than 481 and a geometric mean systemic physiological protective dosage factor ($PPDF_{sys}$) value for each of the four tested ensembles of no less than 328.

7.2.1.2 Class 2 ensembles shall be tested for overall function as specified in Section 8.3, Overall Garment 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/ISEA Z89.1, *American National 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 2 ensembles that are intended for tethered applications 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).

N **7.2.1.3.1** External fittings installed in Class 2 ensembles that are not intended for tethered applications 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 135 N (30 lbf).

7.2.1.4 Exhaust valves installed in Class 2 ensembles shall be tested for mounting strength as specified in Section 8.23, Exhaust Valve Mounting Strength Test, and shall have a failure force greater than 135 N (30 lbf).

7.2.1.5 Exhaust valves installed in Class 2 ensembles shall be tested for inward leakage as specified in Section 8.24, Exhaust Valve Inward Leakage Test, and shall not exhibit a leakage rate exceeding 30 mL/min (1.83 $in.^3$/min).

7.2.2 Class 2 Garment Element Requirements.

Δ **7.2.2.1** 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 the liquid chemical warfare agent sulfur mustard, distilled [HD, or bis (2-chloroethyl) sulfide, CAS 505-60-2], the average cumulative permeation in 1 hour shall not exceed 4.0 μg/cm^2, and the average cumulative permeation for the first 15-minute interval shall not exceed 1.33 μg/cm^2.

(2) For permeation testing of the liquid chemical warfare agent soman (GD, or O-Pinacolyl methylphosphonofluoridate, CAS 96-64-0), the average cumulative permeation in 1 hour shall not exceed 1.25 μg/cm^2, and the average cumulative permeation for the first 15-minute interval shall not exceed 0.43 μg/cm^2.

(3) For permeation testing of the liquid toxic industrial chemical specified in 8.7.6 for Class 2, the average cumulative permeation in 1 hour shall not exceed 6.0 μg/cm^2, and the average cumulative permeation for the first 15-minute interval shall not exceed 2.0 μg/cm^2.

(4) For permeation testing of the gas and vapor toxic industrial chemicals specified in 8.7.6 for Class 2, the average cumulative permeation in 1 hour shall not exceed 6.0 μg/cm^2, and the average cumulative permeation for the first 15-minute interval shall not exceed 2.0 μg/cm^2.

7.2.2.2 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).

7.2.2.3 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).

7.2.2.4 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).

7.2.2.5 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 34 N/25 mm (7.5 lbf/1 in.).

7.2.2.6 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 34 N/25 mm (7.5 lbf/1 in.).

7.2.2.7 Class 2 garment materials and seams shall be tested for resistance to liquid or bloodborne pathogens as specified in Section 8.20, Viral Penetration Resistance Test, and shall allow no penetration of the Phi-X-174 bacteriophage for at least 1 hour.

7.2.2.8 Class 2 Garment Visor Requirements.

Δ **7.2.2.8.1** 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 the liquid chemical warfare agent sulfur mustard, distilled [HD, or bis (2-chloroethyl) sulfide, CAS 505-60-2), the average cumulative permeation in 1 hour shall not exceed 4.0 μg/cm^2, and the average cumulative permeation for the first 15-minute interval shall not exceed 1.33 μg/cm^2.

(2) For permeation testing of the liquid chemical warfare agent soman (GD, or O-Pinacolyl methylphosphonofluoridate, CAS 96-64-0), the average cumulative permeation in 1 hour shall not exceed 1.25 μg/cm^2, and the average cumulative permeation for the first 15-minute interval shall not exceed 0.43 μg/cm^2.

(3) For permeation testing of the liquid toxic industrial chemical specified in 8.7.6 for Class 2, the average cumulative permeation in 1 hour shall not exceed 6.0 μg/cm^2, and the average cumulative permeation for the first 15-minute interval shall not exceed 2.0 μg/cm^2.

(4) For permeation testing of the gas and vapor toxic industrial chemicals specified in 8.7.6 for Class 2, the average cumulative permeation in 1 hour shall not exceed 6.0 μg/cm^2, and the average cumulative permeation for the first 15-minute interval shall not exceed 2.0 μg/cm^2.

7.2.2.8.2 Class 2 garment visor materials shall be tested for high mass impact resistance as specified in Section 8.13, Visor High-Mass Impact Resistance Test, and shall have no full-thickness punctures, cracks, holes, or factures.

•

7.2.2.8.3 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 34 N/25 mm (7.5 lbf/1 in.).

7.2.2.8.4 Class 2 garment visor materials shall be tested for resistance to liquid or bloodborne pathogens as specified in Section 8.20, Viral Penetration Resistance Test, and shall allow no penetration of the Phi-X-174 bacteriophage for at least 1 hour.

N **7.2.2.9 Class 2 Elastomeric Interface Material Requirements.**

N **7.2.2.9.1*** Elastomeric interface materials shall have an elongation at rupture of not less than 125 percent when tested as specified in Section 8.28, Ultimate Tensile Strength Test.

N **7.2.2.9.2** Where the Class 2 garment includes elastomeric interface materials, each elastomeric interface material 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 the liquid chemical warfare agent sulfur mustard, distilled [HD, or bis (2-chloroethyl) sulfide, CAS 505-60-2], the average cumulative permeation in 1 hour shall not exceed 4.0 μg/cm^2, and the average cumulative permeation for the first 15-minute interval shall not exceed 1.33 μg/cm^2.

(2) For permeation testing of the liquid chemical warfare agent soman (GD, or O-Pinacolyl methylphosphonofluoridate, CAS 96-64-0), the average cumulative permeation in 1 hour shall not exceed 1.25 μg/cm^2, and the average cumulative permeation for the first 15-minute interval shall not exceed 0.43 μg/cm^2.

(3) For permeation testing of the liquid toxic industrial chemical specified in 8.7.6 for Class 2, the average cumulative permeation in 1 hour shall not exceed 6.0 μg/cm^2, and the average cumulative permeation for the first 15-minute interval shall not exceed 2.0 μg/cm^2.

(4) For permeation testing of the gas and vapor toxic industrial chemicals specified in 8.7.6 for Class 2, the average cumulative permeation in 1 hour shall not exceed 6.0 μg/cm^2, and the average cumulative permeation for the first 15-minute interval shall not exceed 2.0 μg/cm^2.

N **7.2.2.9.3** Where the Class 2 garment includes elastomeric interface materials, each elastomeric interface material shall be tested for cut resistance as specified in Section 8.14, Cut Resistance Test, and shall have a blade travel distance of not less than 20 mm (0.8 in.).

N **7.2.2.9.4** Where the Class 2 garment includes elastomeric interface materials, each elastomeric interface material 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 7 N (1.6 lbf).

N **7.2.2.9.5** Where the Class 2 garment includes elastomeric interface materials, each elastomeric interface material shall be tested for ultimate tensile strength as specified in Section 8.28, Ultimate Tensile Strength Test, and shall have an ultimate tensile strength of not less than 4 MPa (580 psi).

N **7.2.2.9.6** Where the Class 2 garment includes elastomeric interface materials, each elastomeric interface gasket material 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 Class 2 Glove Element Requirements.

7.2.3.1 Class 2 gloves shall be tested for liquidtight integrity as specified in Section 8.21, Liquidtight Integrity Test 2, and shall show no leakage.

Δ **7.2.3.2** Class 2 glove 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 the liquid chemical warfare agent sulfur mustard, distilled [HD, or bis (2-chloroethyl) sulfide, CAS 505-60-2], the average cumulative permeation in 1 hour shall not exceed 4.0 $\mu g/cm^2$, and the average cumulative permeation for the first 15-minute interval shall not exceed 1.33 $\mu g/cm^2$.
(2) For permeation testing of the liquid chemical warfare agent soman (GD, or O-Pinacolyl methylphosphonofluoridate, CAS 96-64-0), the average cumulative permeation in 1 hour shall not exceed 1.25 $\mu g/cm^2$, and the average cumulative permeation for the first 15-minute interval shall not exceed 0.43 $\mu g/cm^2$.
(3) For permeation testing of the liquid toxic industrial chemical specified in 8.7.6 for Class 2, the average cumulative permeation in 1 hour shall not exceed 6.0 $\mu g/cm^2$, and the average cumulative permeation for the first 15-minute interval shall not exceed 2.0 $\mu g/cm^2$.
(4) For permeation testing of the gas and vapor toxic industrial chemicals specified in 8.7.6 for Class 2 the average cumulative permeation in 1 hour shall not exceed 6.0 $\mu g/cm^2$, and the average cumulative permeation for the first 15-minute interval shall not exceed 2.0 $\mu g/cm^2$.

7.2.3.3 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 20 mm (0.8 in.).

7.2.3.4 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).

7.2.3.5 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).

7.2.3.6 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.

7.2.3.7 Class 2 glove materials and seams shall be tested for resistance to liquid or bloodborne pathogens as specified in Section 8.20, Viral Penetration Resistance Test, and shall allow no penetration of the Phi-X-174 bacteriophage for at least 1 hour.

7.2.4 Class 2 Footwear Element Requirements.

7.2.4.1 Class 2 footwear shall be tested for liquidtight integrity as specified in Section 8.21, Liquidtight Integrity Test 2, and shall show no leakage.

Δ **7.2.4.2** Class 2 footwear upper materials 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 the liquid chemical warfare agent sulfur mustard, distilled [HD, or bis (2-chloroethyl) sulfide, CAS 505-60-2], the average cumulative permeation in 1 hour shall not exceed 4.0 $\mu g/cm^2$, and the average cumulative permeation for the first 15-minute interval shall not exceed 1.33 $\mu g/cm^2$.
(2) For permeation testing of the liquid chemical warfare agent soman (GD, or O-Pinacolyl methylphosphonofluoridate, CAS 96-64-0), the average cumulative permeation in 1 hour shall not exceed 1.25 $\mu g/cm^2$, and the average cumulative permeation for the first 15-minute interval shall not exceed 0.43 $\mu g/cm^2$.
(3) For permeation testing of the liquid toxic industrial specified in 8.7.6 for Class 2, the average cumulative permeation in 1 hour shall not exceed 6.0 $\mu g/cm^2$, and the average cumulative permeation for the first 15-minute interval shall not exceed 2.0 $\mu g/cm^2$.
(4) For permeation testing of the gas and vapor toxic industrial chemicals specified in 8.7.6 for Class 2, the average cumulative permeation in 1 hour shall not exceed 6.0 $\mu g/cm^2$, and the average cumulative permeation for the first 15-minute interval shall not exceed 2.0 $\mu g/cm^2$.

7.2.4.3 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 20 mm (0.8 in.).

7.2.4.4 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).

7.2.4.5 Class 2 footwear soles and heels shall be tested for abrasion resistance as specified in Section 8.17, Abrasion Resistance Test 1, and the relative volume loss shall be not greater than 250 mm^3 (0.015 $in.^3$).

7.2.4.6 Class 2 footwear shall be tested for slip resistance as specified in Section 8.18, Slip Resistance Test, and shall have a coefficient of friction of 0.40 or greater.

7.2.4.7 Class 2 footwear upper material shall be tested for resistance to liquid or bloodborne pathogens as specified in Section 8.20, Viral Penetration Resistance Test, and shall allow no penetration of the Phi-X-174 bacteriophage for at least 1 hour.

7.2.4.8 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 7.2.4.1, 7.2.4.2, 7.2.4.3, 7.2.4.4, 7.2.4.6, and 7.2.4.7, excluding 7.2.4.5.

7.2.4.9 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 8.22, Abrasion Resistance Test 2, and shall show no wear-through after 3000 cycles.

Δ **7.2.4.10** Class 2 footwear shall meet the performance requirements specified in ASTM F2413, *Standard Specification for Performance Requirements for Protective (Safety) Toe Cap Footwear*, for impact-, compression-, and puncture-resistant footwear with the exception that flex resistance to cracking shall not be evaluated. Testing shall be performed as specified in ASTM F2412, *Standard Test Methods for Foot Protection*.

Δ **7.2.4.11** Where socks are used as part of a protective ensemble and the manufacturer permits the use of any outer boot of the footwear element that is certified to NFPA 1951, NFPA 1971, NFPA 1991, NFPA 1992, or NFPA 1999, the outer boot of the footwear element shall meet the minimum height requirement specified in 6.4.3 and cut resistance performance requirement specified in 7.2.4.3.

N 7.3 Class 2R Ensembles.

N 7.3.1 Class 2R Ensemble General Requirements.

N 7.3.1.1* Class 2R ensembles shall be tested for overall inward leakage as specified in Section 8.2, Man-In-Simulant Test (MIST), and shall have a geometric mean local physiological protective dosage factor ($PPDF_i$) value at each PAD location for the four ensembles tested of no less than 481 and a geometric mean systemic physiological protective dosage factor ($PPDF_{sys}$) value for each of the four tested ensembles of no less than 328.

N 7.3.1.2 Class 2R ensembles shall be tested for overall function as specified in Section 8.3, Overall Garment 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.

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

N 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.

N 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.

N 7.3.1.3 External fittings installed in Class 2R ensembles that are intended for tethered applications 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).

N 7.3.1.3.1 External fittings installed in Class 2R ensembles that are not intended for tethered applications 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 135 N (30 lbf).

N 7.3.1.4 Exhaust valves installed in Class 2R ensembles shall be tested for mounting strength as specified in Section 8.23, Exhaust Valve Mounting Strength Test, and shall have a failure force greater than 135 N (30 lbf).

N 7.3.1.5 Exhaust valves installed in Class 2R ensembles shall be tested for inward leakage as specified in Section 8.24, Exhaust Valve Inward Leakage Test, and shall not exhibit a leakage rate exceeding 30 mL/min (1.83 $in.^3$/min).

N 7.3.2 Class 2R Garment Element Requirements.

N 7.3.2.1 Class 2R 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 the liquid chemical warfare agent sulfur mustard, distilled (HD, or bis [2-chloroethyl] sulfide, CAS 505-60-2), the average cumulative permeation in 1 hour shall not exceed 4.0 $\mu g/cm^2$, and the average cumulative permeation for the first 15-minute interval shall not exceed 1.33 $\mu g/cm^2$.

(2) For permeation testing of the liquid chemical warfare agent soman (GD, or O-Pinacolyl methylphosphonofluoridate, CAS 96-64-0), the average cumulative permeation in 1 hour shall not exceed 1.25 $\mu g/cm^2$, and the average cumulative permeation for the first 15-minute interval shall not exceed 0.43 $\mu g/cm^2$.

(3) For permeation testing of the liquid industrial chemicals specified in 8.7.6 for Class 2R, the average cumulative permeation in 1 hour shall not exceed 6.0 $\mu g/cm^2$, and the average cumulative permeation for the first 15-minute interval shall not exceed 2.0 $\mu g/cm^2$.

(4) For permeation testing of the gas and vapor industrial chemicals specified in 8.7.6 for Class 2R, the average cumulative permeation in 1 hour shall not exceed 6.0 $\mu g/cm^2$, and the average cumulative permeation for the first 15-minute interval shall not exceed 2.0 $\mu g/cm^2$.

N 7.3.2.2 Class 2R 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 200 N (45 lbf).

N 7.3.2.2.1 If used as part of a sock, Class 2R 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).

N 7.3.2.3 Class 2R 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 49 N (11 lbf).

N 7.3.2.3.1 If used as part of a sock, Class 2R 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).

N 7.3.2.4 Class 2R 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).

N 7.3.2.5 Class 2R 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 67 N/25 mm (15 lbf/1 in.).

N 7.3.2.6 Class 2R 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 67 N/25 mm (15 lbf/1 in.).

N 7.3.2.7 Class 2R garment materials and seams shall be tested for resistance to liquid or bloodborne pathogens as specified in Section 8.20, Viral Penetration Resistance Test, and shall allow no penetration of the Phi-X-174 bacteriophage for at least 1 hour.

N 7.3.2.8 Class 2R Garment Visor Requirements.

N 7.3.2.8.1 Class 2R 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 the liquid chemical warfare agent sulfur mustard, distilled (HD, or bis [2-chloroethyl]

sulfide, CAS 505-60-2), the average cumulative permeation in 1 hour shall not exceed 4.0 μg/cm², and the average cumulative permeation for the first 15-minute interval shall not exceed 1.33 μg/cm².

(2) For permeation testing of the liquid chemical warfare agent soman (GD, or O-Pinacolyl methylphosphonofluoridate, CAS 96-64-0), the average cumulative permeation in 1 hour shall not exceed 1.25 μg/cm², and the average cumulative permeation for the first 15-minute interval shall not exceed 0.43 μg/cm².

(3) For permeation testing of the liquid industrial chemicals specified in 8.7.6 for Class 2R, the average cumulative permeation in 1 hour shall not exceed 6.0 μg/cm², and the average cumulative permeation for the first 15-minute interval shall not exceed 2.0 μg/cm².

(4) For permeation testing of the gas and vapor industrial chemicals specified in 8.7.6 for Class 2R, the average cumulative permeation in 1 hour shall not exceed 6.0 μg/cm², and the average cumulative permeation for the first 15-minute interval shall not exceed 2.0 μg/cm².

N **7.3.2.8.2** Class 2R garment visor materials shall be tested for high mass impact resistance as specified in Section 8.13, Visor High-Mass Impact Resistance Test, and shall have no full-thickness punctures, cracks, holes, or fractures.

N **7.3.2.8.3** Class 2R 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 67 N/25 mm (15 lbf/1 in.).

N **7.3.2.8.4** Class 2R garment visor materials shall be tested for resistance to liquid or bloodborne pathogens as specified in Section 8.20, Viral Penetration Resistance Test, and shall allow no penetration of the Phi-X-174 bacteriophage for at least 1 hour.

N **7.3.2.9 Class 2R Elastomeric Interface Material Requirements.**

N **7.3.2.9.1*** Elastomeric interface materials shall have an elongation at rupture of not less than 125 percent when tested as specified in Section 8.28, Ultimate Tensile Strength Test.

N **7.3.2.9.2** Where the Class 2R garment includes elastomeric interface materials, each elastomeric interface material 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 the liquid chemical warfare agent sulfur mustard, distilled (HD, or bis [2-chloroethyl] sulfide, CAS 505-60-2), the average cumulative permeation in 1 hour shall not exceed 4.0 μg/cm², and the average cumulative permeation for the first 15-minute interval shall not exceed 1.33 μg/cm².

(2) For permeation testing of the liquid chemical warfare agent soman (GD, or O-Pinacolyl methylphosphonofluoridate, CAS 96-64-0), the average cumulative permeation in 1 hour shall not exceed 1.25 μg/cm², and the average cumulative permeation for the first 15-minute interval shall not exceed 0.43 μg/cm².

(3) For permeation testing of the liquid industrial chemicals specified in 8.7.6 for Class 2R, the average cumulative permeation in 1 hour shall not exceed 6.0 μg/cm², and the average cumulative permeation for the first 15-minute interval shall not exceed 2.0 μg/cm².

(4) For permeation testing of the gas and vapor industrial chemicals specified in 8.7.6 for Class 2R, the average cumulative permeation in 1 hour shall not exceed 6.0 μg/cm², and the average cumulative permeation for the first 15-minute interval shall not exceed 2.0 μg/cm².

N **7.3.2.9.3** Where the Class 2R garment includes elastomeric interface materials, each elastomeric interface material shall be tested for cut resistance as specified in Section 8.14, Cut Resistance Test, and shall have a blade travel distance of not less than 20 mm (0.8 in.).

N **7.3.2.9.4** Where the Class 2R garment includes elastomeric interface materials, each elastomeric interface material 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 7 N (1.6 lbf).

N **7.3.2.9.5** Where the Class 2R garment includes elastomeric interface materials, each elastomeric interface material shall be tested for ultimate tensile strength as specified in Section 8.28, Ultimate Tensile Strength Test, and shall have an ultimate tensile strength of not less than 4 MPa (580 psi).

N **7.3.2.9.6** Where the Class 2R garment includes elastomeric interface materials, each elastomeric interface material 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).

N **7.3.3 Class 2R Glove Element Requirements.**

N **7.3.3.1** Class 2R gloves shall be tested for liquidtight integrity as specified in Section 8.21, Liquidtight Integrity Test 2, and shall show no leakage.

N **7.3.3.2** Class 2R glove 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 the liquid chemical warfare agent sulfur mustard, distilled (HD, or bis [2-chloroethyl] sulfide, CAS 505-60-2), the average cumulative permeation in 1 hour shall not exceed 4.0 μg/cm², and the average cumulative permeation for the first 15-minute interval shall not exceed 1.33 μg/cm².

(2) For permeation testing of the liquid chemical warfare agent soman (GD, or O-Pinacolyl methylphosphonofluoridate, CAS 96-64-0), the average cumulative permeation in 1 hour shall not exceed 1.25 μg/cm², and the average cumulative permeation for the first 15-minute interval shall not exceed 0.43 μg/cm².

(3) For permeation testing of the liquid industrial chemicals specified in 8.7.6 for Class 2R, the average cumulative permeation in 1 hour shall not exceed 6.0 μg/cm², and the average cumulative permeation for the first 15-minute interval shall not exceed 2.0 μg/cm².

(4) For permeation testing of the gas and vapor industrial chemicals specified in 8.7.6 for Class 2R, the average cumulative permeation in 1 hour shall not exceed 6.0 μg/cm², and the average cumulative permeation for the first 15-minute interval shall not exceed 2.0 μg/cm².

N **7.3.3.3** Class 2R glove materials shall be tested for cut resistance as specified in Section 8.14, Cut Resistance Test, and shall have a blade travel distance of not less than 20 mm (0.8 in.).

N **7.3.3.4** Class 2R 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).

N **7.3.3.5** Class 2R 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).

N **7.3.3.6** Class 2R 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.

N **7.3.3.7** Class 2R glove materials and seams shall be tested for resistance to liquid or bloodborne pathogens as specified in Section 8.20, Viral Penetration Resistance Test, and shall allow no penetration of the Phi-X-174 bacteriophage for at least 1 hour.

N **7.3.4 Class 2R Footwear Element Requirements.**

N **7.3.4.1** Class 2R footwear shall be tested for liquidtight integrity as specified in Section 8.21, Liquidtight Integrity Test 2, and shall show no leakage.

N **7.3.4.2** Class 2R footwear upper materials 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 the liquid chemical warfare agent sulfur mustard, distilled (HD, or bis [2-chloroethyl] sulfide, CAS 505-60-2), the average cumulative permeation in 1 hour shall not exceed 4.0 μg/cm^2, and the average cumulative permeation for the first 15-minute interval shall not exceed 1.33 μg/cm^2.

(2) For permeation testing of the liquid chemical warfare agent soman (GD, or O-Pinacolyl methylphosphonofluoridate, CAS 96-64-0), the average cumulative permeation in 1 hour shall not exceed 1.25 μg/cm^2, and the average cumulative permeation for the first 15-minute interval shall not exceed 0.43 μg/cm^2.

(3) For permeation testing of the liquid industrial chemicals specified in 8.7.6 for Class 2R, the average cumulative permeation in 1 hour shall not exceed 6.0 μg/cm^2, and the average cumulative permeation for the first 15-minute interval shall not exceed 2.0 μg/cm^2.

(4) For permeation testing of the gas and vapor industrial chemicals specified in 8.7.6 for Class 2R, the average cumulative permeation in 1 hour shall not exceed 6.0 μg/cm^2, and the average cumulative permeation for the first 15-minute interval shall not exceed 2.0 μg/cm^2.

N **7.3.4.3** Class 2R footwear upper materials shall be tested for cut resistance as specified in Section 8.14, Cut Resistance Test, and shall have a blade travel distance of not less than 20 mm (0.8 in.).

N **7.3.4.4** Class 2R 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).

N **7.3.4.5** Class 2R footwear soles and heels shall be tested for abrasion resistance as specified in Section 8.17, Abrasion Resistance Test 1, and the relative volume loss shall be not greater than 250 mm^3 (0.015 in.^{3}).

N **7.3.4.6** Class 2R footwear shall be tested for slip resistance as specified in Section 8.18, Slip Resistance Test, and shall have a coefficient of friction of 0.40 or greater.

N **7.3.4.7** Class 2R footwear upper material shall be tested for resistance to liquid or bloodborne pathogens as specified in Section 8.20, Viral Penetration Resistance Test, and shall allow no penetration of the Phi-X-174 bacteriophage for at least 1 hour.

N **7.3.4.8** Where the manufacturer specifies the use of a footwear cover to be worn over standard footwear, Class 2R 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 7.3.4.7, excluding 7.3.4.5.

N **7.3.4.9** Where the manufacturer specifies the use of a footwear cover to be worn over standard footwear, Class 2R footwear covers shall be tested for abrasion resistance as specified in Section 8.22, Abrasion Resistance Test 2, and shall show no wear-through after 3000 cycles.

N **7.3.4.10** Class 2R footwear shall meet the performance requirements specified in ASTM F2413, *Standard Specification for Performance Requirements for Protective (Safety) Toe Cap Footwear,* for impact-, compression-, and puncture-resistant footwear with the exception that flex resistance to cracking shall not be evaluated. Testing shall be performed as specified in ASTM F2412, *Standard Test Methods for Foot Protection*.

N **7.3.4.11** Where socks are used as part of a protective ensemble and the manufacturer permits the use of any outer boot of the footwear element that is certified to NFPA 1951, NFPA 1971, NFPA 1991, NFPA 1992, or NFPA 1999, the outer boot of the footwear element shall meet the minimum height requirement specified in 6.4.3 and cut resistance performance requirement specified in 7.3.4.3.

7.4 Class 3 Ensembles.

7.4.1 Class 3 Ensemble General Requirements.

7.4.1.1* Class 3 ensembles shall be tested for overall inward leakage as specified in Section 8.2, Man-In-Simulant Test (MIST), and shall have a geometric mean local physiological protective dosage factor ($PPDF_i$) value at each PAD location for the four ensembles tested of no less than 160 and a geometric mean systemic physiological protective dosage factor ($PPDF_{sys}$) value for each of the four ensembles tested of no less than 69.

7.4.1.2 Class 3 ensembles shall be tested for overall function as specified in Section 8.3, Overall Garment 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; the garment closure shall remain engaged during the entire garment function testing.

7.4.1.2.1 Where hoods are provided, garments shall accommodate head protection devices meeting the dimensional requirements of Type I, Class G helmets of ANSI/ISEA Z89.1, *American National Standard on Industrial Head Protection.*

7.4.1.2.2 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.

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

7.4.1.3 External fittings installed in Class 3 ensembles that are intended for tethered applications 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).

N **7.4.1.3.1** External fittings installed in Class 3 ensembles that are not intended for tethered applications 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 135 N (30 lbf).

7.4.1.4 Exhaust valves installed in Class 3 ensembles shall be tested for mounting strength as specified in Section 8.23, Exhaust Valve Mounting Strength Test, and shall have a failure force greater than 135 N (30 lbf).

7.4.1.5 Exhaust valves installed in Class 3 ensembles shall be tested for inward leakage as specified in Section 8.24, Exhaust Valve Inward Leakage Test, and shall not exhibit a leakage rating exceeding 30 mL/min (1.83 $in.^3$/min).

7.4.2 Class 3 Garment Element Requirements.

Δ **7.4.2.1** 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 the liquid chemical warfare agent sulfur mustard, distilled [HD, or bis (2-chloroethyl) sulfide, CAS 505-60-2], the average cumulative permeation in 1 hour shall not exceed 4.0 $\mu g/cm^2$, and the average cumulative permeation for the first 15-minute interval shall not exceed 1.33 $\mu g/cm^2$.

(2) For permeation testing of the liquid chemical warfare agent soman (GD, or O-Pinacolyl methylphosphonofluoridate, CAS 96-64-0), the average cumulative permeation in 1 hour shall not exceed 1.25 $\mu g/cm^2$, and the average cumulative permeation for the first 15-minute interval shall not exceed 0.43 $\mu g/cm^2$.

(3) For permeation testing of the liquid toxic industrial chemical specified in 8.7.6 for Class 3, the average cumulative permeation in 1 hour shall not exceed 6.0 $\mu g/cm^2$, and the average cumulative permeation for the first 15-minute interval shall not exceed 2.0 $\mu g/cm^2$.

(4) For permeation testing of the gas and vapor toxic industrial chemicals specified in 8.7.6 for Class 3, the average cumulative permeation in 1 hour shall not exceed 6.0 $\mu g/cm^2$, and the average cumulative permeation for the first 15-minute interval shall not exceed 2.0 $\mu g/cm^2$.

7.4.2.2 Class 3 garment materials and seams shall be tested for resistance to liquid or bloodborne pathogens as specified in Section 8.20, Viral Penetration Resistance Test, and shall allow no penetration of the Phi-X-174 bacteriophage for at least 1 hour.

7.4.2.3 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).

Δ **7.4.2.4** 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 (5.6 lbf).

7.4.2.5 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).

7.4.2.6 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.

N **7.4.2.7** Class 3 garment materials shall be tested for evaporative resistance as specified in Section 8.19, Evaporative Resistance Test, and shall have an evaporative resistance of not greater than 30 $Pa \cdot m^2/W$.

7.4.2.8 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 34 N/25 mm (7.5 lbf/1 in.).

7.4.2.9 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 34 N/25 mm (7.5 lbf/1 in.).

7.4.2.10 Class 3 Garment Visor Requirements.

N **7.4.2.10.1** Elastomeric interface materials shall have an elongation at rupture of not less than 125 percent when tested according to Section 8.28, Ultimate Tensile Strength Test.

Δ **7.4.2.10.2** Class 3 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 the liquid chemical warfare agent sulfur mustard, distilled (HD, or bis [2-chloroethyl] sulfide, CAS 505-60-2), the average cumulative permeation in 1 hour shall not exceed 4.0 $\mu g/cm^2$, and the average cumulative permeation for the first 15-minute interval shall not exceed 1.33 $\mu g/cm^2$.

(2) For permeation testing of the liquid chemical warfare agent soman (GD, or O-Pinacolyl methylphosphonofluoridate, CAS 96-64-0), the average cumulative permeation in 1 hour shall not exceed 1.25 $\mu g/cm^2$, and the average cumulative permeation for the first 15-minute interval shall not exceed 0.43 $\mu g/cm^2$.

(3) For permeation testing of the liquid industrial chemicals specified in 8.7.6 for Class 3, the average cumulative permeation in 1 hour shall not exceed 6.0 $\mu g/cm^2$, and the average cumulative permeation for the first 15-minute interval shall not exceed 2.0 $\mu g/cm^2$.

(4) For permeation testing of gas and vapor toxic industrial chemicals specified in 8.7.6 for Class 3, the average cumulative permeation in 1 hour shall not exceed 6.0 $\mu g/cm^2$, and the average cumulative permeation for the first 15-minute interval shall not exceed 2.0 $\mu g/cm^2$.

7.4.2.10.3 Class 3 garment visor materials shall be tested for high-mass impact resistance as specified in Section 8.13, Visor High-Mass Impact Resistance Test, and shall have no full-thickness punctures, cracks, holes, or fractures.

•

7.4.2.10.4 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 34 N/25 mm (7.5 lbf/1 in.).

N **7.4.2.10.5** Class 3 garment visor materials shall be tested for resistance to liquid or bloodborne pathogens as specified in Section 8.20, Viral Penetration Resistance Test, and shall allow no penetration of the Phi-X-174 bacteriophage for at least 1 hour.

N **7.4.2.11 Class 3 Elastomeric Interface Material Requirements.**

N **7.4.2.11.1*** Elastomeric interface materials shall have an elongation at rupture of not less than 125 percent when tested as specified in Section 8.28, Ultimate Tensile Strength Test.

N **7.4.2.11.2** Where the Class 3 garment includes elastomeric interface materials, each elastomeric interface material 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 the liquid chemical warfare agent sulfur mustard, distilled (HD, or bis [2-chloroethyl] sulfide, CAS 505-60-2), the average cumulative permeation in 1 hour shall not exceed 4.0 $\mu g/cm^2$, and the average cumulative permeation for the first 15-minute interval shall not exceed 1.33 $\mu g/cm^2$.
(2) For permeation testing of the liquid chemical warfare agent soman (GD, or O-Pinacolyl methylphosphonofluoridate, CAS 96-64-0), the average cumulative permeation in 1 hour shall not exceed 1.25 $\mu g/cm^2$, and the average cumulative permeation for the first 15-minute interval shall not exceed 0.43 $\mu g/cm^2$.
(3) For permeation testing of the liquid toxic industrial chemical specified in 8.7.6 for Class 3, the average cumulative permeation in 1 hour shall not exceed 6.0 $\mu g/cm^2$, and the average cumulative permeation for the first 15-minute interval shall not exceed 2.0 $\mu g/cm^2$.
(4) For permeation testing of the gas and vapor toxic industrial chemicals specified in 8.7.6 for Class 3, the average cumulative permeation in 1 hour shall not exceed 6.0 $\mu g/cm^2$, and the average cumulative permeation for the first 15-minute interval shall not exceed 2.0 $\mu g/cm^2$.

N **7.4.2.11.3** Where the Class 3 garment includes elastomeric interface materials, each elastomeric interface material shall be tested for cut resistance as specified in Section 8.14, Cut Resistance Test, and shall have a blade travel distance of not less than 20 mm (0.8 in.).

N **7.4.2.11.4** Where the Class 3 garment includes elastomeric interface materials, each elastomeric interface material shall be tested for puncture resistance as specified in Section 8.15, Puncture Resistance Test 1, shall have a puncture resistance of not less than 7 N (1.6 lbf).

N **7.4.2.11.5** Where the Class 3 garment includes elastomeric interface materials, each elastomeric interface material shall be tested for ultimate tensile strength as specified in Section 8.28, Ultimate Tensile Strength Test, and shall have an ultimate tensile strength of not less than 4 MPa (580 psi).

N **7.4.2.11.6** Where the Class 3 garment includes elastomeric interface materials, each elastomeric interface material 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).

7.4.3 Class 3 Glove Element Requirements.

7.4.3.1 Class 3 gloves shall be tested for liquidtight integrity as specified in Section 8.21, Liquidtight Integrity Test 2, and shall show no leakage.

7.4.3.2 Class 3 glove 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 the liquid chemical warfare agent sulfur mustard, distilled [HD, or bis (2-chloroethyl) sulfide, CAS 505-60-2], the average cumulative permeation in 1 hour shall not exceed 4.0 $\mu g/cm^2$, and the average cumulative permeation for the first 15-minute interval shall not exceed 1.33 $\mu g/cm^2$.
(2) For permeation testing of the liquid chemical warfare agent soman (GD, or O-Pinacolyl methylphosphonofluoridate, CAS 96-64-0), the average cumulative permeation in 1 hour shall not exceed 1.25 $\mu g/cm^2$, and the average cumulative permeation for the first 15-minute interval shall not exceed 0.43 $\mu g/cm^2$.
(3) For permeation testing of the liquid toxic industrial chemical specified in 8.7.6 for Class 3, the average cumulative permeation in 1 hour shall not exceed 6.0 $\mu g/cm^2$, and the average cumulative permeation for the first 15-minute interval shall not exceed 2.0 $\mu g/cm^2$.
(4) For permeation testing of the gas and vapor toxic industrial chemicals specified in 8.7.6 for Class 3, the average cumulative permeation in 1 hour shall not exceed 6.0 $\mu g/cm^2$, and the average cumulative permeation for the first 15-minute interval shall not exceed 2.0 $\mu g/cm^2$.

7.4.3.3 Class 3 glove materials and seams shall be tested for resistance to liquid or bloodborne pathogens as specified in Section 8.20, Viral Penetration Resistance Test, and shall allow no penetration of the Phi-X-174 bacteriophage for at least 1 hour.

7.4.3.4 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 20 mm (0.8 in.).

7.4.3.5 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 9 N (2 lbf).

7.4.3.6 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).

7.4.3.7 Class 3 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.

7.4.4 Class 3 Footwear Element Requirements.

7.4.4.1 Class 3 footwear shall be tested for liquidtight integrity as specified in Section 8.21, Liquidtight Integrity Test 2, and shall show no leakage.

7.4.4.2 Class 3 footwear upper materials 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 the liquid chemical warfare agent sulfur mustard, distilled [HD, or bis (2-chloroethyl) sulfide, CAS 505-60-2], the average cumulative permeation in 1 hour shall not exceed 4.0 $\mu g/cm^2$, and the average cumulative permeation for the first 15-minute interval shall not exceed 1.33 $\mu g/cm^2$.
(2) For permeation testing of the liquid chemical warfare agent soman (GD, or O-Pinacolyl methylphosphonofluoridate, CAS 96-64-0), the average cumulative permeation in 1 hour shall not exceed 1.25 $\mu g/cm^2$, and the average cumulative permeation for the first 15-minute interval shall not exceed 0.43 $\mu g/cm^2$.
(3) For permeation testing of the liquid toxic industrial chemical specified in 8.7.6 for Class 3, the average cumulative permeation in 1 hour shall not exceed 6.0 $\mu g/cm^2$, and the average cumulative permeation for the first 15-minute interval shall not exceed 2.0 $\mu g/cm^2$.
(4) For permeation testing of the gas and vapor toxic industrial chemicals specified in 8.7.6 for Class 3, the average cumulative permeation in 1 hour shall not exceed 6.0 $\mu g/cm^2$, and the average cumulative permeation for the first 15-minute interval shall not exceed 2.0 $\mu g/cm^2$.

7.4.4.3 Class 3 footwear upper materials and seams shall be tested for resistance to liquid or bloodborne pathogens as specified in Section 8.20, Viral Penetration Resistance Test, and shall allow no penetration of the Phi-X-174 bacteriophage for at least 1 hour.

7.4.4.4 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 20 mm (0.8 in.).

7.4.4.5 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).

7.4.4.6 Class 3 footwear soles and heels shall be tested for abrasion resistance as specified in Section 8.17, Abrasion Resistance Test, and the relative volume loss shall be not greater than 250 mm^3.

7.4.4.7 Class 3 footwear shall be tested for slip resistance as specified in Section 8.18, Slip Resistance Test, and shall have a coefficient of friction of 0.40 or greater.

7.4.4.8 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 7.4.4.1, 7.4.4.2, 7.4.4.3, 7.4.4.4, 7.4.4.5, and 7.4.4.7, excluding 7.4.4.6.

7.4.4.9 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 8.22, Abrasion Resistance Test 2, and shall show no wear-through after 3000 cycles.

7.4.4.10 Where footwear is designed and configured according to 6.4.10 the following requirements shall be met:

(1) The integrated sock shall meet the requirements specified in 7.4.4.2 and 7.4.4.3.
(2) The outer boot shall meet the requirements specified in 7.4.4.4 and 7.4.4.5.
(3) The integrity cover shall meet the requirements in 7.4.4.1, 7.4.4.7, and 7.4.4.9.

***N* 7.4.4.11** Where socks are used as part of a protective ensemble and the manufacturer permits the use of any outer boot of the footwear element that is certified to NFPA 1951, NFPA 1971, NFPA 1991, NFPA 1992, or NFPA 1999, the outer boot of the footwear element shall meet the minimum height requirement specified in 6.4.3 and cut resistance performance requirement specified in 7.4.4.4.

***N* 7.4.5 Class 3 Hood Element Requirements.**

***N* 7.4.5.1** Where a Class 3 protective hood is provided as a separate element and is not attached to the garment, the Class 3 protective hood shall meet all of the applicable requirements specified in 7.4.1, with the exception of 7.4.2.6 and 7.4.2.7 when the hood is part of a CBRN PAPR.

N* 7.4.5.2 Where the Class 3 hood includes an elastomeric interface material, the elastomeric material shall have an elongation at rupture of not less than 125 percent when tested as specified in Section 8.28, Ultimate Tensile Strength Test.

***N* 7.4.5.3** Where the Class 3 hood includes an elastomeric interface material, the elastomeric interface material 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 the liquid chemical warfare agent sulfur mustard, distilled [HD, or bis (2-chloroethyl) sulfide, CAS 505-60-2], the average cumulative permeation in 1 hour shall not exceed 4.0 $\mu g/cm^2$, and the average cumulative permeation for the first 15-minute interval shall not exceed 1.33 $\mu g/cm^2$.
(2) For permeation testing of the liquid chemical warfare agent soman (GD, or O-Pinacolyl methylphosphonofluoridate, CAS 96-64-0), the average cumulative permeation in 1 hour shall not exceed 1.25 $\mu g/cm^2$, and the average cumulative permeation for the first 15-minute interval shall not exceed 0.43 $\mu g/cm^2$.
(3) For permeation testing of the liquid toxic industrial chemical specified in 8.7.6, the average cumulative permeation in 1 hour shall not exceed 6.0 $\mu g/cm^2$, and the average cumulative permeation for the first 15-minute interval shall not exceed 2.0 $\mu g/cm^2$.
(4) For permeation testing of the gas and vapor industrial chemicals specified in 8.7.6 for Class 3, the average cumulative permeation in 1 hour shall not exceed 6.0 $\mu g/cm^2$, and the average cumulative permeation for the first 15-minute interval shall not exceed 2.0 $\mu g/cm^2$.

***N* 7.4.5.4** Where the Class 3 hood includes an elastomeric interface material, the elastomeric interface material shall be tested for cut resistance as specified in Section 8.14, Cut Resistance Test, and shall have a blade travel distance of not less than 20 mm (0.8 in.).

***N* 7.4.5.5** Where the Class 3 hood includes an elastomeric interface material, the elastomeric interface material 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 7 N (1.6 lbf).

N **7.4.5.6** Where the Class 3 hood includes an elastomeric interface material, the elastomeric interface material shall be tested for ultimate tensile strength as specified in Section 8.28, Ultimate Tensile Strength Test, and shall have an ultimate tensile strength of not less than 4 MPa (580 psi).

N **7.5 Class 3R Ensembles.**

N **7.5.1 Class 3R Ensemble General Requirements.**

N **7.5.1.1*** Class 3 ensembles shall be tested for overall inward leakage as specified in Section 8.2, Man-In-Simulant Test (MIST), and shall have a geometric mean local physiological protective dosage factor ($PPDF_i$) value at each PAD location for the four ensembles tested of no less than 160 and a geometric mean systemic physiological protective dosage factor ($PPDF_{sys}$) value for each of the four ensembles tested of no less than 69.

N **7.5.1.2** Class 3R ensembles shall be tested for overall function as specified in Section 8.3, Overall Garment 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; the garment closure shall remain engaged during the entire garment function testing.

N **7.5.1.2.1** Where hoods are provided, garments shall accommodate head protection devices meeting the dimensional requirements of Type I, Class G helmets of ANSI/ISEA Z89.1, *American National Standard on Industrial Head Protection.*

N **7.5.1.2.2** 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.

N **7.5.1.2.3** Where protective flaps cover the closure, the protective flaps shall remain closed for the duration of the overall garment function test.

N **7.5.1.3** External fittings installed in Class 3R ensembles that are intended for tethered operations 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).

N **7.5.1.3.1** External fittings installed in Class 3R ensembles that are not intended for tethered applications 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 135 N (30 lbf).

N **7.5.1.4** Exhaust valves installed in Class 3R ensembles shall be tested for mounting strength as specified in Section 8.23, Exhaust Valve Mounting Strength Test, and shall have a failure force greater than 135 N (30 lbf).

N **7.5.1.5** Exhaust valves installed in Class 3R ensembles shall be tested for inward leakage as specified in Section 8.24, Exhaust Valve Inward Leakage Test, and shall not exhibit a leakage rating exceeding 30 mL/min (1.83 $in.^3$/min).

N **7.5.2 Class 3R Garment Element Requirements.**

N **7.5.2.1** Class 3R 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 the liquid chemical warfare agent sulfur mustard, distilled (HD, or bis [2-chloroethyl] sulfide, CAS 505-60-2), the average cumulative permeation in 1 hour shall not exceed 4.0 $\mu g/cm^2$, and the average cumulative permeation for the first 15-minute interval shall not exceed 1.33 $\mu g/cm^2$.

(2) For permeation testing of the liquid chemical warfare agent soman (GD, or O-Pinacolyl methylphosphonofluoridate, CAS 96-64-0), the average cumulative permeation in 1 hour shall not exceed 1.25 $\mu g/cm^2$, and the average cumulative permeation for the first 15-minute interval shall not exceed 0.43 $\mu g/cm^2$.

(3) For permeation testing of the liquid industrial chemicals specified in 8.7.6 for Class 3R, the average cumulative permeation in 1 hour shall not exceed 6.0 $\mu g/cm^2$, and the average cumulative permeation for the first 15-minute interval shall not exceed 2.0 $\mu g/cm^2$.

(4) For permeation testing of the gas and vapor industrial chemicals specified in 8.7.6 for Class 3R, the average cumulative permeation in 1 hour shall not exceed 6.0 $\mu g/cm^2$, and the average cumulative permeation for the first 15-minute interval shall not exceed 2.0 $\mu g/cm^2$.

N **7.5.2.2** Class 3R garment materials and seams shall be tested for resistance to liquid or bloodborne pathogens as specified in Section 8.20, Viral Penetration Resistance Test, and shall allow no penetration of the Phi-X-174 bacteriophage for at least 1 hour.

N **7.5.2.3** Class 3R 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).

N **7.5.2.4** Class 3R 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).

N **7.5.2.5** Class 3R 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).

N **7.5.2.6** Class 3R 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.

N **7.5.2.7** Class 3R garment materials shall be tested for evaporative resistance as specified in Section 8.19, Evaporative Resistance Test, and shall have an evaporative resistance of not greater than 30 $Pa \cdot m^2/W$.

N **7.5.2.8** Class 3R 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 34 N/25 mm (7.5 lbf/1 in.).

N **7.5.2.9** Class 3R 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 34 N/25 mm (7.5 lbf/1 in.).

***N* 7.5.2.10 Class 3R Garment Visor Requirements.**

***N* 7.5.2.10.1** Class 3R 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 the liquid chemical warfare agent sulfur mustard, distilled (HD, or bis [2-chloroethyl] sulfide, CAS 505-60-2), the average cumulative permeation in 1 hour shall not exceed 4.0 $\mu g/cm^2$, and the average cumulative permeation for the first 15-minute interval shall not exceed 1.33 $\mu g/cm^2$.

(2) For permeation testing of the liquid chemical warfare agent soman (GD, or O-Pinacolyl methylphosphonofluoridate, CAS 96-64-0), the average cumulative permeation in 1 hour shall not exceed 1.25 $\mu g/cm^2$, and the average cumulative permeation for the first 15-minute interval shall not exceed 0.43 $\mu g/cm^2$.

(3) For permeation testing of the liquid industrial chemicals specified in 8.7.6 for Class 3R, the average cumulative permeation in 1 hour shall not exceed 6.0 $\mu g/cm^2$, and the average cumulative permeation for the first 15-minute interval shall not exceed 2.0 $\mu g/cm^2$.

(4) For permeation testing of the gas and vapor industrial chemicals specified in 8.7.6 for Class 3R, the average cumulative permeation in 1 hour shall not exceed 6.0 $\mu g/cm^2$, and the average cumulative permeation for the first 15-minute interval shall not exceed 2.0 $\mu g/cm^2$.

***N* 7.5.2.10.2** Class 3R garment visor materials shall be tested for high-mass impact resistance as specified in Section 8.13, Visor High-Mass Impact Resistance Test, and shall have no full-thickness punctures, cracks, holes, or factures.

***N* 7.5.2.10.3** Class 3R 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 34 N/25 mm (7.5 lbf/1 in.).

***N* 7.5.2.10.4** Class 3R garment visor materials shall be tested for resistance to liquid or bloodborne pathogens as specified in Section 8.20, Viral Penetration Resistance Test, and shall allow no penetration of the Phi-X-174 bateriophage for at least 1 hour.

***N* 7.5.2.11 Class 3R Elastomeric Interface Material Requirements.**

N* 7.5.2.11.1 Elastomeric interface materials shall have an elongation at rupture of not less than 125 percent when tested as specified in Section 8.28, Ultimate Tensile Strength Test.

***N* 7.5.2.11.2** Where the Class 3R garment includes elastomeric interface materials, each elastomeric interface material 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 the liquid chemical warfare agent sulfur mustard, distilled (HD, or bis [2-chloroethyl] sulfide, CAS 505-60-2), the average cumulative permeation in 1 hour shall not exceed 4.0 $\mu g/cm^2$, and the average cumulative permeation for the first 15-minute interval shall not exceed 1.33 $\mu g/cm^2$.

(2) For permeation testing of the liquid chemical warfare agent soman (GD, or O-Pinacolyl methylphosphonofluoridate, CAS 96-64-0), the average cumulative permeation in 1 hour shall not exceed 1.25 $\mu g/cm^2$, and the average cumulative permeation for the first 15-minute interval shall not exceed 0.43 $\mu g/cm^2$.

(3) For permeation testing of the liquid industrial chemicals specified in 8.7.6 for Class 3R, the average cumulative permeation in 1 hour shall not exceed 6.0 $\mu g/cm^2$, and the average cumulative permeation for the first 15-minute interval shall not exceed 2.0 $\mu g/cm^2$.

(4) For permeation testing of the gas and vapor industrial chemicals specified in 8.7.6 for Class 3R, the average cumulative permeation in 1 hour shall not exceed 6.0 $\mu g/cm^2$, and the average cumulative permeation for the first 15-minute interval shall not exceed 2.0 $\mu g/cm^2$.

***N* 7.5.2.11.3** Where the Class 3R garment includes elastomeric interface materials, each elastomeric interface material shall be tested for cut resistance as specified in Section 8.14, Cut Resistance Test, and shall have a blade travel distance of not less than 20 mm (0.8 in.).

***N* 7.5.2.11.4** Where the Class 3R garment includes elastomeric interface materials, each elastomeric interface material 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 7 N (1.6 lbf).

***N* 7.5.2.11.5** Where the Class 3R garment includes elastomeric interface materials, each elastomeric interface material shall be tested for ultimate tensile strength as specified in Section 8.28, Ultimate Tensile Strength Test, and shall have an ultimate tensile strength of not less than 4 MPa (580 psi).

***N* 7.5.2.11.6** Where the Class 3R garment includes elastomeric interface materials, each elastomeric interface material 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).

***N* 7.5.3 Class 3R Glove Element Requirements.**

***N* 7.5.3.1** Class 3R gloves shall be tested for liquidtight integrity as specified in Section 8.21, Liquidtight Integrity Test 2, and shall show no leakage.

***N* 7.5.3.2** Class 3R 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 the liquid chemical warfare agent sulfur mustard, distilled (HD, or bis [2-chloroethyl] sulfide, CAS 505-60-2), the average cumulative permeation in 1 hour shall not exceed 4.0 $\mu g/cm^2$, and the average cumulative permeation for the first 15-minute interval shall not exceed 1.33 $\mu g/cm^2$.

(2) For permeation testing of the liquid chemical warfare agent soman (GD, or O-Pinacolyl methylphosphonofluoridate, CAS 96-64-0), the average cumulative permeation in 1 hour shall not exceed 1.25 $\mu g/cm^2$, and the average cumulative permeation for the first 15-minute interval shall not exceed 0.43 $\mu g/cm^2$.

(3) For permeation testing of the liquid industrial chemicals specified in 8.7.6 for Class 3R, the average cumulative permeation in 1 hour shall not exceed 6.0 $\mu g/cm^2$, and the average cumulative permeation for the first 15-minute interval shall not exceed 2.0 $\mu g/cm^2$.

(4) For permeation testing of the gas and vapor industrial chemicals specified in 8.7.6 for Class 3R, the average cumulative permeation in 1 hour shall not exceed 6.0 $\mu g/cm^2$, and the average cumulative permeation for the first 15-minute interval shall not exceed 2.0 $\mu g/cm^2$.

N **7.5.3.3** Class 3R glove materials and seams shall be tested for resistance to liquid or bloodborne pathogens as specified in Section 8.20, Viral Penetration Resistance Test, and shall allow no penetration of the Phi-X-174 bacteriophage for at least 1 hour.

N **7.5.3.4** Class 3R glove materials shall be tested for cut resistance as specified in Section 8.14, Cut Resistance Test, and shall have a blade travel distance of not less than 20 mm (0.8 in.).

N **7.5.3.5** Class 3R 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).

N **7.5.3.6** Class 3R 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).

N **7.5.3.7** Class 3R 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.

N **7.5.4 Class 3R Footwear Element Requirements.**

N **7.5.4.1** Class 3R footwear shall be tested for liquidtight integrity as specified in Section 8.21, Liquidtight Integrity Test 2, and shall show no leakage.

N **7.5.4.2** Class 3R footwear upper material 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 the liquid chemical warfare agent sulfur mustard, distilled (HD, or bis [2-chloroethyl] sulfide, CAS 505-60-2), the average cumulative permeation in 1 hour shall not exceed 4.0 $\mu g/cm^2$, and the average cumulative permeation for the first 15-minute interval shall not exceed 1.33 $\mu g/cm^2$.
(2) For permeation testing of the liquid chemical warfare agent soman (GD, or O-Pinacolyl methylphosphonofluoridate, CAS 96-64-0), the average cumulative permeation in 1 hour shall not exceed 1.25 $\mu g/cm^2$, and the average cumulative permeation for the first 15-minute interval shall not exceed 0.43 $\mu g/cm^2$.
(3) For permeation testing of the liquid industrial chemicals specified in 8.7.6 for Class 3R, the average cumulative permeation in 1 hour shall not exceed 6.0 $\mu g/cm^2$, and the average cumulative permeation for the first 15-minute interval shall not exceed 2.0 $\mu g/cm^2$.
(4) For permeation testing of the gas and vapor industrial chemicals specified in 8.7.6 for Class 3R, the average cumulative permeation in 1 hour shall not exceed 6.0 $\mu g/cm^2$, and the average cumulative permeation for the first 15-minute interval shall not exceed 2.0 $\mu g/cm^2$.

N **7.5.4.3** Class 3R footwear upper materials and seams shall be tested for resistance to liquid or bloodborne pathogens as specified in Section 8.20, Viral Penetration Resistance Test, and shall allow no penetration of the Phi-X-174 bacteriophage for at least 1 hour.

N **7.5.4.4** Class 3R footwear upper materials shall be tested for cut resistance as specified in Section 8.14, Cut Resistance Test, and shall have a blade travel distance of not less than 20 mm (0.8 in.).

N **7.5.4.5** Class 3R 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).

N **7.5.4.6** Class 3R footwear soles and heels shall be tested for abrasion resistance as specified in Section 8.17, Abrasion Resistance Test, and the relative volume shall not be greater than 250 mm^3.

N **7.5.4.7** Class 3R footwear shall be tested for slip resistance as specified in Section 8.18, Slip Resistance Test, and shall have a coefficient of friction of 0.40 or greater.

N **7.5.4.8** Where the manufacturer specifies the use of a footwear cover to be worn over standard footwear, Class 3R footwear covers shall meet the requirements specified in 7.5.4.1, 7.5.4.2, 7.5.4.3, 7.5.4.4, 7.5.4.5, and 7.5.4.7, excluding 7.5.4.6.

N **7.5.4.9** Where the manufacturer specifies the use of a footwear cover to be worn over standard footwear, Class 3R footwear covers shall be tested for abrasion resistance as specified in Section 8.22, Abrasion Resistance Test 2, and shall show no wear-through after 3000 cycles.

N **7.5.4.10** Where footwear is designed and configured according to 6.4.10, the following requirements shall be met:

(1) The socks shall meet the requirements specified in 7.5.4.2 and 7.5.4.3.
(2) The outer boot shall meet the requirements specified in 7.5.4.4 and 7.5.4.5.
(3) The integrity cover shall meet the requirements in 7.5.4.1, 7.5.4.7, and 7.5.4.9.

N **7.5.4.11** Where socks are used as part of a protective ensemble and the manufacturer permits the use of any outer boot of the footwear element that is certified to NFPA 1951, NFPA 1971, NFPA 1991, NFPA 1992, or NFPA 1999, the outer boot of the footwear element shall meet the minimum height requirement specified in 6.4.3 and cut resistance performance requirement specified in 7.5.4.4.

N **7.5.5 Class 3R Hood Element Requirements.**

N **7.5.5.1** Where a Class 3R protective hood is provided as a separate element and is not attached to the garment, the Class 3R protective hood shall meet all of the applicable requirements specified in 7.5.1, with the exception of 7.5.2.6 and 7.5.2.7 when the hood is part of a CBRN PAPR.

N **7.5.5.2*** Where the Class 3R hood includes an elastomeric interface material, the elastomeric interface material shall have an elongation at rupture of not less than 125 percent when tested as specified in Section 8.28, Ultimate Tensile Strength Test.

N **7.5.5.3** Where the Class 3R hood includes an elastomeric interface material, the elastomeric interface material 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 the liquid chemical warfare agent sulfur mustard, distilled (HD, or bis [2-chloroethyl] sulfide, CAS 505-60-2), the average cumulative permeation in 1 hour shall not exceed 4.0 $\mu g/cm^2$, and the average cumulative permeation for the first 15-minute interval shall not exceed 1.33 $\mu g/cm^2$.

(2) For permeation testing of the liquid chemical warfare agent soman (GD, or O-Pinacolyl methylphosphonofluoridate, CAS 96-64-0), the average cumulative permeation in 1 hour shall not exceed 1.25 $\mu g/cm^2$, and the average cumulative permeation for the first 15-minute interval shall not exceed 0.43 $\mu g/cm^2$.

(3) For permeation testing of the liquid industrial chemicals specified in 8.7.6 for Class 3R, the average cumulative permeation in 1 hour shall not exceed 6.0 $\mu g/cm^2$, and the average cumulative permeation for the first 15-minute interval shall not exceed 2.0 $\mu g/cm^2$.

(4) For permeation testing of the gas and vapor industrial chemicals specified in 8.7.6 for Class 3R, the average cumulative permeation in 1 hour shall not exceed 6.0 $\mu g/cm^2$, and the average cumulative permeation for the first 15-minute interval shall not exceed 2.0 $\mu g/cm^2$.

N **7.5.5.4** Where the Class 3R hood includes an interface gasket, the elastomeric interface material shall be tested for cut resistance as specified in Section 8.14, Cut Resistance Test, and shall have a blade travel distance of not less than 20 mm (0.8 in.).

N **7.5.5.5** Where the Class 3R hood includes an interface gasket, the elastomeric interface material 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 7 N (1.6 lbf).

N **7.5.5.6** Where the Class 3R hood includes an interface gasket, the elastomeric interface material shall be tested for ultimate tensile strength as specified in Section 8.28, Ultimate Tensile Strength Test, and shall have an ultimate tensile strength of not less than 4 MPa (580 psi).

7.6 Class 4 Ensembles.

7.6.1 Class 4 Ensemble General Requirements.

7.6.1.1 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.

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

7.6.1.2.1 Where hoods are provided, garments shall accommodate head protection devices meeting the dimensional requirements of Type I, Class G helmets of ANSI/ISEA Z89.1, *American National Standard on Industrial Head Protection.*

7.6.1.2.2 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.

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

7.6.1.3 External fittings installed in Class 4 ensembles that are intended for tethered applications 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).

N **7.6.1.3.1** External fittings installed in Class 4 ensembles that are not intended for tethered applications 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 135 N (30 lbf).

7.6.1.4 Exhaust valves installed in Class 4 ensembles shall be tested for mounting strength as specified in Section 8.23, Exhaust Valve Mounting Strength Test, and shall have a failure force greater than 135 N (30 lbf).

7.6.1.5 Exhaust valves installed in Class 4 ensembles shall be tested for inward leakage as specified in Section 8.24, Exhaust Valve Inward Leakage Test, and shall not exhibit a leakage rating exceeding 30 mL/min (1.83 $in.^3$/min).

7.6.2 Class 4 Garment Element Requirements.

7.6.2.1 Class 4 garment materials and seams shall be tested for resistance to liquid or bloodborne pathogens as specified in Section 8.20, Viral Penetration Resistance Test, and shall allow no penetration of the Phi-X-174 bacteriophage for at least 1 hour.

7.6.2.2 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).

7.6.2.3 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).

7.6.2.4 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).

7.6.2.5 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.

N **7.6.2.6** Class 3 garment materials shall be tested for evaporative resistance as specified in Section 8.19, Evaporative Resistance Test, and shall have an evaporative resistance of not greater than 30 $Pa \cdot m^2/W$.

7.6.2.7 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 34 N/25 mm (7.5 lbf/1 in.).

•

7.6.2.8 Class 4 Garment Visor Requirements.

7.6.2.8.1 Class 4 garment visor materials shall be tested for high-mass impact resistance as specified in Section 8.13, Visor

High-Mass Impact Resistance Test, and shall have no full-thickness punctures, cracks, holes, or fractures.

•

7.6.2.8.2 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 34 N/25 mm (7.5 lbf/1 in.).

N **7.6.2.9 Class 4 Elastomeric Interface Material Requirements.**

N **7.6.2.9.1*** Elastomeric interface materials shall have an elongation at rupture of not less than 125 percent when tested as specified in Section 8.28, Ultimate Tensile Strength Test.

N **7.6.2.9.2** Where the Class 4 garment includes elastomeric interface materials, each elastomeric interface material shall be tested for cut resistance as specified in Section 8.14, Cut Resistance Test, and shall have a blade travel distance of not less than 20 mm (0.8 in.).

N **7.6.2.9.3** Where the Class 4 garment includes elastomeric interface materials, each elastomeric interface material 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 7 N (1.6 lbf).

N **7.6.2.9.4** Where the Class 4 garment includes elastomeric interface materials, each elastomeric interface material shall be tested for ultimate tensile strength as specified in Section 8.28, Ultimate Tensile Strength Test, and shall have an ultimate tensile strength of not less than 4 MPa (550 psi).

N **7.6.2.9.5** Where the Class 4 garment includes elastomeric interface materials, each elastomeric interface gasket material 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).

7.6.3 Class 4 Glove Element Requirements.

7.6.3.1 Class 4 gloves shall be tested for liquidtight integrity as specified in Section 8.21, Liquidtight Integrity Test 2, and shall show no leakage.

7.6.3.2 Class 4 glove materials and seams shall be tested for resistance to liquid or bloodborne pathogens as specified in Section 8.20, Viral Penetration Resistance Test, and shall allow no penetration of the Phi-X-174 bacteriophage for at least 1 hour.

7.6.3.3 Class 4 glove materials shall be tested for cut resistance as specified in Section 8.14, Cut Resistance Test, and shall have a blade travel distance of not less than 20 mm (0.8 in.).

7.6.3.4 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 9 N (2 lbf).

7.6.3.5 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).

7.6.3.6 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 bare-handed control less than 200 percent.

7.6.4 Class 4 Footwear Element Requirements.

7.6.4.1 Class 4 footwear shall be tested for liquidtight integrity as specified in Section 8.21, Liquidtight Integrity Test 2, and shall show no leakage.

7.6.4.2 Class 4 footwear upper material shall be tested for resistance to liquid or bloodborne pathogens as specified in Section 8.20, Viral Penetration Resistance Test, and shall allow no penetration of the Phi-X-174 bacteriophage for at least 1 hour.

7.6.4.3 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 20 mm (0.8 in.).

7.6.4.4 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).

7.6.4.5 Class 4 footwear soles and heels shall be tested for abrasion resistance as specified in Section 8.17, Abrasion Resistance Test, and the volume loss shall be not greater than 250 mm^3 (0.015 $in.^3$).

7.6.4.6 Class 4 footwear shall be tested for slip resistance as specified in Section 8.18, Slip Resistance Test, and shall have a coefficient of friction of 0.40 or greater.

7.6.4.7 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 7.6.4.1, 7.6.4.2, 7.6.4.3, 7.6.4.4, 7.6.4.6, and 7.6.4.8, excluding 7.6.4.5.

7.6.4.8 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 8.22, Abrasion Resistance Test 2, and shall show no wear-through after 3000 cycles.

7.6.4.9 Where footwear is designed and configured according to Section 6.4.10, the following requirements shall be met:

(1) The integrated socks shall meet the requirements specified in 7.6.4.2.
(2) The outer boot shall meet the requirements specified in 7.6.4.3 and 7.6.4.4.
(3) The integrity cover shall meet the requirements specified in 7.6.4.1, 7.6.4.7, and 7.6.4.8.

N **7.6.4.10** Where socks are used as part of a protective ensemble and the manufacturer permits the use of any outer boot of the footwear element that is certified to NFPA 1951, NFPA 1971, NFPA 1991, NFPA 1992, or NFPA 1999, the outer boot of the footwear element shall meet the minimum height requirement specified in 6.4.3 and cut resistance performance requirement specified in 7.6.4.3.

N **7.6.5 Class 4 Hood Element Requirements.**

N **7.6.5.1** Where a Class 4 protective hood is provided as a separate element and is not attached to the garment, the Class 4 protective hood shall meet all of the applicable requirements specified in 7.6.1, with the exception of 7.6.2.5 and 7.6.2.6 when the hood is part of a CBRN PAPR.

N **7.6.5.2*** Where the Class 4 hood includes an elastomeric interface material, the elastomeric interface material shall have an

elongation at rupture of not less than 125 percent when tested as specified in Section 8.28, Ultimate Strength Test.

N **7.6.5.3** Where the Class 4 hood includes an elastomeric interface material, the elastomeric interface material shall be tested for cut resistance as specified in Section 8.14, Cut Resistance Test, and shall have a blade travel distance of not less than 20 mm (0.8 in.).

N **7.6.5.4** Where the Class 4 hood includes an elastomeric interface material, the elastomeric interface material 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 7 N (1.6 lbf).

N **7.6.5.5** Where the Class 4 hood includes an elastomeric interface material, the elastomeric interface material shall be tested for ultimate tensile strength as specified in Section 8.28, Ultimate Tensile Strength Test, and shall have an ultimate tensile strength of not less than 4 MPa (580 psi).

N **7.7 Class 4R Ensembles.**

N **7.7.1 Class 4R Ensemble General Requirements.**

N **7.7.1.1** Class 4R 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.

N **7.7.1.2** Class 4R ensembles shall be tested for overall function as specified in Section 8.3, Overall Garment Function and Integrity Test, and shall allow the test subject to complete all tasks within 15 minutes; the garment closure shall remain engaged during the entire garment function testing.

N **7.7.1.2.1** Where hoods are provided, garments shall accommodate head protection devices meeting the dimensional requirements of Type I, Class G helmets of ANSI/ISEA Z89.1, *American National Standard on Industrial Head Protection*.

N **7.7.1.2.2** 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.

N **7.7.1.2.3** Where protective flaps cover the closure, the protective flaps shall remain closed for the duration of the overall garment function test.

N **7.7.1.3** External fittings installed in Class 4R ensembles that are intended for tethered applications 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).

N **7.7.1.3.1** External fittings installed in Class 4R ensembles that are not intended for tethered applications 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 135 N (30 lbf).

N **7.7.1.4** Exhaust valves installed in Class 4R ensembles shall be tested for mounting strength as specified in Section 8.23, Exhaust Valve Mounting Strength Test, and shall have a failure force greater than 135 N (30 lbf).

N **7.7.1.5** Exhaust valves installed in Class 4R ensembles shall be tested for inward leakage as specified in Section 8.24, Exhaust Valve Inward Leakage Test, and shall not exhibit a leakage rating exceeding 30 mL/min (1.83 in.^{3}/min).

N **7.7.2 Class 4R Garment Element Requirements.**

N **7.7.2.1** Class 4R garment materials and seams shall be tested for resistance to liquid or bloodborne pathogens as specified in Section 8.20, Viral Penetration Resistance Test, and shall allow no penetration of the Phi-X-174 bacteriophage for at least 1 hour.

N **7.7.2.2** Class 4R 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).

N **7.7.2.3** Class 4R 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).

N **7.7.2.4** Class 4R 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 not greater than 0.057 N·m (½ in.·lbf) at an angular deflection of 60 degrees at −25°C (−13°F).

N **7.7.2.5** Class 4R 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.

N **7.7.2.6** Class 4R garment materials shall be tested for evaporative resistance as specified in Section 8.19, Evaporative Resistance Test, and shall have an evaporative resistance of not greater than 30 Pa·m^2/W.

N **7.7.2.7** Class 4R 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 34 N/25 mm (7.5 lbf/1 in.).

N **7.7.2.8** Class 4R 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 34 N/25 mm (7.5 lbf/1 in.).

N **7.7.2.9 Class 4R Garment Visor Requirements.**

N **7.7.2.9.1** Class 4R garment visor materials shall be tested for resistance to liquid or bloodborne pathogens as specified in Section 8.20, Viral Penetration Resistance Test, and shall allow no penetration of the Phi-X-174 bacteriophage for at least 1 hour.

N **7.7.2.9.2** Class 4R garment visor materials shall be tested for high-mass impact resistance as specified in Section 8.13, Visor High-Mass Impact Resistance Test, and shall have no full-thickness punctures, cracks, holes, or fractures.

N **7.7.2.9.3** Class 4R 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 34 N/25 mm (7.5 lbf/1 in.).

N **7.7.2.10 Class 4R Elastomeric Interface Material Requirements.**

N **7.7.2.10.1*** Elastomeric interface materials shall have an elongation at rupture of not less than 125 percent when tested as specified in Section 8.28, Ultimate Tensile Strength Test.

N **7.7.2.10.2** Where the Class 4R garment includes elastomeric interface materials, each elastomeric interface material shall be tested for cut resistance as specified in Section 8.14, Cut Resistance Test, and shall have a blade travel distance of not less than 20 mm (0.8 in.).

N **7.7.2.10.3** Where the Class 4R garment includes elastomeric interface materials, each elastomeric interface material 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 7 N (1.6 lbf).

N **7.7.2.10.4** Where the Class 4R garment includes elastomeric interface materials, each elastomeric interface material shall be tested for ultimate tensile strength as specified in Section 8.29, Ultimate Tensile Strength Test, and shall have an ultimate tensile strength of not less than 4 MPa (580 psi).

N **7.7.2.10.5** Where the Class 4R garment includes elastomeric interface materials, each elastomeric interface material 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).

N **7.7.3 Class 4R Glove Element Requirements.**

N **7.7.3.1** Class 4R gloves shall be tested for liquidtight integrity as specified in Section 8.22, Liquidtight Integrity Test 2, and shall show no leakage.

N **7.7.3.2** Class 4R 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.

N **7.7.3.3** Class 4R glove materials shall be tested for cut resistance as specified in Section 8.14, Cut Resistance Test, and shall have a blade travel distance of not less than 20 mm (0.8 in.).

N **7.7.3.4** Class 4R 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).

N **7.7.3.5** Class 4R 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).

N **7.7.3.6** Class 4R 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.

N **7.7.4**

N **7.7.4.1** Class 4R footwear shall be tested for liquidtight integrity as specified in Section 8.22, Liquidtight Integrity Test 2, and shall show no leakage.

N **7.7.4.2** Class 4R 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.

N **7.7.4.3** Class 4R footwear upper materials shall be tested for cut resistance as specified in Section 8.14, Cut Resistance Test, and shall have a blade travel distance of not less than 20 mm (0.8 in.).

N **7.7.4.4** Class 4R 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).

N **7.7.4.5** Class 4R footwear soles and heels shall be tested for abrasion resistance as specified in Section 8.17, Abrasion Resistance Test 1, and the volume loss shall be not greater than 250 mm^3.

N **7.7.4.6** Class 4R footwear shall be tested for slip resistance as specified in Section 8.18, Slip Resistance Test, and shall have a coefficient of friction of 0.40 or greater.

N **7.7.4.7** Where the manufacturer specifies the use of a footwear cover to be worn over standard footwear, Class 4R footwear covers shall meet the requirements specified in 7.7.4.1, 7.7.4.2, 7.7.4.3, 7.7.4.4, 7.7.4.6, and 7.7.4.8, excluding 7.7.4.5.

N **7.7.4.8** Where the manufacturer specifies the use of a footwear cover to be worn over standard footwear, Class 4R footwear covers shall be tested for abrasion resistance as specified in Section 8.22, Abrasion Resistance Test 2, and shall show no wear-through after 3000 cycles.

N **7.7.4.9** Where footwear is designed and configured according to 6.4.10, the following requirements shall be met:

(1) The socks shall meet the requirements specified in 7.7.4.2.
(2) The outer boot shall meet the requirements specified in 7.7.4.3 and 7.7.4.4.
(3) The integrity cover shall meet the requirements specified in 7.7.4.1, 7.7.4.7, and 7.7.4.8.

N **7.7.4.10** Where socks are used as part of a protective ensemble and the manufacturer permits the use of any outer boot of the footwear element that is certified to NFPA 1951, NFPA 1971, NFPA 1991, NFPA 1992, or NFPA 1999, the outer boot of the footwear element shall meet the minimum height requirement specified in 6.4.3 and cut resistance performance requirement specified in 7.7.4.3.

N **7.7.5 Class 4R Hood Element Requirements.**

N **7.7.5.1** Where a Class 4R protective hood is provided as a separate element and is not attached to the garment, the Class 4R protective hood shall meet all of the applicable requirements specified in 7.7.1, with the exception of 7.7.2.5 and 7.7.2.6 when the hood is part of a CBRN PAPR.

N **7.7.5.2*** Where the Class 4R hood includes an elastomeric interface material, the elastomeric gasket material shall have an elongation at rupture of not less than 125 percent when tested as specified in Section 8.28, Ultimate Tensile Strength Test.

N **7.7.5.3** Where the Class 4R hood includes an elastomeric interface material, the elastomeric gasket material shall be tested for cut resistance as specified in Section 8.14, Cut Resistance Test, and shall have a blade travel distance of not less than 20 mm (0.8 in.).

N **7.7.5.4** Where the Class 4R hood includes an elastomeric interface material, the elastomeric interface material 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 7 N (1.6 lbf).

N **7.7.5.5** Where the Class 4R hood includes an elastomeric interface material, the elastomeric interface material shall be tested for ultimate tensile strength as specified in Section 8.28, Ultimate Tensile Strength Test, and shall have an ultimate tensile strength of not less than 4 MPa (580 psi).

N **7.8 Optional Chemical Flash Fire Escape Protection Requirements.**

N **7.8.1** Class 1 ensembles and ensemble elements shall also meet the applicable requirements specified in Section 7.1.

N **7.8.2** Class 2 ensembles and ensemble elements shall also meet the applicable requirements specified in Section 7.2.

N **7.8.3** Class 2R ensembles and ensemble elements shall also meet the applicable requirements specified in Section 7.3.

N **7.8.4** Class 3 ensembles and ensemble elements shall also meet the applicable requirements specified in Section 7.4.

N **7.8.5** Class 3R ensembles and ensemble elements shall also meet the applicable requirements specified in Section 7.5.

N **7.8.6** Class 4 ensembles and ensemble elements shall also meet the applicable requirements specified in Section 7.6.

N **7.8.7** Class 4R ensembles and ensemble elements shall also meet the applicable requirements specified in Section 7.8.

N **7.8.8** Protective ensembles or elements shall be tested for overall flash protection as specified by Section 8.29, Overall Ensemble Flash Test, and shall show afterflame times no longer than 2 seconds; in subsequent testing by test subjects of the ensemble shall allow no liquid penetration; and where a hood with visor is provided shall allow test subjects to have a visual acuity of 20/100.

N **7.8.9** Garment materials and, where applicable, visor, glove, footwear, and elastomeric interface materials shall be tested for heat transfer performance (HTP) as specified in Section 8.30, Heat Transfer Performance Test, and shall have an average HTP rating of not less than 12 cal/cm^2.

N **7.8.10** Garment materials and, where applicable, visor, glove, footwear, and elastomeric interface materials shall be tested for resistance to flame impingement as specified in Section 8.27, Flammability Resistance Test, and shall not burn a distance greater than 100 mm (4 in.), shall not sustain burning for more than 2 seconds, and shall not melt and drip.

N **7.9 Optional Stealth Requirements.**

N **7.9.1** Class 1 ensembles and ensemble elements shall also meet the applicable requirements specified in Section 7.1.

N **7.9.2** Class 2 ensembles and ensemble elements shall also meet the applicable requirements specified in Section 7.2.

N **7.9.3** Class 2R ensembles and ensemble elements shall also meet the applicable requirements specified in Section 7.3.

N **7.9.4** Class 3 ensembles and ensemble elements shall also meet the applicable requirements specified in Section 7.4.

N **7.9.5** Class 3R ensembles and ensemble elements shall also meet the applicable requirements specified in Section 7.5.

N **7.9.6** Class 4 ensembles and ensemble elements shall also meet the applicable requirements specified in Section 7.6.

N **7.9.7** Class 4R ensembles and ensemble elements shall also meet the applicable requirements specified in Section 7.8.

N **7.9.8** Garment, glove, footwear, and hood outer materials shall be tested for color/visibility in accordance with Section 8.31, Color/Visibility Test Method, and shall have a Y brightness value less than 25 and an L* value less than 55.

N **7.9.9** Ensembles shall be tested for audible signature as specified in Section 8.32, Audible Signature Test, and the audible signature in dBA shall be reported on both the product label and in the technical data package.

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 section of each test method.

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

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

8.1.2.1 Samples shall be conditioned at a temperature of 21°C ± 3°C (70°F ± 5°F) and a relative humidity of 65 percent ± 5 percent until equilibrium is reached, as specified in ASTM D1776, *Standard Practice for Conditioning and Testing Textiles*, or for at least 24 hours, whichever is shorter.

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

Δ **8.1.3 Flexural Fatigue Procedure for Garment Materials.** Samples shall be subjected to flexural fatigue in accordance with ASTM F392/F392M, *Standard Practice for Conditioning Flexible Barrier Materials for Flex Durability*, with the following modifications:

(1) In lieu of Flexing Conditions A, B, C, D, or E, standard class 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) In lieu of Flexing Conditions A, B, C, D, or E, test specimens for Class Type R shall have a flex period of 1000 cycles at 45 cycles per minute. A cycle shall be a full flex and twisting action.
(3) Anisotropic materials shall be tested in both machine and transverse directions.
(4) All layers of garment material in the ensemble shall be present during flex conditioning.

Δ **8.1.4 Abrasion Procedure for Element Materials.** Samples shall be abraded in accordance with ASTM D4157, *Standard Test Method for Abrasion Resistance of Textile Fabrics (Oscillatory Cylinder Method)*, under the following conditions 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) Standard class specimens shall be abraded for 10 continuous cycles. Class Type R specimens shall be abraded for 100 continuous cycles.
(6) All layers of the element material shall be subjected to the abrasion conditioning.

8.1.5 Flexural Fatigue Procedure for Gloves.

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

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

Δ **8.1.6 Flexural Fatigue Procedure for Footwear.** Sample footwear shall be subjected to 100,000 flexes in accordance with Appendix B of FIA Standard 1209, *Whole Shoe Flex*, with the following modifications:

(1) Water shall not be used.
(2) The flex speed shall be 60 ± 2 cycles per minute.
(3) Alternative flexing equipment shall be permitted to be used when the flexing equipment meets the following parameters:
   (a) The alternative flexing equipment is capable of providing the angle of flex as described in FIA 1209.
   (b) The alternative flexing equipment is capable of a flex speed of 60 ± 2 cycles per minute.
   (c) The alternative flexing equipment provides a means of securing the footwear during flexing.

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

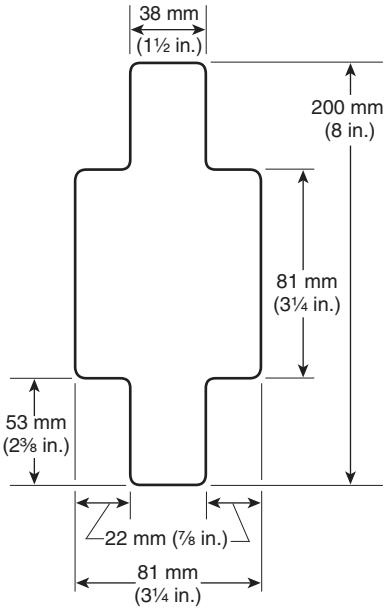


FIGURE 8.1.4 Specimen Configuration.

8.1.8 Elevated Humidity Conditioning Procedure for Garment, Glove, Footwear Seam, Closure, Visor Materials, and Exhaust Valves. Samples 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 D1776, *Standard Practice for Conditioning and Testing Textiles*, or for at least 24 hours, whichever is shorter.

N **8.1.9 Class Type R Ensemble Preconditioning Procedure.**

N **8.1.9.1** Samples shall be washed and dried alternately for a total of five washing cycles and five drying cycles.

N **8.1.9.2** Samples shall be washed and dried with all closures fastened.

N **8.1.9.3** A front-loading washer/extractor shall be used for washing the samples.

N **8.1.9.4** The wash load shall be two-thirds the rated capacity of the washer.

N **8.1.9.4.1** If ballast is needed to reach two-thirds capacity, ballast shall be used.

N **8.1.9.4.2** Two-thirds of the rated capacity shall not be exceeded.

N **8.1.9.5** The wash cycle procedure in Table 8.1.9.5 shall be followed.

N **8.1.9.6** A tumble dryer with a dry stack temperature of 38°C to 49°C (100°F to 120°F) measured 20 minutes into the drying cycle shall be used for drying the samples.

N **8.1.9.7** Samples shall be removed from the dryer after 20 minutes of tumble drying. At the conclusion of the final drying cycle, the sample shall be allowed to dry completely for at least 48 hours in accordance with 8.1.2.

8.2 Man-In-Simulant Test (MIST).

8.2.1 Application. This test shall apply to Class 1, Class 2, Class 2R, Class 3, and Class 3R ensembles.

Table 8.1.9.5 Wash Cycle Procedure for Type R Ensembles

Operation	Time (min)	Temperature °C ± 3°C	Temperature °F ± 5°F	Water Level
Suds using AATCC detergent #1993, 1.0 g/4 L (1 gal) water				
Drain	1			
Carryover	5	49	120	Low
Drain	1			
Rinse	2	38	100	High
Drain	1			
Rinse	2	38	100	High
Drain	1			
Rinse	2	38	100	High
Drain	1			
Extract	5			

8.2.2 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 for Class Type R shall be conditioned as specified in 8.1.9.

N **8.2.2.3** 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 6.1.7, 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.

N **8.2.3.9** Where socks are used as part of the protective ensemble, it shall be permitted that testing be performed on only one representative outer boot style for the evaluation of the ensemble.

8.2.4 Apparatus.

8.2.4.1 Test Facility.

8.2.4.1.1 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.

8.2.4.1.2 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 and for the test subject(s) to carry out the physical exercise routine specified in 8.2.5.8.

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

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

8.2.4.2 Test Chemical and Analytical Equipment.

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

8.2.4.2.2* The standard concentration of MeS in the vapor chamber shall be 150 mg/m^3 ± 15 mg/m^3 as measured by a real-time infrared analysis of the chamber air or other validated real-time analytical technique.

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

8.2.4.2.4 The generation of liquid aerosol shall be avoided.

8.2.4.2.5 The sensitivity of the analytical technique used for the measurement of MeS in the PADs shall provide a detection limit of 30 ng MeS per PAD. The analytical technique shall have an upper limit of quantification of 31,500 ng.

Δ **8.2.4.3* Passive Adsorbent Dosimeters (PADs).** The test shall be conducted using passive adsorbent dosimeters (PADs) that affix directly to the skin of the test subjects and that have the following characteristics:

(1) The PADs shall be a foil packet that contains an adsorbent material covered by a high-density polyethylene film that acts as a pseudo-skin barrier.
(2) The PADs shall have an uptake rate of 3.0 cm/min or greater.

8.2.4.4 Test Subjects.

8.2.4.4.1 All test subjects shall be medically and physically suitable to perform these tests without danger to themselves, and a medical certificate for each test subject shall have been issued within 12 months prior to testing.

8.2.4.4.2 Test subjects shall be familiar with the use of chemical protective ensembles and with the selected CBRN SCBA.

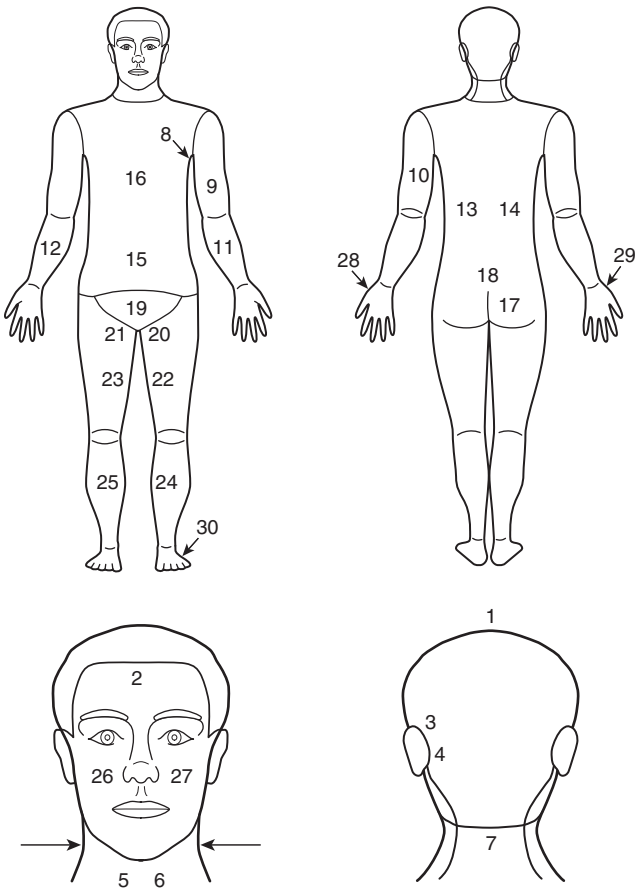
8.2.5 Procedure.

8.2.5.1 Test subjects shall have followed pretrial procedures that include proper hydration and avoiding personal hygiene products that could contain MeS.

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 pretrial procedures to minimize contamination. Test subjects shall also follow pretrial 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 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.

Δ **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 lb) human dummy using both hands a distance of 10 m (33 ft) over a 15-second period. Stop and rest for 15 seconds. Repeat exercise twice.
(2) Duck squat, pivot right, pivot left, stand. Rotate orientation 90 degrees to wind stream between each repetition. Repeat exercise twice in each orientation for a total of 1 minute.
(3) Stand erect. With arms at sides, bend body to left and return, bend body forward and return, bend body to right and return. Rotate orientation 90 degrees to wind stream between each repetition. Repeat exercise twice in each orientation for a total of 1 minute.
(4) Stand erect. Extend arms overhead in the lateral direction, then bend elbows. Extend arms overhead in the frontal direction, then bend elbows. Rotate orientation 90 degrees to wind stream between each repetition. Repeat exercise twice in each orientation for a total of 1 minute.
(5) Stand erect. Extend arms perpendicular to the sides of torso. Twist torso left and return, twist torso right and return. Rotate orientation 90 degrees to wind stream between each repetition. Repeat exercise twice in each orientation for a total of 1 minute.
(6) Stand erect. Reach arms across chest completely to opposite sides. Rotate orientation 90 degrees to wind stream between each repetition. Repeat exercise twice in each orientation for a total of 1 minute.
(7) Climb two steps of the ladder and touch the ceiling with one hand (use alternate hands each time). Climb down, squat, and touch the floor with both hands. Repeat exercise three times within 1 minute.
(8) Crawl in place for 1 minute. Rotate orientation 90 degrees to wind stream every 15 seconds.
(9) Sit on stool (facing wind) 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 activity 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.

8.2.5.9.2 In the decontamination area, all exposed ensemble surfaces, including such items as the respirator, boots, gloves, and helmets, shall be washed with a liquid soap solution.

8.2.5.9.2.1 If the garment is designed for wet decontamination, it shall be washed with the soap solution as well.

8.2.5.9.2.2 Alternative decontamination methods, such as an air wash, shall be permitted if the selected decontamination method can be demonstrated to remove MeS to levels that do not result in contamination of the test subjects during the doffing of the protective ensemble.

8.2.5.9.3 The decontaminated test subject shall move to the first-stage undressing room where all remaining items of clothing, except underwear, shall be doffed. The undressing process shall not exceed 5 minutes.

8.2.5.9.4 As soon as the garment is unsealed and the PADs on the test subject's body are exposed to the ambient atmosphere in the first-stage undressing room, three fresh PADs shall be placed near the test subject to detect background MeS concentrations.

8.2.5.9.5 As soon as all items of clothing, except underwear, are removed, the decontaminated test subject shall proceed to the second-stage undressing room and the background PADs shall be collected and handled as specified in 8.2.5.9.7. The exposure time for the first-stage undressing room background PADs shall be recorded.

8.2.5.9.6 When the test subject enters the second-stage undressing room, three additional PADs shall be placed near the test subject and the exposure PADs shall be removed from the test subject's body. Both the second-stage undressing room background PADs and the exposure PADs taken off the test subject's body shall be handled as specified in 8.2.5.9.7. The exposure time for the second-stage undressing room PADs shall be recorded.

8.2.5.9.7 Where an adhesive is used on the back of the PADs, each PAD shall be backed with aluminum foil, placed in individual sealed glass vials with a nonadsorbent lid liner, and shall remain at room temperature of 25°C ± 3°C (77°F ± 5°F) for 30 min ± 5 min immediately after exposure.

8.2.6 PAD Qualification and Analysis.

8.2.6.1 The uptake rate for each lot of PADs shall be determined in accordance with 8.2.6.2, using a minimum of seven PADs selected randomly from the lot.

8.2.6.2* Measurement of PAD Uptake Rate.

8.2.6.2.1 The PAD uptake rate shall be measured by exposing PADs in a small-scale chamber under the following conditions:

(1) The concentration of MeS shall be 1 mg/m^3 ± 0.5 mg/m^3.
(2) The temperature shall be 35°C ± 2°C (94°F ± 4°F).
(3) The relative humidity shall be 55 percent ± 20 percent.
(4) The flow of MeS in the humidified air or nitrogen shall be at a rate of 1 cm/sec ± 0.2 cm/sec over the PAD.
(5) The exposure shall be conducted for a period of 30 min +1/-0 min.

8.2.6.2.2 The PAD uptake rate shall be calculated in accordance with the procedures provided in 8.2.6.2.1. The average of all PAD uptake rates shall be calculated and used in the calculation of MeS dosage on the test subject PADs.

8.2.6.3 After their initial 30 minutes at room temperature, the PADs shall be subjected to one of the following handling and analysis procedures:

(1) The PADs shall be stored at a cold temperature sufficient to prevent the migration of MeS from the adhesive until extraction or analysis.
(2) The PADs shall be extracted within 4 hours.
(3) The adsorbent shall be removed and thermally desorbed within 4 hours.

8.2.6.3.1 The determination of a sufficiently low temperature that prevents migration of the MeS from the adhesive shall be made by exposing 12 PADs simultaneously in the test chamber in a vertical position at a concentration of 100 mg/m^3 of MeS for 30 min +5/–0 min. After this exposure, the PADs shall be covered in foil, each placed in a sealed container, and stored at 25°C ± 3°C (77°F ± 5°F) for 30 min ± 5 min. Four of the PADs shall be packed in dry ice for 24 hours, four placed in the proposed cold storage temperature for 24 hours, and four extracted or analyzed within 4 hours. The average mass absorbed on the four PADs stored at the proposed storage temperature shall equal with 95 percent confidence the average mass absorbed on four PADs stored for 24 hours in dry ice and the four PADs analyzed immediately after exposure.

8.2.6.3.2 Where liquid extraction of the PADs samples is performed, the liquid extracts shall be stored at 0°C to 4°C (32°F to 39°F) for up to 14 days following their exposure before analysis.

8.2.6.4 The actual MeS vapor exposure concentration and the actual time of exposure shall be used to determine the uptake rate from the following equation:

N

$$u = m / ACt \qquad \textbf{[8.2.6.4]}$$

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

8.2.6.5 The range of the analytical technique shall be sufficient to measure the expected range of MeS dosage on the test subject PADs.

8.2.6.5.1 When liquid extraction is used as the analytical technique, the calibration curve used for determining the equipment response to MeS shall be established using at least four MeS concentration standards accounting for the proper density of the extraction solvent.

8.2.6.6 For the test results to be considered valid for a given ensemble, no more than one PAD from each of the body region locations tested (i.e., no more than one PAD of the 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 dosage measured by each PAD ($Ct_{inside,i}$) shall be determined using the average uptake rate determined for the PAD lot used in the evaluation of a specific ensemble using the following equation:

N

[8.2.7.1]

$$Ct_{inside,i} = m_i / u_{avg} A$$

where:

$Ct_{inside,i}$ = MeS vapor dosage at the specific PAD (mg/min/cm^3)
m_i = total mass of MeS measured on the specific PAD (mg)
u_{avg} = average uptake of the PAD lot (cm/min)
A = average active area of the PAD (cm^2)

8.2.7.1.1 The protection factor at each PAD location shall be calculated using the following equation where the $Ct_{outside}$ shall be determined from the measured chamber vapor dosage of the individual trial over the entire exposure. The value for $Ct_{outside}$ shall be the average of the chamber MS concentration readings taken during the course of the test subject exposure period:

N

[8.2.7.1.1]

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

8.2.7.1.2 Where the measured total mass of MeS for a given PAD falls below 30 ng, the value of 30 ng shall be used for that specific PAD.

8.2.7.2 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:

N

[8.2.7.2]

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

Δ **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.

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

Δ **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 2.3.9 to calculate the systemic PPDF 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. The value of PF_i used in the calculation is the average of the measured PF_i for each body region listed in the table under the heading "Body Region I for BRHA Model."

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

Body Region	PAD Location	OSED (mg·min·m^{-3})
Head/neck	1, 2, 3, 4, 5, 6 26, 27	100
Torso/buttocks (excluding perineum)	13, 14, 15, 16, 17, 18, 19	100
Arm/hand	8, 9, 10, 11, 12, 28, 29	50
Leg/foot	22, 23, 24, 25, 30	100
Perineum	20, 21	25

N

[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.

8.2.8 Report.

8.2.8.1* The individual specimen and geometric mean local $PPDF_i$ values for each PAD location shall be recorded and reported.

8.2.8.2* The $PPDF_{sys}$ value for each specimen and the geometric mean $PPDF_{sys}$ value for the ensemble tested shall be recorded and reported.

8.2.8.3 A spreadsheet shall be prepared that shows all test measurements and calculations including at least the following:

(1) The MeS vapor exposure concentration for PAD lot qualification
(2) The exposure time used for PAD lot qualification
(3) The measured MeS mass on each PAD used for PAD lot qualification
(4) The individual and the average PAD uptake rates
(5) The measured MeS mass on each PAD used in the dressing room, first-stage undressing room, and second-stage undressing room
(6) The measured MeS mass on each PAD placed on the test subject
(7) The calculated vapor dosage for each PAD placed on the test subject

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

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

Body Region *i* forBRHA Model	PADs Mapped to This Region (Average Dosage from Each PAD, Then Calculate PF_i)	Area of Body Region(dz_i, cm^2)	ED_{50i} for Severe Effects (VX) for Body Region (mg/ Individual)
Scalp	1, 2	350	0.76
Ears	3, 4	50	0.46
Face, cheeks, and neck	5, 6, 26, 27	300	0.48
Chin and neck	5, 6	200	0.36
Nape	7	100	1.72
Abdomen	16	2858	2.23
Back	13, 14, 18	2540	2.65
Axillae	8	200	2.07
Upper arm medial	9	488	2.8
Upper arm lateral	10	706	6.57
Elbow fold	9, 10, 11, 12	50	2.09
Elbow	9, 10, 11, 12	50	2.25
Forearm extensor	11, 12	487	2.8
Forearm flexor	11, 12	706	6.57
Hands dorsum	28, 29	200	2.91
Hands palmar	28, 29	200	9.24
Buttocks	17	953	4.26
Groin	15, 19	300	1.22
Scrotum	20, 21	200	0.11
Thigh anterior	22, 23	2845	6.57
Thigh posterior	22, 23	1422	4.26
Knee	22, 23, 24, 25	200	7.14
Popliteal space (back of knees)	22, 23, 24, 25	100	2.09
Shins	24, 25	1897	6.57
Calves	24, 25	948	2.8
Feet dorsum	30	500	6.6
Feet plantar	30	300	7.14

8.3 Overall Garment Function and Integrity Test.

8.3.1 Application. This test method shall apply to complete ensembles with gloves, footwear, hoods, and respirator if applicable.

•

8.3.2 Samples.

Δ 8.3.2.1 Samples shall be complete ensembles with gloves, footwear, hoods, and respirator as applicable.

***N* 8.3.2.2** Samples for Class Type R shall be conditioned as specified in 8.1.9.

8.3.2.3 Samples shall be conditioned as specified in 8.1.2.

8.3.3 Specimens.

8.3.3.1 Specimens shall be complete ensembles with gloves, footwear, hoods, and respirator, as applicable.

8.3.3.2 At least three specimens shall be tested.

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

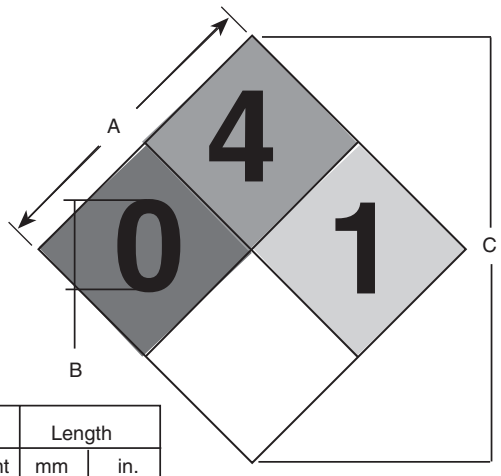
8.3.3.4 Where the ensemble offers multiple types of external fittings, each type of external fitting shall be installed in the ensemble prior to testing.

8.3.3.5 Where the ensemble uses the respirator facepiece as the ensemble visor as specified in 6.1.7, each style of the ensemble shall be tested with each style of the respirator specified by the manufacturer.

***N* 8.3.3.6** Where socks are used as part of the protective ensemble, it is permitted that testing be performed on only one representative outer boot style for the evaluation of the ensemble.

***N* 8.3.4 Apparatus.** The equipment and supplies specified in ASTM F1154, *Standard Practices for Qualitatively Evaluating the Comfort, Fit, Function, and Durability of Protective Ensembles and Ensemble Components*, shall be used along with the following additional items:

(1) A Snellen eye chart for a 6 m (20 ft) distance
(2) A stopwatch or other timing device
(3) A protractor or other device to measure the angle of the placard relative to the test subject
(4) An NFPA 704–based placard as seen in Figure 8.3.4.



	Length	
Measurement	mm	in.
A	64	2.5
B	25	1
C	90	3.5

FIGURE 8.3.4 NFPA 704 Placard.

8.3.5 Procedure.

Δ **8.3.5.1** Overall function and integrity shall be measured in accordance with ASTM F1154, *Standard Practices for Qualitatively Evaluating the Comfort, Fit, Function, and Durability of Protective Ensembles and Ensemble Components*, with the following parameters:

(1) Both Procedures A and B, specified in ASTM F1154, shall be used. Testing of ensembles immediately following testing as specified in Section 8.2, Man-In-Simulant Test (MIST), shall be permitted.
(2) Specimens to be tested shall meet the sizing range of the test subjects as determined in 5.3.4. Specimens shall be donned in accordance with the manufacturer's instructions.
(3) Testing shall be conducted at 25°C ± 6°C (77°F ± 10°F) and relative humidity of 50 percent ± 20 percent.
(4) Following the exercise procedures, Class 1, Class 2, Class 2R, Class 3, and Class 3R ensembles shall be measured for liquidtight integrity as specified in Section 8.4, Liquidtight Integrity Test 1.
(5) Where hoods are provided, a determination shall be made that the ensemble is designed to accommodate at least head protection meeting the dimensional requirements for Type 1, Class G helmets of ANSI/ISEA Z89.1, *American National Standard for Industrial Head Protection*. Nonencapsulating ensemble hoods shall be permitted to accommodate head protection worn either inside or outside the ensemble.
(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 or glasses 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.

8.3.5.2 Where hoods with visors or facepieces are provided, visual acuity testing within the ensemble shall be conducted using a standard 6.1 m (20 ft) eye chart with a normal lighting range of 100 foot-candles to 150 foot-candles at the chart and with the test subject positioned at a distance of 6.1 m (20 ft) from the chart.

8.3.5.3 Where hoods with visors or facepieces are provided, the test subject shall then read the standard eye chart through the lens of the respirator facepiece, if present, and ensemble visor or facepiece to determine the test subject's visual acuity.

N **8.3.5.4** The field of vision for the test subject shall be assessed for the up, down, left, and right orientation angles used in the NFPA 704–based placard with random numbers between 0 and 4 in each of the quadrants. The placard shall be 2 m (6 ft)/0/–0.1 m (0.3 ft) away from the eye of the test subject and perpendicular to the field of view line of sight being measured.

N **8.3.5.5** Where encapsulating ensembles are evaluated, at the end of testing, the test subject shall be instructed to remove his or her hands from each of the gloves while still wearing the ensemble, touch the bypass value of the SCBA, and then reinsert his or her hands into the gloves. The test subject shall perform this action in accordance with the manufacturer's instructions. This action shall be sequentially repeated for a total of five times. The time for completing this action shall be timed using a stopwatch or other suitable timing device.

8.3.6 Report.

N **8.3.6.1** The average time required for the all test subjects to complete all portions of the exercises shall be calculated and reported.

8.3.6.2 Where liquidtight integrity testing is performed, a diagram shall be prepared for each test that identifies the locations of any liquid leakage as detected on the liquid-absorptive garment inside the specimen or on the interior surface of the specimen.

8.3.6.3 The length of time it takes for the test subjects to satisfactorily complete both exercise procedures shall be recorded and reported.

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

8.3.6.5 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.

N **8.3.6.6** Where ensembles with visors are provided, the angular degree for the up, down, left, and right defining the field of vision shall be measured and reported. The average angular degree for each direction for all test subjects shall be calculated and reported.

N **8.3.6.7** Where encapsulating ensembles are evaluated, the time for each test subject to completely remove his or her hands from the gloves and reinsert his or her hands in the gloves five times sequentially shall be recorded and reported. The average time for all test subjects shall be calculated and reported.

N **8.3.6.8** Where closures are covered by a protective flap, any disengagement of the protective flap observed during the exercise procedures shall be recorded and reported.

N **8.3.6.9** Any disengagement of the closures observed after the exercise procedures shall be recorded and reported.

8.3.7 Interpretation.

8.3.7.1 For Class 1, Class 2, Class 2R, Class 3, and Class 3R ensembles, evidence of liquid on the liquid-absorptive garment inside the specimen or on the interior surface of the ensemble shall constitute failure.

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

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

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

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

N **8.3.7.5** Where ensembles with visors are provided, the average angular field of vision in each direction shall be used to determine pass or fail performance.

N **8.3.7.6** Where encapsulating ensembles are evaluated, the average time for all test subjects to completely remove their hands from the gloves and reinsert their hands in the gloves five times sequentially shall be used to determine pass or fail performance.

N **8.3.7.7** Where closures are covered by a protective flap, any disengagement of the closure of the protective flap after the exercise sequences shall constitute failure.

N **8.3.7.8** Any disengagement of the closures after the exercise sequences shall constitute failure.

8.4 Liquidtight Integrity Test 1.

8.4.1 Application.

8.4.1.1 This test method shall apply to Class 1, Class 2, Class 2R, Class 3, and Class 3R ensembles.

8.4.1.2 Specific requirements for testing Class 1, Class 2, and Class 2R ensembles shall be as specified in 8.4.8.

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

8.4.2 Samples.

Δ **8.4.2.1** Samples shall be complete ensembles with gloves, footwear, hoods, and respirator, if applicable.

N **8.4.2.2** Samples for Class Type R shall be conditioned as specified in 8.1.9.

8.4.2.3 Samples shall be conditioned as specified in 8.1.2.

8.4.3 Specimens.

8.4.3.1 Specimens shall be complete ensembles with gloves, footwear, hoods, and respirator, if applicable.

8.4.3.2 At least three specimens shall be tested.

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

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

8.4.3.5 Where the ensemble utilizes the respirator facepiece as the ensemble visor as specified in 6.1.7, each style of the ensemble shall be tested with each style of the respirator specified by the manufacturer.

N **8.4.3.6** Where socks are used as part of the protective ensemble, it shall be permitted that testing be performed on only one representative outer boot style for the evaluation of the ensemble.

8.4.4 Apparatus. The apparatus and supplies for testing shall be those specified in ASTM F1359/F1359M, *Standard Test Method for Liquid Penetration Resistance of Protective Clothing or Protective Ensembles Under a Shower Spray While on a Manikin*, using the following modification: The left arm of the manikin shall be positioned with the upper arm against the side of the manikin and the lower arm bent upward at the elbow at a 135-degree angle.

8.4.5 Procedure.

Δ **8.4.5.1** Liquidtight integrity testing of garments shall be conducted in accordance with Procedure A of ASTM F1359/F1359M, *Standard Test Method for Liquid Penetration Resistance of Protective Clothing or Protective Ensembles Under a Shower Spray While on a Manikin*, with the following modifications:

(1) No provisions for garments with a partial barrier layer shall be allowed.
(2) The method used for mounting the manikin in the spray chamber shall not interfere with the water spray.
(3) At the end of the liquid spray exposure period, excess liquid shall be removed from the surface of the specimen.

8.4.5.2 The specimen shall be inspected within 2 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.

Δ **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 1, Class 2, and Class 2R Ensembles. Testing shall be performed with the suited manikin exposed to the liquid spray for a total of 20 minutes, 5 minutes in each of the four manikin orientations.

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

N **8.5.2.3** Samples for Class 4R shall be conditioned as specified in 8.1.9.

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 6.1.7, 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. A minimum of two test subjects shall be used.

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.

N **8.5.3.8** Where socks are used as part of the protective ensemble, it shall be permitted that testing be performed on only one representative outer boot style for the evaluation of the ensemble.

8.5.4 Apparatus.

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

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 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.

N **8.5.4.6** Test subjects shall wear a close-fitting, one- or multiple-piece full-body indicator garment made of black synthetic material that is sized to the individual test subject. The indicator garment shall be clean and free of visible lint, to the extent practicable, prior to the test subject donning the test ensemble.

N **8.5.4.7** Visual inspection of the test subject, while wearing the indicator garment, shall be performed under illumination by black light in a dark room after doffing the candidate garments. Inspection shall be performed while the test subject is fully illuminated by black light with a wavelength of 365 nm.

N **8.5.4.8*** A separate handheld black light with a wavelength of 365 nm and an intensity of 1200 $\mu W/cm^2$ at 380 nm shall be used to inspect areas where the presence of fluorescent particles might be unclear.

N **8.5.4.9** A 35 mm camera, or digital equivalent, with the appropriate capabilities and settings for taking photographs under UV light shall be provided for documenting the visual condition of the test subject before and after the exposure to the aerosol.

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

8.5.4.11 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.

8.5.4.12 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 2.75 μm ± 0.75 μm.

N **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.

N **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.

N **8.5.5.4** The 10 masked areas each shall have a minimum area of 13 cm^3 (2 in.^{2}) and shall be distributed over the indicator garment.

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.

•

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

N **8.5.5.8*** During the 30-minute test period, the test subject shall perform the following three series of stationary exercises. The stationary exercises shall be as specified in Procedure A of ASTM F1154, *Standard Practices for Qualitatively Evaluating the Comfort, Fit, Function, and Durability of Protective Ensembles and Ensemble Components*, 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.

N **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.

•

N **8.5.5.11** After doffing, the masked areas shall be unmasked and the test subject shall be examined under black light in the viewing area for evidence of particulate inward leakage.

N **8.5.5.12** Photographs shall be taken of the test subject under black light with the following minimum positions:

(1) Front, right, back, and left side of test subject neck and head
(2) Front, right, back, and left side of test subject upper torso
(3) Front, right, back, and left side of test subject lower torso

N **8.5.5.12.1** The exposure of the black light should be bracketed to provide photographs with varying contrast to permit documentation of any observed fluorescence.

N **8.5.5.13*** A separate black light shall be used to inspect any areas where the presence of fluorescent particles might be unclear.

N **8.5.5.14** The laboratory shall be permitted (but is not required) to further sample any areas that are suspect for particle contamination using the procedures established in 8.5.8. These procedures, when used, shall be employed for documentation purposes only and shall not be used for interpreting compliance with the performance requirement.

N **8.5.6 Sampling and Analysis of Black Indicator Garment.**

N **8.5.6.1** The test subject's black indicator garment shall be sampled to recover aerosol that has deposited. This skin-rinse sampling shall be performed by pressing a tube against the portion of the black indicator garment to be sampled and adding 20 mL (0.68 oz) of 0.01 N sodium hydroxide (NaOH). The solution shall be washed over the black indicator garment for approximately 10 seconds, then pipetted into a clean container.

N **8.5.6.2** All samples shall be labeled appropriately before they are analyzed.

N **8.5.6.3** For each of the black indicator garment-rinse samples, approximately 5 mL (0.17 oz) of each of the samples shall be analyzed in a fluorometer to determine the mass of aerosol that is present in the sample. The results shall be recorded and verified to identify and eliminate any errors in reading or recording the data.

N **8.5.7** After each trial, upon completion of the skin-rinse sampling and black light photography, the test subject shall return to a locker room and shower.

N **8.5.8 Report.**

N **8.5.8.1** Photographic records documenting the test ensemble and results shall consist of the following:

(1) Photographs of the test subject in the full test ensemble immediately before entering the aerosol chamber, with additional photographs, included as warranted, of the test subject in the ensemble showing design details
(2) Black light photographs of the test subject after doffing that cover all body locations, with the test subjects wearing shorts, and for female test subjects, a sports bra
(3) The test conditions, including the following:
    (1) Challenge aerosol mass concentration averaged for the duration of the test
    (2) Average wind speed, temperature, and relative humidity for the test
    (3) Date of test and test operator
(4) Specific observations for the location of any deposited aerosol on the test subjects
(5) Any notable observations by the test operators (especially system openings, mask breaches, or poor fits)
(6) Any supplemental test data sampling and analysis of the black indicator garments provided for documentation

N **8.5.8.2** If post-exposure photographs show no aerosol deposits and show only a black garment in a dark room, the following statement shall be permitted to be used in lieu of post-exposure photographs: "No visible aerosol deposits were revealed in the photographs."

8.5.9 Interpretation. 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 1, Class 2, Class 2R, Class 3, Class 3R, Class 4, or Class 4R ensembles.

8.6.2 Samples.

8.6.2.1 Samples for conditioning shall be external fitting assemblies mounted into the ensemble material using the means of mounting and the fabrication methods used to install the external fitting into the actual ensemble.

8.6.2.2 Samples shall be conditioned as specified in 8.1.2.

8.6.3 Specimens.

8.6.3.1 Specimens shall be external fitting assemblies mounted into the ensemble material using the means of mounting and the fabrication methods used to install the external fitting into the actual ensemble.

8.6.3.2 At least three specimens shall be tested.

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 the CBRN barrier layer and the CBRN barrier layer's seams used in ensembles and ensemble elements for CBRN terrorism agent protection.

8.7.1.2 Specific requirements for testing the CBRN barrier layer of garments, hoods, elastomeric interface material, and socks shall be as specified in 8.7.10.

8.7.1.3 Specific requirements for testing the CBRN barrier layer of visors shall be as specified in 8.7.11.

8.7.1.4 Specific requirements for testing the CBRN barrier layer of gloves shall be as specified in 8.7.12.

8.7.1.5 Specific requirements for testing the CBRN barrier layer of footwear shall be as specified in 8.7.13.

8.7.1.6 Specific requirements for testing the CBRN barrier layer's seams of garments, hoods, socks, visors, and gloves shall be as specified in 8.7.14.

N **8.7.1.7** Specific requirements for testing elastomeric interface materials shall be specified in 8.7.15.

8.7.2 Samples.

Δ **8.7.2.1** Samples for conditioning shall be as specified according to the specific requirements in 8.7.10, 8.7.11, 8.7.12, 8.7.13, 8.7.14, and 8.7.15, as appropriate.

Δ **8.7.2.2** Samples shall be conditioned as specified according to the specific requirements in 8.7.10, 8.7.11, 8.7.12, 8.7.13, 8.7.14, and 8.7.15, as appropriate.

8.7.2.3 Samples shall then be cut to the specimen size.

8.7.2.4 All layers of the samples during conditioning shall be present and configured in the order and orientation as worn.

8.7.3 Specimens.

8.7.3.1 Specimens shall be the CBRN barrier layer or the CBRN barrier layer's seam of the size required to fit the permeation test cell.

8.7.3.2 At least three specimens shall be tested against each challenge chemical.

8.7.3.3 Any outer shell or other composite layers normally worn over the specimen shall be permitted to be included on top of the specimen in the test. The outer shell or other composite layers shall be placed on the test specimen through the cell cap port after the test cell has been assembled.

8.7.3.4 If the specimen is the outermost layer of the composite, then it shall be tested without any additional layers on top.

8.7.3.5 Any separable layers normally worn underneath the specimen shall not be permitted to be included in the test.

8.7.3.6 Specimens with nonuniform surfaces shall be permitted to be treated with an impermeable nonreactive sealant outside the area of the specimen exposed to the challenge chemical, in order to allow sealing of the test cell to a uniform surface of the specimen.

8.7.3.7 Following any sample preparation, the specimens shall be conditioned at a temperature of 32°C ± 1°C (90°F ± 2°F) and at a relative humidity of 80 percent ± 5 percent, for at least 24 hours prior to testing in accordance with 8.7.7.1.1.

8.7.4 Apparatus.

8.7.4.1 A controlled environmental chamber shall be used to maintain the test cell, air flow control system, and reagent chemicals within ±1.0°C (±2.0°F) of the test temperature and ±5 percent of the test relative humidity. The controlled environment chamber shall be sized so that it can be used for conditioning test materials, test cells when not in use, challenge chemicals, and other test apparatus prior to testing, as well as holding the test cells horizontally during use while connected to the air delivery system with manifold and to the effluent sampling mechanism.

8.7.4.2* The test cell shall be a two-chambered cell for contacting the specimen with the challenge chemical on the specimen's normal outside surface and for flowing a collection medium on the specimen's normal inside surface, consisting of parts shown in Figure 8.7.4.2(a) and individual part detail shown in Figure 8.7.4.2(b) through Figure 8.7.4.2(f),

8.7.4.3* An air delivery system and manifold shall be used to provide oil-free, conditioned air to the test cell/fixtures at a rate of 2 standard liters per minute (SLPM) per test cell/fixture with a temperature precision of ±0.2°C and a relative humidity precision of ±5 percent. The manifold shall be designed to deliver 0.3 L/min for the challenge side of the test cell and 1 L/min for the collection side of the test cell and maintain at the test temperature. All parts of the air delivery system and manifold shall be chemically inert and nonabsorptive to the challenge chemical.

8.7.4.4* An analytical system shall be used to evaluate the amount of challenge chemical in the effluent air streams from the collection side of the test cell and shall be selected to provide the ability to measure the challenge chemical at 0.1 $\mu g/cm^2$ over a 60-minute exposure period. The analytical system shall be permitted to include a bubbler tube, solid sorbent, or real-time chemical analyzer. The selected analytical system shall be able to determine all of the challenge chemical permeating through the specimen in 60 minutes.

8.7.4.5 A vacuum pump capable of creating vacuum of at least 5 in. water column shall be used for testing the integrity of the assembled test cell.

8.7.4.6 A manometer or pressure gauge capable of measuring pressures or vacuums to 10 in. water column with an accuracy of 5 percent of scale shall be used for testing the integrity of the assembled test cell.

8.7.5 Supplies.

8.7.5.1 Syringe needles capable of delivering 1 μL droplets ± 1 percent of the challenge chemical shall be used for dispensing liquid challenge chemical onto the surface of the specimen in the test cell.

8.7.5.2* Replacement O-rings shall be available for use in the permeation test cell.

8.7.5.2.1* If unknown, the compatibility of the O-ring material with the challenge chemical shall be verified before use.

8.7.5.2.2 If an O-ring shows any signs of chemical degradation in the form of softening, hardening, swelling, deterioration, or loss of shape or function, an O-ring of different material shall be used that does not show chemical degradation.

8.7.5.3* An inert impermeable surrogate material shall be used as a negative control during validation tests.

8.7.6 Chemicals.

Δ **8.7.6.1*** The following challenge chemicals shall be tested as liquids at a concentration of 95 percent or greater, except where otherwise specified:

(1) Liquid chemical warfare agents for Class 1, Class 2, Class 2R, Class 3, and Class 3R ensemble element materials and seams

(a) Sulfur mustard, distilled [HD, or bis(2-chloroethyl) sulfide, CAS 505-60-2]

(b) Soman (GD, or O-Pinacolyl methylphosphonofluoridate, CAS 96-64-0)

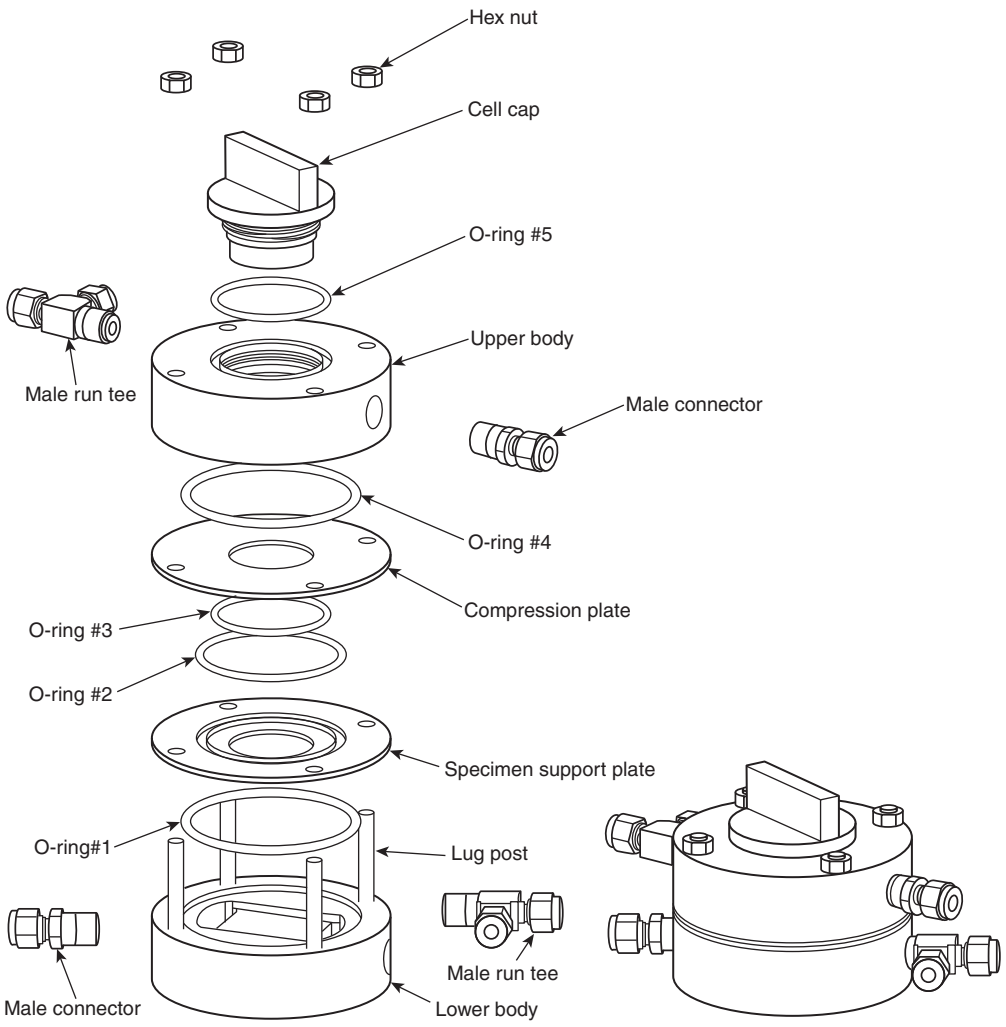


FIGURE 8.7.4.2(a) Diffusion Test Cell Assembly. (Copyright ©2006 W.L. Gore & Associates, Inc. Used by permission).

(2) Liquid toxic industrial chemicals for Class 1 ensemble elements materials
   (a) Dimethyl sulfate (DMS, sulfuric acid dimethyl ester, CAS 77-78-1)
   (b) Sulfuric acid, 93.1 percent, specific gravity 1.84, 66° Baumé (CAS 7664-93-9)
   (c) Tetrachloroethylene (perchloroethylene, CAS 127-18-4)
   (d) Toluene (toluol, CAS 108-88-3)

(3) Liquid toxic industrial chemical for Class 2, Class 2R, Class 3, and Class 3R ensemble element materials and seams
   (a) Dimethyl sulfate (DMS, sulfuric acid dimethyl ester, CAS 77-78-1)

8.7.6.2 Process for Determining the Mass of Liquid Chemical Challenge Applied.

8.7.6.2.1 Prior to assembling the test cell and conducting the test, the mass of the applied challenge chemical shall be determined using the procedure specified in 8.7.6.2.2 to 8.7.6.2.4.

8.7.6.2.2* The challenge chemical shall be applied to an inert impermeable surrogate specimen in the pattern described in 8.7.7.4.

8.7.6.2.3 After application, the inert impermeable surrogate specimen shall be visually inspected to verify that the liquid chemical challenge was correctly applied.

8.7.6.2.4 The inert impermeable surrogate specimen with the applied liquid chemical challenge shall be placed in a closed large vial containing a known volume of solvent compatible with the analysis procedure in 8.7.6.2.5 to 8.7.6.2.8.

8.7.6.2.5 The large vial with solvent and impermeable surrogate specimen with the applied liquid challenge chemical shall be agitated for at least 1 hour to ensure complete extraction of the challenge chemical.

8.7.6.2.6 After agitation, the solvent vial shall be removed and submitted for analysis of the liquid challenge chemical, using a procedure capable of detecting 1.0 mg of the liquid challenge chemical.

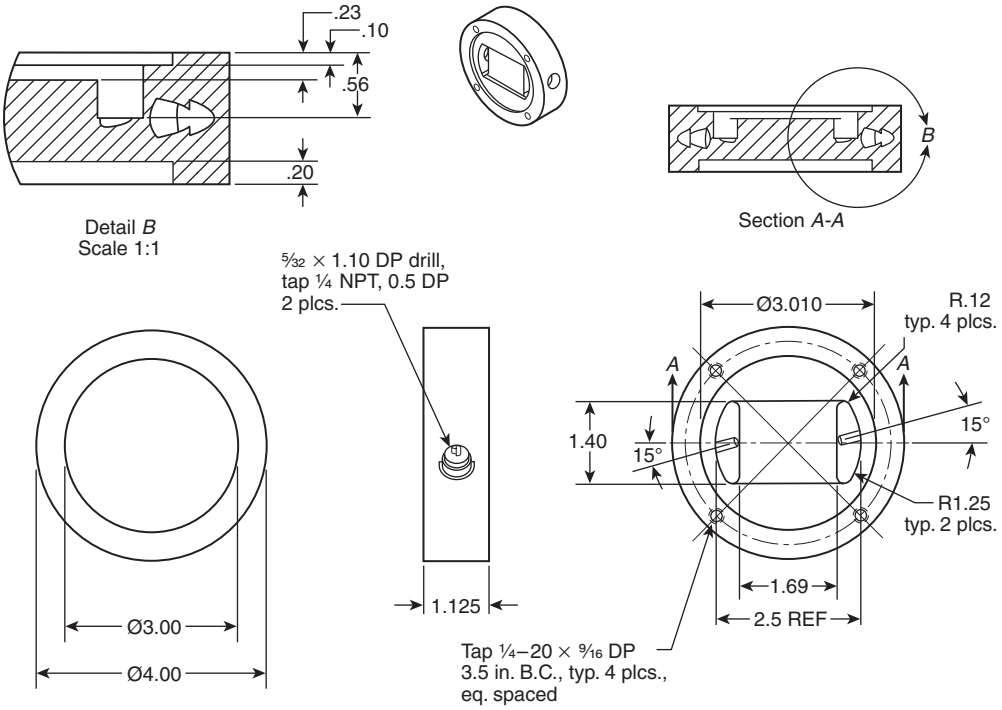


FIGURE 8.7.4.2(b) Lower Body (Collection Side). (Copyright ©2006 W.L. Gore & Associates, Inc. Used by permission).

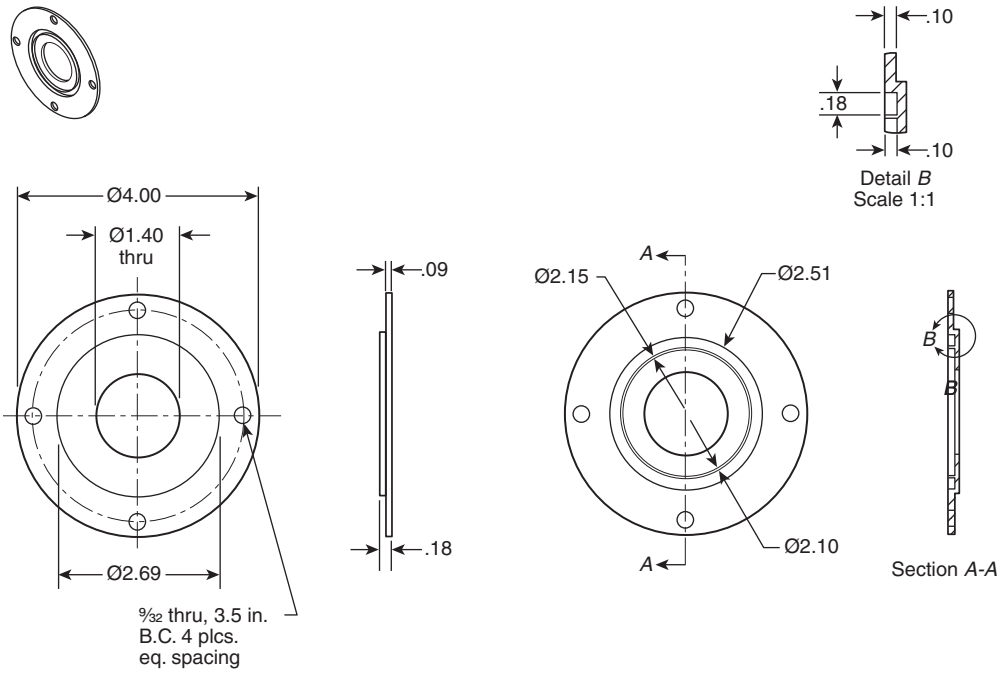


FIGURE 8.7.4.2(c) Sample Support Plate. (Copyright ©2006 W.L. Gore & Associates, Inc. Used by permission).

8.7.6.2.7 Using the mass of the liquid challenge chemical detected in the extraction procedure and the exposed area of the test specimen defined by the test cell, the exposure concentration shall be 20 g/m^2 (+1.0/–0.0 g/m^2) for Class 1 ensemble materials and 10 g/m^2 (+1.0/–0.0 g/m^2) for Class 2 and Class 3 ensemble materials.

8.7.6.2.8 The number of 1 μL liquid droplets shall be adjusted to conform to the 20 g/m^2 or 10 g/m^2 (+1.0/–0.0 g/m^2) concentration requirement, depending on the class of ensemble materials being tested.

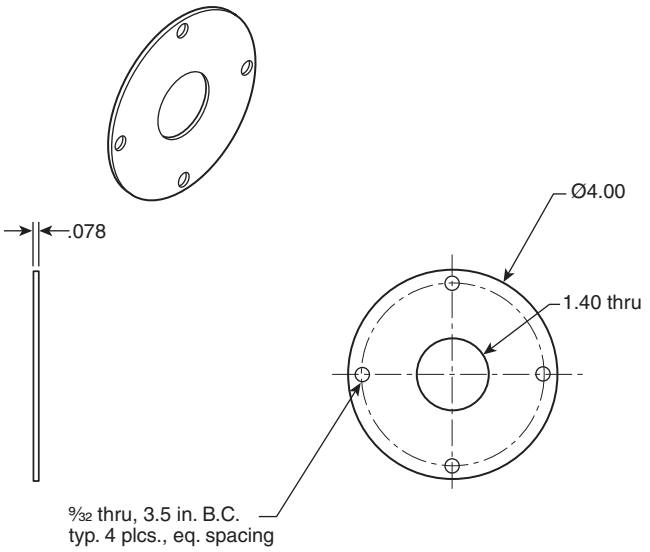


FIGURE 8.7.4.2(d) Compression Plate. (Copyright ©2006 W.L. Gore & Associates, Inc. Used by permission).

Δ 8.7.6.3* The following challenge chemicals shall be tested as gases or vapors in dry air or nitrogen:

(1) Toxic industrial gases for Class 1 ensemble element materials and seams
   (a) Acrolien (allyl aldehyde, CAS 107-02-8)
   (b) Acrylonitrile (VCN, cyanoethylene, CAS 107-13-1)
   (c) Ammonia, anhydrous (NH_3, CAS 7664-41-7)
   (d) Chlorine (Cl2, CAS 7782-50-5)
   (e) Diethylamine (CAS 109-89-7)
   (f) Ethyl acetate (acetic ether, acetic ester, CAS 141-78-6)

(2) Toxic industrial gases and vapors for Class 2, Class 2R, Class 3, and Class 3R ensemble elements materials and seams
   (a) Ammonia (NH3, CAS 7664-41-7)
   (b) Chlorine (Cl2, CAS 7782-50-5)
   (c) Acrolein (allyl aldehyde, CAS 107-02-8)
   (d) Acrylonitrile (VCN, cyanoethylene, CAS 107-13-1)

8.7.7 Procedures.

8.7.7.1 Preconditioning.

Δ 8.7.7.1.1 The test specimen, test equipment, and test cell assembly shall be placed in an environmental chamber for a minimum of 24 hours at 32°C ± 1°C (90°F ± 2°F) and at a relative humidity of 80 percent ± 5 percent, prior to testing.

***N* 8.7.7.1.2** Liquid challenge chemicals shall be at room temperature prior to testing.

8.7.7.2 Test Cell Assembly.

8.7.7.2.1 The test cell shall be assembled in the environmental chamber at 32°C ± 1°C (90°F ± 2°F) and at a relative humidity of 80 percent ± 5 percent.

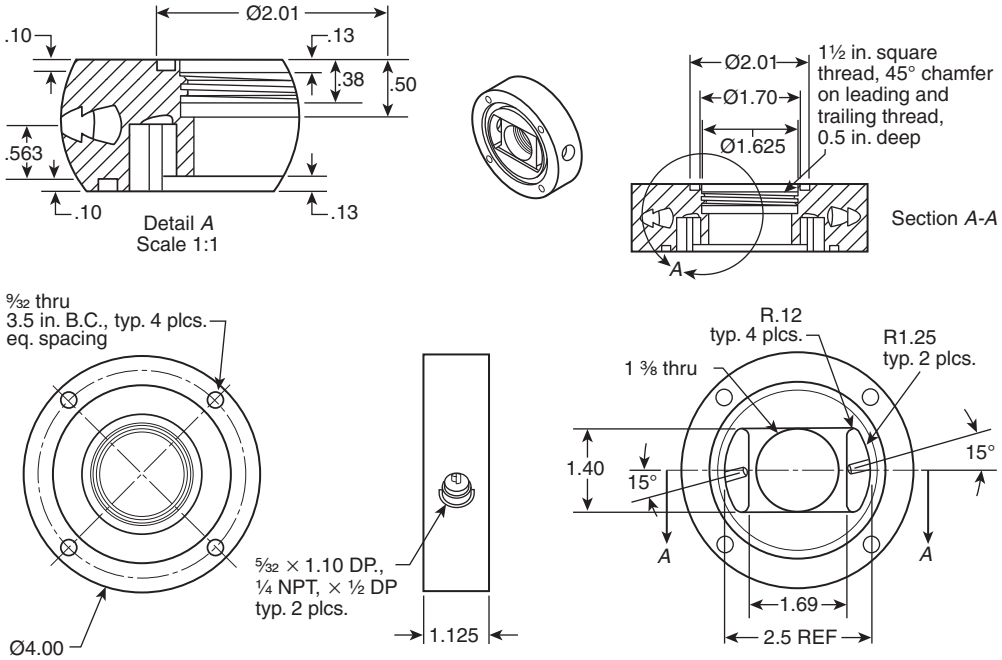


FIGURE 8.7.4.2(e) Upper Body (Challenge Side). (Copyright ©2006 W.L. Gore & Associates, Inc. Used by permission).

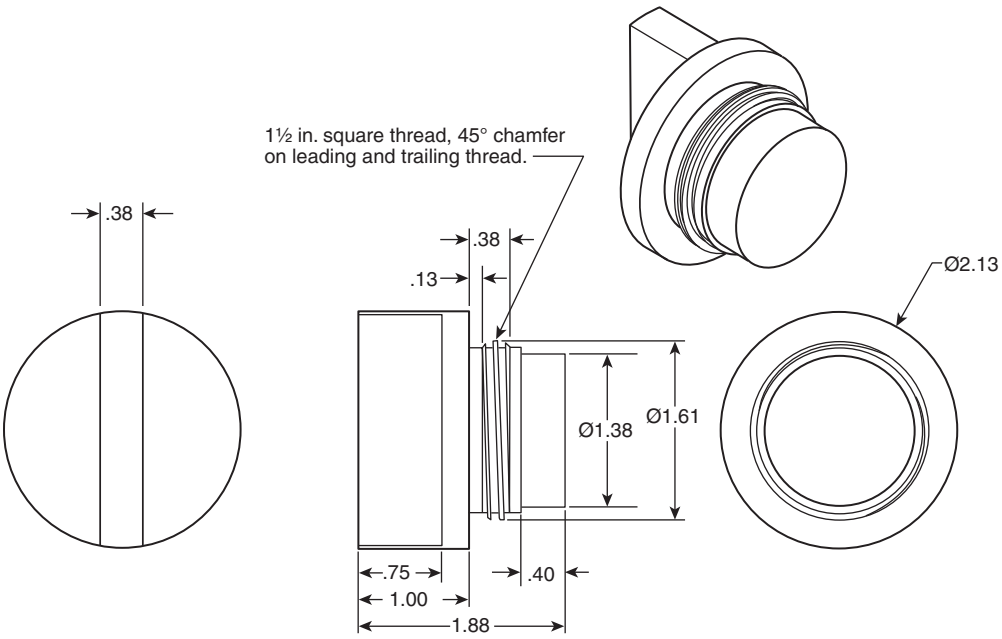


FIGURE 8.7.4.2(f) Top Cap. (Copyright ©2006 W.L. Gore & Associates, Inc. Used by permission).

8.7.7.2.2 O-Ring #1 shall be placed on the lower body (collection side) of the test cell.

8.7.7.2.3 The sample support plate shall be placed on the lower body (collection side) of the test cell.

8.7.7.2.4 O-ring #2 (outer) and O-ring #3 (inner) shall be placed in the respective grooves on the sample support plate.

8.7.7.2.5 The specimen shall be removed from the conditioning location in the environmental chamber and shall be placed on top of the sample support plate.

8.7.7.2.6 With the upper body (challenge side) of the test cell upside down, O-ring #4 shall be placed in the upper body of the test cell on the specimen side and the compression plate shall be positioned over O-ring #4.

8.7.7.2.7 The upper body (challenge side) of the test cell with O-ring #4 and the compression plate shall be inverted, aligned with the lug posts, and joined with the lower body (collection side) of the test cell.

8.7.7.2.8 Using the four cell sealing lugs, the cell halves shall be clamped together and 51.8 cm-kg (45 in.-lb) of torque shall be applied to each lug to ensure a proper cell seal.

8.7.7.2.9 O-ring #5 shall be inserted into the groove around the agent challenge port in the upper body of the test cell, and the cell top cap shall be screwed into place.

8.7.7.2.10 The integrity of the test cell assembly shall be verified using the procedure in 8.7.7.3.

8.7.7.2.11 Each test cell shall be labeled with the challenge chemical to be used in it.

8.7.7.3 Verification of Test Cell Integrity.

Δ **8.7.7.3.1** Test cell integrity shall be performed in the environmental chamber at 32°C ± 1°C (90°F ± 2°F) and at a relative humidity of 80 percent ± 5 percent.

8.7.7.3.2 Valves on the outlet ports of the upper and lower body of the test cell shall be closed.

8.7.7.3.3 Both the upper and lower body inlet ports of the test cell shall be connected to a manometer.

8.7.7.3.4 Both inlet ports shall be connected to a vacuum and the test cell upper body and test cell lower body shall be depressurized to 75 mm (3 in.) water column pressure.

8.7.7.3.5 If the test cell pressure drops below 50 mm (2 in.) of water column within 2 minutes, the test cell shall be reassembled according to the steps in 8.7.7.2.

8.7.7.3.6 Only test cells that have passed this integrity test shall be used for testing.

8.7.7.4 Determination of Procedure for Applying Liquid Challenge Chemicals.

8.7.7.4.1 The liquid chemical challenge concentration shall be 20 g/m^2 (+1.0/–0.0 g/m^2) for Class 1 ensembles.

N **8.7.7.4.2** The liquid chemical challenge concentration shall be 10 g/m^2 (1.0/–0.0 g/m^2) for Class 2 and Class 3 ensemble materials.

Δ **8.7.7.4.3** The number of 1 μL droplets shall be permitted to vary, depending on the density of the liquid chemical challenge.

N **8.7.7.4.3.1** For Class 1 ensemble materials, 16 droplets shall be applied evenly spaced around the perimeter and the remaining droplets placed in the center. If more than 1 droplet is required in the center, the droplets shall be spaced 8.1 mm (⅓ in.) apart. For seams, the droplets in the center shall be spaced along the seam juncture.

N **8.7.7.4.3.2** For Class 2 and Class 3 ensemble materials, 8 droplets shall be applied evenly spaced around the perimeter and the remaining droplets placed in the center. If more than 1 droplet is required in the center, the droplets shall be spaced 8.1 mm (⅓ in.) apart. For seams, the droplets in the center shall be spaced along the seam juncture.

8.7.7.4.4 A mechanical or automated device shall be permitted for uniformly dispensing the droplets onto the surface of the specimen.

Δ **8.7.7.4.5** When testing any liquid chemical, a quality control trial shall be conducted to verify that the application process delivers either 10 g/m^2 (1.0/–0.0 g/m^2) or 20 g/m^2 (1.0/–0.0 g/m^2) using the procedures in 8.7.6.2 as specific to the class of ensemble materials being evaluated.

8.7.7.5 Procedure for Liquid Chemical Challenge.

8.7.7.5.1 The test cell shall be mounted horizontally and connected to the air delivery system in the environmental chamber at 32°C ± 1°C (90°F ± 2°F) and at a relative humidity of 80 percent ± 5 percent. All connections shall be secured.

8.7.7.5.2 The calibrated analytical detection system shall be assembled and initiated according to its instructions.

8.7.7.5.2.1 If bubblers are used, each bubbler shall be filled with the proper collection solvent using a calibrated pipette or equivalent device; the collection solvent shall incorporate an internal standard so adjustments can be made for solvent evaporation/water condensation during sampling.

8.7.7.5.2.2 If solid sorbent tubes are to be used, each sorbent tube shall be cleaned by heating and purging; the absence of any residual chemical shall be verified by the appropriate analysis technique.

N **8.7.7.5.2.3** Sampler tubes shall be attached to the test cell immediately prior to the application of challenge chemical to avoid potentially adverse effects caused by the presence of moisture in the collection media stream.

N **8.7.7.5.2.4** At the conclusion of the specified sampling interval, sampling tubes shall be replaced in a manner that ensures permeant is not lost.

N **8.7.7.5.2.5** Permeant shall be desorbed from sampler tubes immediately following removal from the test chamber.

N **8.7.7.5.2.6** Analysis of permeant extracts shall be performed within 24 hours of extraction.

8.7.7.5.3 The air delivery shall be flowing filtered air at a temperature of 32°C ± 1°C (90°F ± 2°F) and at a relative humidity of 80 percent ± 5 percent, to the collection side of the test cell at least 15 minutes prior to the application of the challenge chemical.

8.7.7.5.4 With the cell top cap removed, 1 µL droplets shall be placed through the agent challenge port of the test cell on the specimen's outer surface within 20 seconds, according to the procedure determined in 8.7.7.4.

8.7.7.5.5 After placing the liquid challenge chemical on the specimen in the test cell, the cell top cap shall be sealed within 5 seconds.

8.7.7.5.5.1 For testing of Class 1, Class 2, and Class 2R ensemble materials, the filtered air at a temperature of 32°C ± 1°C (90°F ± 2°F) and at a relative humidity of 80 percent ± 5 percent shall be flowed only to the collection side of the test cell at a rate of 1.0 L/min ± 0.1 L/min. No air shall be flowed across the challenge side of the test cell.

8.7.7.5.5.2 For testing of Class 3 and Class 3R ensemble materials, the filtered air at a temperature of 32°C ± 1°C (90°F ± 2°F) and at a relative humidity of 80 percent ± 5 percent shall be flowed to the challenge side of the test cell at a rate of 0.3 L/min ± 0.03 L/min and to the collection sides of the test cell at a rate of 1.0 L/min ± 0.1 L/min.

8.7.7.5.6 The challenge chemical in the effluent air stream shall be collected, measured, and analyzed using either discrete or cumulative methods for the first 15-minute +1.0/–0 minutes interval and overall for 60 minutes +1.0 /–0 minutes.

8.7.7.5.7 The collection media for the challenge chemical shall be analyzed using an appropriate analytical procedure.

8.7.7.5.8 At least one test shall be conducted with a specimen, but without the challenge chemical, as a negative control.

•

8.7.7.5.9 The results from tests accompanied by unsuccessful negative controls shall not be used and the test shall be repeated.

8.7.7.6 Procedure for Gas or Vapor Challenge Chemicals.

8.7.7.6.1 The test cell shall be mounted horizontally and connected to the air delivery system in the environmental chamber at 32°C ± 1°C (90°F ± 2°F) and at a relative humidity of 80 percent ± 5 percent. All connections shall be secured.

8.7.7.6.2 The air delivery shall be connected and flowing 1 L/min of filtered air at a temperature of 32°C ± 1°C (90°F ± 2°F) and at a relative humidity of 80 percent ± 5 percent to the collection side of the test cell at least 15 minutes prior to the initiation of any gas or vapor challenge chemical.

8.7.7.6.3 The calibrated analytical detection system shall be assembled and initiated according to its instructions.

N **8.7.7.6.3.1** If bubblers are used, each bubbler shall be filled with the proper collection solvent using a calibrated pipette or equivalent device; the collection solvent shall incorporate an internal standard so adjustments can be made for solvent evaporation/water condensation during sampling.

N **8.7.7.6.3.2** If solid sorbent tubes are to be used, each sorbent tube shall be cleaned by heating and purging; the absence of any residual chemical shall be verified by the appropriate analysis technique.

N **8.7.7.6.3.3** Sampler tubes shall be attached to the test cell immediately prior to the application of challenge chemical to avoid potentially adverse effects caused by the presence of moisture in the collection media stream.

N **8.7.7.6.3.4** At the conclusion of the specified sampling interval, sampling tubes shall be replaced in a manner that ensures permeant is not lost.

N **8.7.7.6.3.5** Permeant shall be desorbed from sampler tubes immediately following removal from the test chamber.

N **8.7.7.6.3.6** Analysis of permeant extracts shall be performed within 24 hours of extraction.

8.7.7.6.4 The initiation of the test shall occur when the gas or vapor challenge chemical is introduced into the challenge side of the test cell.

8.7.7.6.4.1 The supply of the gas or vapor challenge chemical shall be sufficient to maintain the gas or vapor challenge chemical concentration during the exposure period of 60 minutes +1.0/-0.0 minutes.

8.7.7.6.4.2 The gas or vapor challenge chemical shall be at a temperature of 32°C ± 1°C (90°F ± 2°F).

8.7.7.6.4.3 For testing of Class 1 ensemble materials, the concentration of the gas or vapor challenge chemical shall be 10,000 ppm +1,000/–0 ppm (by volume).

N **8.7.7.6.4.4** For testing of Class 2 and Class 2R ensemble materials, the concentration of the gas or vapor challenge chemical shall be 350 ppm +35/–0 ppm (by volume).

8.7.7.6.4.5 For testing of Class 3 and Class 3R ensemble materials, the concentration of the gas or vapor challenge chemical shall be 40 ppm +10/–0 ppm (by volume).

8.7.7.6.5 The challenge chemical in the effluent air stream shall be collected, measured, and analyzed using either discrete or cumulative methods for the first 15-minute +1.0/–0 minutes interval and overall for 60 minutes +1.0/–0 minutes.

8.7.7.6.6 The collection media for the challenge chemical shall be analyzed using an appropriate analytical procedure.

8.7.7.6.7 At least one test shall be conducted with the specimen, but without the challenge chemical, as a negative control.

•

8.7.7.6.8 The results from tests accompanied by unsuccessful negative controls shall not be used, and the test shall be repeated.

8.7.7.7 Test Conclusion, Test Cell Cleaned, and Specimen Disposal.

8.7.7.7.1 At the conclusion of the test, the test cell shall be purged and the air delivery and analytical system shall be shut down.

8.7.7.7.2 Each cell shall be disassembled one at a time.

8.7.7.7.3 The tested specimen shall be inspected for degradation or other obvious abnormalities; these observations shall be recorded with the test results.

8.7.7.7.4 Disposal of tested specimens and other supplies shall be handled according to local, state, federal or other applicable regulations.

8.7.7.7.5 Each component of the test cell shall be rinsed with acetone or other appropriate solvent to remove residual chemicals and allowed to air dry in a clean area.

8.7.7.7.6 Test cells shall be free of residual chemicals prior to reuse.

8.7.8 Report.

8.7.8.1 The cumulative permeation for the first 15-minute interval and overall for the 60-minute exposure shall be calculated, recorded, and reported in $\mu g/cm^2$ for each specimen for each challenge chemical.

8.7.8.1.1 If no challenge chemical is detected at the end of the 60-minute test period, then the cumulative permeation shall be recorded and reported as less than the minimum detectable mass per unit area for the specific chemical being tested.

8.7.8.2 The average cumulative permeation shall be calculated and reported by averaging the results from all specimens for each challenge chemical.

8.7.8.2.1 For the calculation of average cumulative permeation, if the results of one or more of the specimens tested is less than the minimum detectable cumulative permeation, then the minimum detectable cumulative permeation shall be used as the result for those specimens.

8.7.8.2.2 For the calculation of average cumulative permeation, if the results of all the specimens tested are less than the minimum detectable cumulative permeation, then the average cumulative permeation shall be reported as the minimum detectable cumulative permeation.

8.7.8.3* Additional Test Information to Be Reported. The following additional information shall be recorded and reported as part of the individual test report for each material-chemical pair:

(1) Material name
(2) Chemical or chemical mixture identification
(3) Sampling technique, including sorbent material
(4) Desorption technique, including extraction solvent if a sorbent tube is used
(5) Analytical instrumentation or analysis technique, including detector
(6) Method of calibration of analytical instrumentation
(7) Desorption and retention efficiency, as applicable to collection method
(8) Limit of detection of analysis technique
(9) Minimum detectable cumulative permeation mass
(10) Date of test
(11) Testing laboratory
(12) Any observations of degradation or other abnormalities at the conclusion of the testing of each specimen.

8.7.9 Interpretation. The average cumulative permeation for the first 15-minute interval and overall for the 60-minute exposure for each challenge chemical shall be used to determine pass or fail performance.

8.7.10 Specific Requirements for the CBRN Barrier Layer of Garments, Hoods, and Socks.

8.7.10.1 Samples shall be conditioned by flexing as specified in 8.1.3 and 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.

8.7.10.2 Samples shall be conditioned by abrading as specified in 8.1.4 and 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.

8.7.10.3 Preconditioning one sample to both flexing and abrading shall be permitted prior to permeation resistance testing.

8.7.11 Specific Requirements for Testing the CBRN Barrier Layer of Visors.

8.7.11.1 Samples for conditioning shall be visor materials.

8.7.12 Specific Requirements for Testing the CBRN Barrier Layer of Gloves.

8.7.12.1 Samples for conditioning shall be whole gloves.

•

8.7.13 Specific Requirements for Testing the CBRN Barrier Layer of Footwear.

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

8.7.13.2 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.

8.7.13.3 Upper samples for conditioning shall be whole footwear items.

•

8.7.13.4 Footwear upper samples shall be conditioned by abrading as specified in 8.1.4.

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

•

N **8.7.13.6** The chemical permeation test specimen shall be taken from the exact center of the abraded sample so that the center of the permeation test specimen and the center of the abraded specimen coincide.

8.7.14 Specific Requirements for Testing the CBRN Barrier Layer's Seams of Garments, Hoods, Socks, Visors, and Gloves.

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

8.7.14.2 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.

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

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

8.7.14.5 Seam specimens shall be taken from the gauntlet portion of the glove where an external seam is used in the construction of the glove.

N **8.7.15 Specific Requirements for Testing Elastomeric Interface Materials.**

N **8.7.15.1** Samples shall not be subjected to conditioning by flexing or abrasion.

N **8.7.15.2** Specimens shall be taken from elastomeric interface sheet material or formed elastomeric interface items that are representative of the elastomeric interface material nominal thickness.

8.8 Total Heat Loss Test.

8.8.1 Application.

N **8.8.1.1** This test method shall apply to the garment materials used in Class 2, Class 3, and Class 4 ensembles.

N **8.8.1.2** Modifications to this test method for Class 2 garment materials shall be as specified in 8.8.8.

8.8.2 Samples.

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

8.8.2.2 Samples shall be conditioned as specified in 8.1.2.

8.8.3 Specimens.

Δ **8.8.3.1** Specimen size shall be the size required to cover the sweating guarded hot plate.

8.8.3.2 At least three specimens shall be tested.

8.8.3.3 Specimens shall consist of all layers in the protective garment base composite arranged in the order and orientation as worn and shall not include any reinforcement materials.

8.8.4 Apparatus. The test apparatus shall be as specified in ASTM F1868, *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 F1868, *Standard Test Method for Thermal and Evaporative Resistance of Clothing Materials Using a Sweating Hot Plate*, using Part C, with the following modifications:

(1) The specimen shall be placed on the test plate with the side normally facing the human body toward the test plate.
(2) For multiple layers, the layers shall be arranged in the order and orientation as worn.
(3) Each layer shall be smoothed by hand to eliminate wrinkles or bubbles in each layer.
(4) Once the test is started, no further adjustments to the specimen shall be made.

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.

•

N **8.8.7 Interpretation.**

N **8.8.7.1** Pass or fail determination shall be based on the average reported total heat loss (Q_t) measurement of all specimens tested.

N **8.8.7.2** If an individual result from any test set varies more than ±10 percent from the average result, the results from the test set shall be discarded and another set of specimens shall be tested.

N **8.8.8 Requirements for Testing Class 2 Garment Materials.** The results for testing of Class 2 garment materials shall be for reporting purposes only. No minimum average total heat loss requirement shall apply.

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 Samples.

8.9.2.1 Samples for conditioning shall be 1 m (1 yd) squares of material.

8.9.2.2 Samples shall be conditioned as specified in 8.1.2.

8.9.3 Specimens.

8.9.3.1 Specimens shall be the size required by ASTM D751, *Standard Test Methods for Testing Coated Fabrics.*

• *N* **8.9.3.2** At least 10 specimens shall be tested.

8.9.4 Procedure. Specimens shall be tested in accordance with Section 18.2, Tensile Testing Machine with Ring Clamp, of ASTM D751, *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 hood 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 Samples.

8.10.2.1 Samples for conditioning shall be 1 m (1 yd) squares of material.

8.10.2.2 Samples shall be conditioned as specified in 8.1.2.

8.10.3 Specimens.

8.10.3.1 Specimens shall be of the size required by ASTM D2582, *Standard Test Method for Puncture Propagation Tear Resistance of Plastic Film and Thin Sheeting.*

8.10.3.2 At least five specimens in the warp, machine or course direction, and five specimens in the filling, cross-machine or wale direction, shall be tested.

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

8.10.4 Procedure. Specimens shall be tested in accordance with ASTM D2582, *Standard Test Method for Puncture Propagation Tear Resistance of Plastic Film and Thin Sheeting.*

8.10.5 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.

8.11 Cold Temperature Performance Test 1.

8.11.1 Application. This test method shall apply to garment, glove, hood materials, and elastomeric interface materials.

8.11.2 Samples.

8.11.2.1 Samples for conditioning shall be 1 m (1 yd) squares of material.

8.11.2.2 Samples shall be conditioned as specified in 8.1.2.

8.11.3 Specimens.

8.11.3.1 Specimens shall be of the size required by ASTM D747, *Standard Test Method for Apparent Bending Modulus of Plastics by Means of a Cantilever Beam.*

8.11.3.2 At least five specimens in the warp, machine or course direction, and five specimens in the filling, cross-machine or wale direction, shall be tested.

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

Δ **8.11.4 Procedure.** Specimens shall be tested in accordance with ASTM D747, *Standard Test Method for Apparent Bending Modulus of Plastics by Means of a Cantilever Beam*, with the following modifications:

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

[8.11.4]

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

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

(3) Values may be obtained for materials which are too flexible to measure with this apparatus by laminating to a stiffening material that yields a valid test value and subtracting out the stiffening materials Bending Moment when tested alone. Permitted lamination techniques include fastening of one or both ends of the specimens.

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 all types of garment and hood seams and the garment closure assembly used in the construction of the garment and hood. 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 Samples.

8.12.2.1 Samples for conditioning shall be the size required by ASTM D751, *Standard Test Methods for Testing Coated Fabrics*, and 8.12.7 or 8.12.8 as appropriate.

8.12.2.2 Samples shall be conditioned as specified in 8.1.2 and 8.12.7 or 8.12.8 as appropriate.

8.12.2.3 Samples shall be straight seams or closure assemblies cut from finished garments or shall be permitted to be prepared by joining two pieces of the garment material in the same manner as seams or closures in the finished garment are prepared.

N **8.12.2.4** Closure samples shall be permitted to be individual samples cut to the specimen width.

8.12.3 Specimens.

8.12.3.1 Specimens shall be the same as the samples specified in 8.12.2.3.

8.12.3.2 At least five specimens shall be tested for each seam and closure assembly type.

N **8.12.3.3** Closure sample specimen width shall be permitted to be 25 mm ± 6 mm (1 in. ± ¼ in.) larger than the required specimen size. The specimen edges at the closure shall be permitted to be secured by stitching or tacking.

8.12.4 Procedure. All seams and closure assemblies shall be tested in accordance with ASTM D751, *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.

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

8.12.7.2 Specimens shall be conditioned as specified in 8.1.2.

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 Visor High-Mass Impact Resistance Test.

8.13.1 Application.

N **8.13.1.1** This test method shall apply to visor materials.

N **8.13.1.2** Where the visor is constructed of several layers, all layers assembled in the order in which they appear in the suit shall be tested as a composite.

8.13.2 Samples.

Δ **8.13.2.1** Samples shall be at least 305 mm (12 in.) squares of visor material.

8.13.2.2 Samples shall be conditioned as specified in 8.1.2.

8.13.3 Specimens.

8.13.3.1 Specimens shall be 450 mm × 305 mm (17.72 in. × 12 in.).

8.13.3.2 At least five specimens shall be tested.

8.13.4 Procedure. Specimens shall be tested in accordance with Section 9.11 of ANSI/ISEA Z87.1, *American National Standard for Occupational and Educational Personal Eye and Face Protective Devices*, with the following modifications:

(1) Visor material shall be securely mounted to the test fixture as shown in Figure 8.26.4.1.
(2) The sample number shall be indicated.
(3) The impact location shall be in the center apex of the visor between the frame members.
(4) Testing shall be performed on samples conditioned for a minimum of 4 hours at –25°C (–13°F).
(5) Testing shall commence between 60 seconds and 90 seconds.
(6) The sample shall not be allowed to move more than 6 mm (0.25 in.).

•

Δ **8.13.5 Report.** Visible penetration or full-thickness cracks shall be recorded and reported.

8.13.6 Interpretation. Penetration or full-thickness cracking on any specimen shall constitute failing performance.

•

8.14 Cut Resistance Test.

8.14.1 Application.

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

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.

N **8.14.1.4** Modifications to this test method for testing elastomeric interface materials shall be as specified in 8.14.9.

8.14.2 Samples.

8.14.2.1 Samples for conditioning shall be whole gloves, whole footwear, or interface gaskets.

8.14.2.2 Samples shall be conditioned as specified in 8.1.2.

8.14.3 Specimens.

Δ **8.14.3.1** Specimens shall be the size required by ASTM F1790, *Test Methods for Measuring Cut Resistance of Materials Used in Protective Clothing*.

8.14.3.2 At least three specimens shall be tested.

8.14.3.3 Specimens shall be as specified in 8.14.7 or 8.14.8 as appropriate and shall consist of all layers.

Δ **8.14.4 Procedure.** Specimens shall be evaluated in accordance with ASTM F1790, *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 1, Class 2, Class 3R, and Class 4R glove specimens shall be tested at a load of 150 g (5½ oz).

8.14.7.3 Class 3 and Class 4 glove specimens shall be tested at a load of 75 g (2½ 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 1, Class 2, Class 3R, and Class 4R footwear upper specimens shall be tested at a load of 550 g (19½ oz).

8.14.8.3 Class 3 and Class 4 footwear upper specimens shall be tested at a load of 350 g (12½ oz).

N **8.14.9 Specific Requirements for Testing Elastomeric Interface Materials.**

N **8.14.9.1** Specimens shall be taken from elastomeric interface sheet material or formed elastomeric interface items that are representative of the elastomeric interface material nominal thickness.

N **8.14.9.2** Cut resistance testing shall be performed under a load of 50 g (1.75 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.

N **8.15.1.4** Modifications to this test method for testing elastomeric interface materials shall be as specified in 8.15.9.

8.15.2 Samples.

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

8.15.2.2 Samples shall be conditioned as specified in 8.1.2.

8.15.3 Specimens.

8.15.3.1 Specimens shall be at least 150 mm (6 in.) square.

8.15.3.2 At least three specimens shall be tested.

8.15.3.3 Specimens shall be as specified in 8.15.7 or 8.15.8 as appropriate and shall consist of all layers.

8.15.4 Procedure. Specimens shall be tested in accordance with ASTM F1342, *Standard Test Method for Resistance of Protective Clothing Materials to Puncture,* using Method A.

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.

N **8.15.9 Specific Requirements for Testing Elastomeric Interface Materials.** Specimens shall be taken from elastomeric interface sheet material or formed elastomeric interface items that are representative of the elastomeric interface material nominal thickness.

8.16 Glove Hand Function Test.

8.16.1 Application. This test shall apply to gloves.

8.16.2 Samples.

8.16.2.1 Samples for conditioning shall be whole glove pairs.

8.16.2.2 Samples shall be conditioned as specified in 8.1.2.

8.16.3 Specimens.

8.16.3.1 Specimens shall be whole glove pairs, size small and large.

8.16.3.2 At least three specimens size small and three specimens size large shall be tested.

8.16.3.3 Specimens shall be tested as a complete set in new, as distributed, condition.

8.16.3.4 Specimens shall not receive special softening treatments prior to testing.

8.16.4 Apparatus. The apparatus shall be as specified in ASTM F2010/F2010M, *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 F2010, *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 bare-handed control shall be recorded and reported for each test subject.

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

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

8.17 Abrasion Resistance Test 1.

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

8.17.2 Samples.

8.17.2.1 Samples for conditioning shall be uniform cylinders of footwear soles and heel material.

8.17.2.2 Samples shall be conditioned as specified in 8.1.2.

8.17.3 Specimens. At least three specimens shall be tested.

•

8.17.4 Procedure. Abrasion resistance shall be performed in accordance with ISO 4649, *Rubber, vulcanized or thermoplastic — Determination of abrasion resistance using a rotating cylindrical device*, Method A, with a vertical force of 10 N over the abrasion distance of 40 m.

8.17.5 Report. The relative volume loss 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 Slip Resistance Test.

8.18.1 Application. This test method shall apply to footwear.

8.18.2 Samples.

8.18.2.1 Samples for conditioning shall be complete footwear in men's size 9D medium width.

8.18.2.2 Samples shall be conditioned as specified in ISO 13287, *Personal Protective Equipment — Footwear — Test Method for Slip Resistance*.

8.18.3 Specimens.

8.18.3.1 Specimens shall be complete footwear soles of the size required by ISO 13287, *Personal Protective Equipment — Footwear — Test Method for Slip Resistance*.

8.18.3.2 At least three specimens in men's size 9D, medium width shall be tested.

8.18.4 Procedure. Slip resistance shall be performed in accordance with ISO 13287, *Personal protective equipment — Footwear — Test method for slip resistance*, in the following configurations. References to any other flooring and/or contaminant within ISO 13287 shall not apply.

(1) Footwear shall be tested both in the forepart and heel positions.
(2) Footwear shall be tested in the wet condition, which shall be achieved using distilled or deionized water. The water shall be applied to thoroughly wet the testing surface and make a pool at least as wide and long as the test portion of the footwear in the area of initial contact.
(3) Footwear shall be tested on a quarry tile surface that meets the following specifications:
   (a) Is flat, unglazed clay quarry tile, wider than the test specimen and long enough to allow a sliding distance of at least 75 mm without crossing a joint
   (b) Is sufficiently flat to allow it to be secured on the mounting table such that no movement occurs between the tile and mounting table during the test
   (c) Has a ribbed profile or directional marking on the underside to identify the direction in which the tile should be aligned (with the ribs parallel to the sliding direction)
   (d) Conforms to the values specified in Table 8.18.4 when calibrated by the Slider 96 method
(4)* Calibration of the tiles shall be checked after every 10 tests or prior to each day of testing, whichever is the less frequent, to ensure that they are not being worn smooth or otherwise damaged.

8.18.5 Report.

8.18.5.1 The coefficient of each specimen shall be recorded and reported.

8.18.5.2 The average coefficient of all specimens for each configuration shall be calculated, recorded, and reported.

8.18.6 Interpretation. The average coefficient for each configuration shall be used to determine pass/fail performance.

8.19 Evaporative Resistance Test.

8.19.1 Application.

N **8.19.1.1** This test method shall apply to the garment materials used in Class 2, Class 2R, Class 3, Class 3R, Class 4, and Class 4R ensembles.

N **8.19.1.2** Modifications to this test method for Class 2 and Class 2R garment materials shall be as specified in 8.19.8.

8.19.2 Samples.

8.19.2.1 Samples shall be conditioned at a temperature of 25°C ± 7°C (77°F ± 13°F) and a relative humidity of 65 percent ± 5 percent, for at least 4 hours.

N **8.19.2.2** The minimum sample size shall be 51 cm × 51 cm (20 in. × 20 in.).

•

8.19.3 Specimens.

8.19.3.1 Specimen size shall be the size required to cover the sweating guarded hot plate.

8.19.3.2 Evaporative resistance testing shall be conducted on at least three specimens.

8.19.3.3 Specimens shall consist of all layers in the protective garment composite, arranged in the order and orientation as worn, and shall not include any reinforcement materials.

8.19.4 Apparatus.

N **8.19.4.1** The test apparatus shall be as specified in ISO 11092, *Textiles — Physiological effects — Measurement of thermal and water-*

Table 8.18.4 Calibration Values for Quarry Tiles

	Dry CoF	Wet CoF
Minimum	0.57	0.43
Maximum	0.63	0.49

vapour resistance under steady-state conditions (sweating guarded-hotplate test).

N 8.19.4.2 The dimensions for the sweating guarded hot plate shall be a 25.4 cm (10 in.) test plate with a 12.7 cm (5 in.) guard surrounding the test plate.

N 8.19.5 Procedure. Testing shall be conducted in accordance with ISO 11092, *Textiles — Physiological effects — Measurements of thermal and water-vapour resistance under steady-state conditions (sweating guarded-hotplate test)*, with the following modifications:

(1) The specimen shall be placed on the test plate with the side normally facing the human body toward the test plate.
(2) For multiple layers, the layers shall be arranged in the order and orientation as worn.
(3) Each layer shall be smoothed by hand to eliminate wrinkles or bubbles in each layer and, if necessary, secure the edges.
(4) Once the test is started, no further adjustments to the specimen shall be made.

8.19.6 Report.

N 8.19.6.1 The total evaporative resistance (R_{ef}) of each sample shall be recorded and reported.

N 8.19.6.2 The average total evaporative resistance (R_{ef}) of all tested samples shall be recorded and reported.

8.19.7 Interpretation.

N 8.19.7.1 Pass or fail determination shall be based on the average reported total evaporative resistance (R_{et}) measurement of all specimens tested.

N 8.19.7.2 If an individual result from any test set varies more than ±10 percent from the average result, the results from the test set shall be discarded and another set of specimens shall be tested.

N 8.19.8 Requirements for Testing Class 2 and Class 2R Garment Materials. The results for testing of Class 2 and Class 2R garment materials shall be for reporting purposes only. No minimum evaporative resistance requirement shall apply.

8.20 Viral Penetration Resistance Test.

8.20.1 Application.

8.20.1.1 This test shall apply to Class 1, Class 2, Class 2R, Class 3, Class 3R, Class 4, and Class 4R garments, gloves, and footwear materials; garment and glove seams; and visors.

8.20.1.2 Modifications to this test method for testing garment materials after flexing and abrasion shall be as specified in 8.20.7.

8.20.1.3 Modifications to this test method for testing visor or facepiece materials shall be as specified in 8.20.8.

Δ 8.20.1.4 Modifications to this test method for testing glove materials shall be as specified in 8.20.9.

Δ 8.20.1.5 Modifications to this test method for testing footwear materials after abrasion shall be as specified in 8.20.10.

8.20.1.6 Modifications to this test method for testing garment and glove seams shall be as specified in 8.20.11.

8.20.2 Samples.

8.20.2.1 Samples shall be as specified in 8.20.7 through 8.20.11 as appropriate.

8.20.2.2 Samples shall be conditioned as specified in 8.20.7 through 8.20.11 as appropriate and then as specified in 8.1.2.

8.20.3 Specimens.

8.20.3.1 Specimens shall be 75 mm (3 in.) squares.

8.20.3.2 At least three specimens shall be tested for each material type.

8.20.4 Procedure.

8.20.4.1 Biopenetration resistance testing shall be conducted in accordance with ASTM F1671, *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.

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

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

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

8.20.7 Specific Requirements for Testing Garment Materials.

8.20.7.1 Samples shall be conditioned by flexing as specified in 8.1.3. Samples shall be 200 mm × 280 mm (8 in. × 11 in.). Following flexing, one specimen shall be taken from the center of each sample subjected to flexing for viral penetration testing.

8.20.7.2 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.

8.20.7.3 Preconditioning one sample to both flexing and abrading shall be permitted prior to viral penetration testing.

8.20.8 Specific Requirements for Testing Visor or Facepiece Materials.

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

8.20.8.2 Where the ensemble utilizes the respirator facepiece as the ensemble visor as specified in 6.1.7, 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.

8.20.8.3 The specimen shall also include the respirator where applicable.

8.20.9 Specific Requirements for Testing Glove Materials. Samples for conditioning shall be whole gloves.

•

8.20.10 Specific Requirements for Testing Footwear Materials After Abrading.

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

8.20.10.2 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.

8.20.10.3 Upper samples for conditioning shall be whole footwear items.

8.20.10.4 Upper samples shall be as specified in Figure 8.1.4.

•

Δ **8.20.10.5** The upper samples that were taken per 8.20.10.4 shall then be conditioned by abrading as specified in 8.1.4.

8.20.10.6 Following abrasion, only one test specimen for viral penetration resistance testing shall be taken from each sample subjected to abrasion.

8.20.10.7 The chemical permeation test specimen shall be taken from the exact center of the abraded sample so that the center of the penetration test specimen and the center of the abraded specimen coincide.

8.20.11 Specific Requirements for Testing Garment or Glove Seams.

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

8.20.11.2 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.

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

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

N **8.20.12 Specific Requirements for Testing Elastomeric Interface Materials.**

N **8.20.12.1** Samples shall not be subjected to conditioning by flexing or abrasion.

N **8.20.12.2** Specimens shall be taken from elastomeric interface sheet material or formed elastomeric interface items that are representative of the elastomeric interface material nominal thickness.

8.21 Liquidtight Integrity Test 2.

8.21.1 Application.

8.21.1.1 This test method shall apply to Class 1, Class 2, Class 2R, Class 3, Class 3R, Class 4, and Class 4R gloves and footwear.

8.21.1.2 Modifications to this test method for testing gloves shall be as specified in 8.21.7.

8.21.1.3 Modifications to this test method for testing footwear shall be as specified in 8.21.8.

8.21.2 Samples.

8.21.2.1 Samples for conditioning shall be whole glove or footwear elements.

8.21.2.2 Samples shall be conditioned as specified in 8.21.7 or 8.21.8 as appropriate and then as specified in 8.1.2.

8.21.3 Specimens.

8.21.3.1 Specimens shall consist of the whole glove or footwear elements with all layers assembled that are required for the element to be compliant.

8.21.3.2 At least ten glove specimens shall be tested or at least three footwear specimens shall be tested as appropriate.

8.21.4 Procedure. Liquidtight integrity testing of gloves and footwear shall be conducted in accordance with ASTM D5151, *Standard Test Method for Detection of Holes in Medical Gloves*, with the following modifications:

(1) The surface tension of the water used in testing shall be 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.
(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.

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

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

8.21.7 Specific Requirements for Testing Gloves.

8.21.7.1 Specimens shall be conditioned as specified in 8.1.5.

8.21.7.2 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.

8.21.8 Specific Requirements for Testing Footwear.

8.21.8.1 Specimens shall be conditioned as specified in 8.1.6.

8.21.8.2 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.

8.22 Abrasion Resistance Test 2.

8.22.1 Application. This test method shall apply to footwear covers where the barrier layer is configured as an exterior layer.

8.22.2 Samples.

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

8.22.2.2 Samples shall be conditioned as specified in 8.1.3.

8.22.3 Specimens.

8.22.3.1 Specimens shall be the size specified in ASTM D3884, *Standard Guide for Abrasion Resistance of Textile Fabrics (Rotary Platform, Double-Head Method)*.

8.22.3.2 A minimum of five specimens shall be tested.

8.22.4 Procedure. Specimens shall be tested in accordance with ASTM D3884, *Standard Guide for Abrasion Resistance of Textile Fabrics (Rotary Platform, Double-Head Method)*, with the following 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.

8.22.5 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.

8.22.6 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.

8.23 Exhaust Valve Mounting Strength Test.

8.23.1 Application. This test method shall apply to exhaust valves mounted in Class 1, Class 2, Class 2R, Class 3, Class 3R, Class 4, and Class 4R ensembles.

8.23.2 Samples.

8.23.2.1 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.

8.23.2.2 Samples shall be conditioned as specified in 8.1.2.

8.23.3 Specimens.

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

8.23.3.2 At least three specimens shall be tested.

8.23.4 Apparatus.

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

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

8.23.4.1.2 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.

8.23.4.1.3 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.

8.23.4.2 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.

8.23.4.3 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.

8.23.5 Procedure.

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

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

8.23.5.3 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.

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

8.23.6 Report.

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

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

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

8.24 Exhaust Valve Inward Leakage Test.

8.24.1 Application. This test method shall apply to exhaust valves used in Class 1, Class 2, Class 2R, Class 3, Class 3R, Class 4, and Class 4R ensembles.

8.24.2 Samples.

8.24.2.1 Samples shall be individual exhaust valves including mounting means.

8.24.2.2 Samples shall be conditioned as specified in 8.1.8.

8.24.3 Specimens.

8.24.3.1 Specimens shall be individual exhaust valves including mounting means.

8.24.3.2 At least ten specimens shall be tested.

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

8.24.4 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).
(5) The testing shall be carried out in an environment controlled to 21°C ± 3°C (70°F ± 5°F) and a relative humidity of 80 percent ± 5 percent.

8.24.5 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.

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

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

***N* 8.25 Gastight Integrity Test.**

***N* 8.25.1 Application.** This test method shall apply to Class 1 ensembles.

***N* 8.25.2 Sample Preparation.**

***N* 8.25.2.1** Samples shall be complete Class 1 ensemble.

***N* 8.25.2.2** Samples shall be conditioned as specified in 8.1.2.

***N* 8.25.3 Specimens.**

***N* 8.25.3.1** Specimens shall be complete Class 1 ensembles.

***N* 8.25.3.2** At least three specimens shall be tested.

***N* 8.25.3.3** Where the ensemble consists of multiple separate layers, and outer layers are not considered gastight, then only the portion of the Class 1 ensemble that is considered gastight shall be tested.

***N* 8.25.4 Procedure.**

***N* 8.25.4.1** Specimens shall be tested in accordance with ASTM F1052, *Standard Test Method for Pressure Testing of Vapor-Protective Ensembles.*

***N* 8.25.4.2** The following pressures shall be used during testing:

(1) Pre-test expansion pressure of 125 mm (5 in.) water gauge
(2) Test pressure of 100 mm (4 in.) water gauge

***N* 8.25.4.3** Where the ensemble is nonencapsulating, devices or plugs described in ASTM F1052, *Standard Test Method for Pressure Testing of Vapor-Protective Ensembles*, shall be used to seal off open areas, such as the opening of a hood for a respirator facepiece.

***N* 8.25.5 Report.** The ending pressure shall be recorded and reported for each specimen.

***N* 8.25.6 Interpretation.**

***N* 8.25.6.1** The pressure upon completion of the inflation test shall be used to determine pass or fail performance.

***N* 8.25.6.2** Any one specimen failing the test shall constitute failure of the test.

***N* 8.26 Maximum Ensemble Ventilation Rate Test.**

***N* 8.26.1 Application.** This test method shall apply to encapsulating Class 1 ensembles.

***N* 8.26.2 Sample Preparation.**

***N* 8.26.2.1** Samples shall be complete Class 1 ensembles.

***N* 8.26.2.2** Samples shall be conditioned as specified in 8.1.2.

***N* 8.26.3 Specimens.**

***N* 8.26.3.1** Specimens shall be complete Class 1 ensembles.

***N* 8.26.3.2** At least three specimens shall be tested.

***N* 8.26.3.3** The test specimen shall include all outer wear and other items required for the Class 1 ensemble to be compliant with this standard.

***N* 8.26.4 Apparatus.**

***N* 8.26.4.1 Configuration of Whole Suit Maximum Airflow Test.** A suit wall connector capable of accommodating the attachment of an airline hose from a pressurized air source shall be installed in the back mid-torso region of the Class 1 ensemble to be tested as indicated in Figure 8.26.4.1. The connector and airline hose shall allow an airflow rate of 500 L/min. The connector used in this test shall be permitted to be a standard airline connection that is used with airline respiratory equipment.

***N* 8.26.4.2** A flowmeter capable of measuring airflow rates of 0 to 1000 L/min ±25 L/min, calibrated for air and the conditions of use, shall be used on the airline hose.

***N* 8.26.4.3** A pressure gauge capable of measuring pressures from 0 to 510 mm, ±3 mm (0 to 20 in., ±⅛ in.) water column gauge pressure shall be attached via a second suit wall connector at the very top of the Class 1 ensemble.

***N* 8.26.5 Procedure.**

***N* 8.26.5.1** Following the attachment of the two connectors, the gastight integrity of the ensemble shall be tested as specified in Section 8.25.

***N* 8.26.5.2** During the test, the pressure gauge specified in 8.26.5.3 shall be attached to one bulkhead connector; the other bulkhead connector shall be plugged.

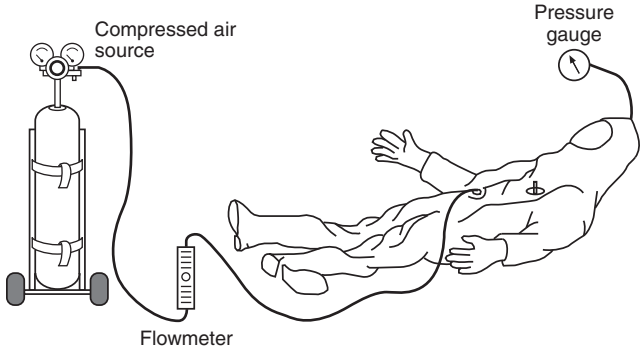


FIGURE 8.26.4.1 Configuration of Whole Suit Maximum Airflow Test.

N **8.26.5.2.1** During the test, a soapy water solution shall be applied around the edges of the connectors to ensure that no leakage occurs through the installed suit wall connectors.

N **8.26.5.2.2** The remaining steps of this procedure shall be completed only if the sample suit shows an ending pressure of 80 mm ($^{33}/_{16}$ in.) water column gauge or higher.

N **8.26.5.3** The suit shall be connected to a pressurized air source capable of providing 500 L/min by attaching an airline to the installed mid-torso suit wall connector.

N **8.26.5.4** Beginning at time zero, air shall be flowed into the suit at a rate of 500 L/min.

N **8.26.5.5** After a period of 5 minutes, the pressure at the head connector shall be measured.

N **8.26.5.6** The specialized fittings installed in the suit for this test shall be plugged to prevent air leakage and the suit shall be subjected to a second overall gastight integrity test as specified in Section 8.25.

N **8.26.6 Report.**

N **8.26.6.1** The maximum internal ensemble pressure during the airflow period shall be recorded and reported.

N **8.26.6.2** The ending ensemble pressure for the gastight integrity tests before and after the airflow period shall be recorded and reported.

N **8.26.7 Interpretation.**

N **8.26.7.1** The maximum internal ensemble pressure shall be used to determine pass or fail performance.

N **8.26.7.2** The ending pressure after ensemble inflation testing subsequent to the maximum ensemble ventilation test shall be used to determine compliance.

N **8.27 Flammability Resistance Test.**

N **8.27.1 Application.**

N **8.27.1.1** This test method shall be applied to the baseline performance of Class 1 ensemble materials and the optional flash fire protection performance of all ensemble materials.

N **8.27.1.2** Modifications to the test method for base Class 1 ensemble material performance shall be as specified in 8.27.7.

N **8.27.1.3** Modifications to the test method for optional flash fire protection performance for Class 1, Class 2, and Class 2R ensemble materials shall be as specified in 8.27.8.

N **8.27.2 Sample Preparation.**

N **8.27.2.1** Samples for conditioning shall be at least 1 m (1 yd) squares of material.

N **8.27.2.2** Samples shall be conditioned as specified in 8.1.2.

N **8.27.3 Specimens.**

N **8.27.3.1** Specimens shall be the size specified in ASTM F1358, *Standard Test Method for Effects of Flame Impingement on Materials Used in Protective Clothing not Designated Primarily for Flame Resistance.*

N **8.27.3.2** Five specimens in each of the warp directions, machine or coarse, and the filling directions, cross-machine or wale, shall be tested.

N **8.27.3.3** Where the material is isotropic, 10 specimens shall be tested.

N **8.27.4 Procedure.**

N **8.27.4.1** Flame resistance testing shall be conducted in accordance with ASTM F1358, *Standard Test Method for Effects of Flame Impingement on Materials Used in Protective Clothing not Designated Primarily for Flame Resistance.*

N **8.27.4.2** Specimens shall be observed for the combination of both melting and dripping.

N **8.27.5 Report.**

N **8.27.5.1** Afterflame times shall be recorded and reported for each specimen and as the average for each material direction.

N **8.27.5.2** Burn distances shall be recorded and reported for each specimen and as the average for each material direction.

N **8.27.5.3** Ignition during the initial 3-second exposure shall be recorded and reported for each specimen.

N **8.27.5.4** Evidence of both melting and dripping during either the 3-second or the 12-second exposure period shall be recorded and reported for each specimen.

N **8.27.6 Interpretation.**

N **8.27.6.1** Ignition of any individual specimen during the initial 3-second exposure shall be used to determine compliance with the ignition requirements.

N **8.27.6.2** The average afterflame time in any direction shall be used to determine compliance with the afterflame requirements.

N **8.27.6.3** The average burn distance in any direction shall be used to determine compliance with burn distance requirements.

N **8.27.6.4** Evidence of both melting and dripping of any specimen shall be used to determine compliance with melting and dripping requirements.

N **8.27.7 Specific Requirements for Testing Base Class 1 Ensemble Materials.**

N **8.27.7.1** Only the 3-second flame exposure shall be used.

N **8.27.7.2** Burn distances and afterflame times shall be determined only for the 3-second exposure.

N **8.27.8 Specific Requirements for Testing Optional Chemical Flash Fire Protection Ensemble Materials.**

N **8.27.8.1** Only the 12-second flame exposure shall be used.

N **8.27.8.2** Burn distances and afterflame times shall only be determined for the 12-second exposure.

N **8.28 Ultimate Tensile Strength Test.**

N **8.28.1 Application.** This method shall apply to elastomeric interface materials.

N **8.28.2 Samples.**

N **8.28.2.1** Samples for conditioning shall be sufficiently sized pieces of elastomeric interface sheet material or individual formed elastomeric interface material items.

N **8.28.2.2** Samples shall be conditioned as specified in 8.1.2.