NFPA®

1991

Standard on Vapor-Protective Ensembles for Hazardous Materials Emergencies and CBRN Terrorism Incidents

2016

IMPORTANT NOTICES AND DISCLAIMERS CONCERNING NFPA® DOCUMENTS

NOTICE AND DISCLAIMER OF LIABILITY CONCERNING THE USE OF NFPA DOCUMENTS

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.

REMINDER: UPDATING OF NFPA STANDARDS

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 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 Amendment and any Errata then in effect.

In order to determine whether an NFPA Standard has been amended through the issuance of Tentative Interim Amendments or corrected by Errata, visit the Document Information Pages on NFPA's website. The Document Information Pages provide up-to-date, document specific information including any issued Tentative Interim Amendments and Errata.

To access the Document Information Page for a specific NFPA Standard, go to http://www.nfpa.org/docinfo to choose from the list of NFPA Standards or use the search feature on the right to select the NFPA Standard number (e.g., NFPA 101). The Document Information page includes postings of all existing Tentative Interim Amendments 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: 978-145591316-9 (Print)
ISBN: 978-145591343-5 (PDF)

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/freeaccess.

NFPA®1991

Standard on

Vapor-Protective Ensembles for Hazardous Materials Emergencies and CBRN Terrorism Incidents

2016 Edition

This edition of NFPA 1991, *Standard on Vapor-Protective Ensembles for 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 November 14, 2015, with an effective date of December 4, 2015, and supersedes all previous editions.

This edition of NFPA 1991 was approved as an American National Standard on December 4, 2015.

Origin and Development of NFPA 1991

In 1985, the National Transportation Safety Board (NTSB) issued Report I-004-5 on a hazardous material incident that occurred in Benicia, California. In that report, the NTSB recommended that standards be developed for protective clothing for protection from hazardous chemicals. The U.S. Department of Transportation (DOT) issued a position that requested private sector standards development to undertake the project of writing the standards on hazardous chemical protective clothing and asked other governmental agencies to assist and participate in the private sector standards development system. DOT time also directly requested that the NFPA develop documents on hazardous chemical protective clothing. The Environmental Protection Agency (EPA), the U.S. Coast Guard (USCG), the Federal Emergency Management Agency (FEMA), and the Occupational Safety and Health Administration (OSHA) either adopted position statements modeled after the DOT position or endorsed the DOT position.

During 1985, the NFPA Standards Council approved a project for development of those standards and assigned the project to the Technical Committee on Fire Service Protective Clothing and Equipment. The Technical Committee established a standing Subcommittee on Hazardous Chemicals Protective Clothing, which began work in Phoenix, Arizona, in March 1986. Representatives from the USCG, FEMA, and OSHA participated on the subcommittee.

At the same time, the American Society for Testing and Materials (now ASTM International) was developing a document on a selection of chemicals for evaluating protective clothing materials that would serve as one of several ASTM testing criteria that would be referenced in the NFPA standards.

The subcommittee met several times over a 2½-year period at different locations across the country and developed two standards, one for vapor-protection and one for liquid-splash protection. NFPA 1991 addresses vapor-protective ensembles designed to protect emergency response personnel against exposure to specified chemicals in vapor and liquid-splash environments during hazardous materials emergencies. Chemical permeation resistance documentation is required for primary suit materials (garment, visor, gloves, and boots) against each chemical in the NFPA battery of chemicals and any additional chemicals or specific chemical mixtures for which the manufacturer is certifying the suit. The NFPA battery of chemicals consists of 21 chemicals, as specified in ASTM F1001, *Standard Guide for Selection of Chemicals to Evaluate Protective Clothing Materials*. These chemicals were selected because they are representative of the classes of chemicals that are encountered during hazardous chemical emergencies.

NFPA 1991 includes performance requirements that were established to reflect simulated use conditions. A suit pressurization test is used to check the airtight integrity of each protective suit. Also, an overall suit water penetration test is designed to ensure the suit provides full body protection against liquid splashes. Primary suit materials must resist permeation for 1 hour or more by each chemical in the NFPA battery. Manufacturers can certify protective suits for additional chemicals if

the same permeation performance is met. Also included are penetration resistance testing of closures and leak and cracking pressure tests for exhaust valves.

These tests allow determination of adequate suit component performance in hazardous chemical environments.

Material testing for burst strength, tear strength, abrasion resistance, flammability resistance, cold temperature performance, and flexural fatigue are required so that materials used for vapor-protective suits will afford adequate protection in the environment in which they will be used.

The first edition of NFPA 1991 was voted on by the Association at the 1989 Fall Meeting in Seattle, Washington, on November 15, 1989, and had an effective date of February 5, 1990.

The Subcommittee on Hazardous Chemicals Protective Clothing began an early revision (4-year cycle) of the 1990 edition of NFPA 1991 in December 1991. During 1993, the NFPA restructured the manner in which committees were organized, and all standing subcommittees were eliminated. Within the Technical Committee on Fire Service Protective Clothing and Equipment, the former standing subcommittees were reorganized as task groups to address specific technical issues, and the technical committee assumed the entire responsibility for NFPA 1991.

The second edition of NFPA 1991 encompassed revised scope and purpose sections to include optional components for enhanced protection and replacement items. Test methods were updated and refined to better ensure repeatability of testing results. Extensive changes were made to the product labels to better accommodate the optional and replacement items.

The second edition was acted on by the membership of the Association at the NFPA Annual Meeting in San Francisco, California, on May 18, 1994, and was issued with an effective date of August 5, 1994.

In January 1995, the entire project for fire service protective clothing and equipment was reorganized by the Standards Council. The new project has a Technical Correlating Committee on Fire and Emergency Services Protective Clothing and Equipment and seven technical committees operating within the project. The former standing Subcommittee on Hazardous Chemicals Protective Clothing was established as the new Technical Committee on Hazardous Materials Protective Clothing and Equipment and has the responsibility for NFPA 1991.

The third edition, with the new title of *Standard on Vapor-Protective Ensembles for Hazardous Materials Emergencies*, represented a complete revision of the second edition and addressed the protection as an ensemble rather than as separate items, but it did provide for replacement elements for gloves and footwear. The third edition was presented to the Association membership at the 1999 November Meeting in New Orleans, Louisiana, on November 17, 1999, and was issued by the Standards Council with an effective date of February 11, 2000.

The 2005 edition (the fourth edition) was a complete revision of NFPA 1991 and was reformatted according to the new style for all NFPA codes and standards. As a result, chapter titles and numbering, as well as paragraph numbering, were changed. While the 2005 edition's content was in a different order than in previous editions, all the material remained. The Committee included in Chapter 4 new requirements for manufacturers' quality assurance programs, and for situations in which hazards involving compliant products are believed to exist, including the appropriate actions in addressing those situations if there is a previously unknown threat to the users. These new requirements apply to all fire and emergency services product standards that are the responsibility of this Project. The formerly optional requirements for protection from chemical and biological terrorism agents are no longer optional and were incorporated into the base requirements for all vapor-protective ensembles. The change provided this additional protection from CBR(N) exposures for the hazardous materials protective ensemble that offers the highest level of protection for emergency responders: the vapor-protective ensemble.

The other two optional requirements, chemical flash fire protection for escape only and liquefied gas protection, remained as optional features that purchasers can specify in purchase specifications. All labeling, design, performance, and testing requirements were reviewed and refined as necessary.

The Technical Committee finished its work on the fifth edition of NFPA 1991 with a complete revision in 2015. A relatively long interval between the fourth and fifth editions occurred due to the Technical Committee's attempts to investigate and transition the permeation resistance requirements for ensemble materials (suit, visor, gloves, footwear, and seams) to a new test method in which the cumulative permeation mass replaced the use of breakthrough time as the basis of acceptable material performance. Cumulative permeation mass is the total amount of chemical that permeates through the chemical in 1 hour. In contrast, breakthrough time was defined as the elapsed time that occurs before the rate of permeation through the material is equal to 0.1 $\mu m/cm^2 \cdot min$. The Technical Committee adopted material permeation resistance criteria on the basis of cumulative permeation mass because this measurement was considered to be more repeatable and meaningful in terms of end user exposure. Extensive research supported this change. The Technical Committee further identified a number of other priorities for modification of NFPA 1991 through a comprehensive survey to industry end users to either improve current criteria or address unmet needs. Other changes in the 2016 edition include the following:

(1) A title change to include CBRN terrorism incidents, based on the transfer of Class 1 requirements from NFPA 2001 and the reorganization of NFPA 1994.

(2) A mandatory requirement for encapsulation of the wearers and their breathing apparatus has been affirmed based on the anticipation of non-encapsulating requirements being included as new set of Class 1 criteria in NFPA 1994.
(3) Overcovers and detachable visor materials are no longer permitted for achieving certification for base ensemble criteria.
(4) Tape is prohibited from being used to secure or seam components of the ensemble.
(5) Protective covers are required to protect the suit closure.
(6) A vapor inward leakage test using sulfur hexafluoride has been replaced with the Man-in-Simulant Test (MIST) performed at a higher concentration.
(7) Some changes have been made in the chemical battery, with acrolein and acrylonitrile replacing cyanogen chloride, hydrogen cyanide, and phosgene as more relevant skin toxic chemicals; more persistent chemical warfare agent Soman (GD) has replaced Sarin (GB).
(8) An impact resistance requirement for the visor has replaced burst and puncture/tear testing of visor materials.
(9) A field of vision assessment has been added to the evaluation of the ensemble.
(10) A maximum time has been set for individual wearers to be able to remove and reinsert their hands into the ensemble glove system.
(11) Improvements have been made to the flame resistance test and its interpretation.
(12) Several test methods for glove and footwear test methods and criteria have been updated.
(13) Modifications have been made to increase the repeatability of the flash fire test.
(14) The shelf life of the ensemble is required to be reported.

Correlating Committee on Fire and Emergency Services Protective Clothing and Equipment

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

Eric J. Beck, *Secretary*
Mine Safety Appliances Company, PA [M]
Rep. Compressed Gas Association

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

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]

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

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

Beverly F. Gulledge, Tyco/Scott Safety, NC [M]

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

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

Thomas M. Hosea, US 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]

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

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

Anthony D. Putorti, Jr., National Institute of Standards & Technology, MD [RT]

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

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

Alternates

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

Brandi L. Chestang, U.S. Department of the Navy, FL [RT]
(Alt. to Thomas M. Hosea)

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, CA [M]
(Alt. to Beverly F. Gulledge)

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, US Department of Agriculture, MT [E]
(Alt. to David V. Haston)

Stephen R. Sanders, 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)

Craig Weinschenk, National Institute of Standards & Technology, MD [RT]
(Alt. to Daniel Madrzykowski)

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, US Department of Defense, VA [E]
Rep. TC on Hazardous Materials PC&E

Tricia L. Hock, 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, CA [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*
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]
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]
Bruce S. Kelly, Fairfield County Hazardous Incident Response Team, OR [C]
Michael P. Kienzle, W. L. Gore & Associates, Inc., MD [M]
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]
Louis V. Ott, Gentex Corporation, PA [M]
Rep. International Safety Equipment Association
Paul G. Rogers, Fire Department City of New York, NY [U]
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)
John Berna, Fire Department City of New York, NY [U]
(Alt. to Paul G. Rogers)
D. Mark Bledsoe, U.S. Federal Bureau of Investigations, VA [U]
(Alt. to Brian J. Clifford)
Ted J. Cooper, U.S. Department of the Navy, FL [RT]
(Alt. to A. Ira Harkness)
William A. Fithian, Safety Equipment Institute (SEI), VA [RT]
(Alt. to Patricia A. Gleason)
Elaina Franks, Kappler, Inc., AL [M]
(Alt. to Philip C. Mann)
Pamela A. Kavalesky, Intertek Testing Services, NY [RT]
(Alt. to Jason L. Allen)
Beth C. Lancaster, U.S. Department of Defense, VA [E]
(Voting Alt. to U.S. DOD Rep.)
Brian Lyons, International Enviroguard, TX [M]
(Alt. to Louis V. Ott)
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)
Richard C. Shoaf, St. Charles Fire Department, MO [U]
(Alt. to Richard P. Daly, Jr.)
William M. Starrett, Rossville, TN [L]
(Voting Alt. to IAFF Rep.)
Grace G. Stull, International Personnel Protection, Inc., TX [M]
(Alt. to Jeffrey O. Stull)
Michael D. Sutcliffe, Austin Fire Department, TX [U]
(Alt. to Todd W. Haines)
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 1991

Standard on

Vapor-Protective Ensembles for Hazardous Materials Emergencies and CBRN Terrorism Incidents

2016 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 mandatory sections of the document are given in Chapter 2 and those for extracts in 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 shall 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 specify minimum requirements for the design, performance, testing, documentation, and certification of vapor-protective ensembles and ensemble elements used by emergency response personnel during hazardous materials incidents and for protection from chemicals, biological agents, and radiological particulates (CBRN) encountered as terrorism agents.

1.1.2* This standard shall also specify additional *optional* criteria for vapor-protective ensembles that provide escape protection from chemical flash fires encountered during hazardous materials incidents.

1.1.3 This standard shall specify requirements for new vapor-protective ensembles and new ensemble elements.

1.1.4 This standard alone shall not specify requirements for protective clothing for any fire fighting applications.

1.1.5 This standard alone shall not specify requirements for protection against ionizing radiation, cryogenic liquid hazards, or explosive atmospheres.

1.1.6* This standard shall not specify requirements for the respiratory protection that is necessary for proper protection with the protective ensemble. Respiratory protection for hazardous materials emergencies and CBRN terrorism incidents is a critical part of the overall protection and shall be specified by the authority having jurisdiction.

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

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

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

1.2 Purpose.

1.2.1* The purpose of this standard shall be to establish a minimum level of protection for emergency response personnel against adverse vapor, liquid-splash, and particulate environments during hazardous materials incidents, and from specified chemical and biological terrorism agents in vapor, liquid splash, and particulate environments during CBRN terrorism incidents.

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

1.2.1.2 The purpose of this standard shall also be to 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 vapor-protective ensembles and compliant ensemble elements.

1.2.1.3 The purpose of these options shall be to provide emergency response organizations the flexibility to specify neither, one, or both of these options in their purchase specifications according to the anticipated exposure and expected needs of the emergency response organization.

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

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

1.3 Application.

1.3.1 This standard shall apply to the design, manufacturing, testing, documentation and certification of new vapor-protective ensembles and new ensemble elements. This edition of NFPA 1991 shall not apply to vapor-protective ensembles and ensemble elements manufactured to previous editions of NFPA 1991.

1.3.2* This standard alone shall not apply to protective clothing for any fire-fighting applications.

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

1.3.4 This standard shall not apply to use requirements for vapor-protective ensembles or ensemble elements as these requirements are specified in NFPA 1500.

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

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

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,* 2012 edition.

NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program,* 2013 edition.

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

2.3 Other Publications.

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

ANSI Z87.1, *American National Standard for Occupational and Educational Eye and Face Protection,* 2010.

ANSI Z89.1, *Standard for Industrial Head Protection*, 2009.

2.3.2 ASTM Publications. American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM D747, *Standard Test Method for Apparent Bending Modulus of Plastics by Means of a Cantilever Beam*, 2009.

ASTM D751, *Standard Test Methods for Coated Fabrics*, 2006 (2011).

ASTM D1776, *Standard Practice for Conditioning and Testing Textiles*, 2008e1.

ASTM D2136, *Standard Test Method for Coated Fabrics — Low Temperature Bend Test*, 2012.

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

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

ASTM D6413, *Standard Test Method for Flame Resistance of Textiles (Vertical Test)*, 2013b.

ASTM F392, *Standard Test Method for Flex Durability of Flexible Barrier Materials*, 2011.

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

ASTM F903, *Standard Test Method for Resistance of Materials Used in Protective Clothing to Prevent Penetration by Liquids*, 2010.

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

ASTM F1052, *Standard Test Method for Pressure Testing of Vapor-Protective Ensembles*, 2009.

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*, 2011e1.

ASTM F1342, *Standard Test Method for Resistance of Protective Clothing Materials to Puncture*, 2005 (2013) e1.

ASTM F1358, *Standard Test Method for Effects of Flame Impingement on Materials Used in Protective Clothing Not Designated Primarily for Flame Resistance*, 2008.

ASTM F1359, *Standard Test Method for Liquid Penetration Resistance of Protective Clothing or Protective Ensembles Under a Shower Spray While on a Mannequin*, 2013.

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

ASTM F1930, *Standard Test Method for Evaluation of Flame Resistant Clothing for Protection Against Fire Simulations Using an Instrumented Manikin,* 2013.

ASTM F2010, *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*, 2008.

ASTM F2913, *Standard Test Method for Measuring the Coefficient of Friction for Evaluation of Slip Performance of Footwear and Test Surfaces/Flooring Using a Whole Shoe Tester*, 2011.

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

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

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

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

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

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

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

ISO 17021, *Conformity assessment — Requirements for bodies providing audit and certification of management systems*, 2011.

ISO 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.

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

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

2.3.6 Other Publications.

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

Assessment of the U.S. Army Chemical And Biological Defense Command Report 1: Technical Assessment of the Man-In-Simulant Test (MIST) Program, National Research Council Report, The National Academies, 500 Fifth St. N.W., Washington, D.C. 20001, 1997.

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

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

3.3.2 Agents.

3.3.2.1 ***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.

3.3.2.2 ***CBRN Terrorism Agents.*** The term used to refer to chemical terrorism agents, including chemical warfare agents and toxic industrial chemicals, biological terrorism agents, and radiological particulate terrorism agents. *(See also 3.3.2.1, 3.3.2.3, and 3.3.2.5.)*

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

3.3.2.4* ***Chemical Warfare (CW) Agents.*** Liquid, solid, and gas chemical agents (most are liquid) traditionally used during warfare or armed conflict to kill or incapacitate an enemy. *(See also 3.3.2.3 and 3.3.2.6.)*

3.3.2.5 ***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.

3.3.2.6 ***Toxic Industrial Chemicals.*** Highly toxic solid, liquid, or gaseous chemicals that have been identified as mass casualty threats that could be used as weapons of terrorism to inflict casualties, generally on a civilian population during a terrorist attack. *(See also 3.3.2.3 and 3.3.2.4.)*

3.3.3 Boot. See 3.3.68.

3.3.4 Bootie. A sock-like extension of the garment or suit leg that covers the entire foot.

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

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

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

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

3.3.9 Chemical and Biological Terrorism Incidents. Situations involving the release of chemical or biological warfare agents in civilian areas by terrorists.

3.3.10 Chemical and Biological Terrorism Vapor-Protective Ensemble. See 3.3.64.

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

3.3.12 Chemical-Protective Elements. See 3.3.24.

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

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

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

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

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

3.3.18 Cracking Pressure. The pressure at which the suit exhaust valve begins to open, releasing exhaust air to the outside suit environment.

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

3.3.20 Element(s). See 3.3.24.

3.3.21 Emergency Response Personnel. Personnel assigned to organizations that have the responsibility for responding to hazardous materials emergencies.

3.3.22 Encapsulating. A type of ensemble that provides vapor- or gastight protection, or liquidtight protection, or both, and completely covers the wearer and the wearer's respiratory equipment.

3.3.23 Ensemble. See 3.3.64.

3.3.24* Ensemble Elements. The compliant products that provide protection to the upper and lower torso, arms, legs, head, hands, and feet.

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

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

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

3.3.28 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.

3.3.29 Footwear. See 3.3.68.

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

3.3.31 Garment. See 3.3.70.

3.3.32 Glove. See 3.3.69.

3.3.33* Hazardous Materials. A substance (solid, liquid, or gas) that when released is capable of creating harm to people, the environment, and property.

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

3.3.35 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.

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

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

3.3.38 Liquid Splash-Protective Ensemble. Multiple elements of compliant protective clothing and equipment products that when worn together provide protection from some risks, but not all risks, of hazardous materials emergency incident operations involving liquids.

3.3.39 Maintenance. Procedures for inspection, repair, and removal from service of vapor-protective ensembles.

3.3.40 Manufacturer. The entity that directs and controls compliant product design, compliant product manufacturing, or compliant product quality assurance; also, the entity that assumes the liability for the compliant product or provides the warranty for the compliant product.

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

3.3.42 Model. The collective term used to identify a group of individual vapor-protective ensembles or 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.

3.3.43 Outer Boot. A secondary boot worn over the footwear ensemble element or bootie for the purpose of providing physical protection in order to meet the requirements of this standard.

3.3.44 Outer Garment. A secondary garment worn over the suit ensemble element for the purpose of providing physical protection in order to meet the requirements of this standard.

3.3.45 Outer Glove. A secondary glove worn over the glove ensemble element for the purpose of providing physical protection in order to meet the requirements of this standard.

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

3.3.47* Primary Materials. Vapor-protective ensemble and element materials limited to the suit material, hood and visor material, glove material, and footwear material that provide protection from chemical and physical hazards.

3.3.48 Product Label. A label or marking affixed to each compliant vapor-protective ensemble and compliant ensemble element by the manufacturer. Such labels contain compliance statements, certification statements, general information, care, maintenance, or similar data. The product label is not the certification organization's label, symbol, or identifying mark; however, the certification organization's label, symbol, or identifying mark is attached to or a part of the product label.

3.3.49 Protective Ensemble. See 3.3.64.

3.3.50 Protective Footwear. See 3.3.68.

3.3.51 Protective Glove. See 3.3.69.

3.3.52 Protective Suit. See 3.3.70.

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

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

3.3.55 Respiratory Equipment. A positive-pressure, self-contained breathing apparatus (SCBA) or combination SCBA/supplied-air breathing apparatus.

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

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

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

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

3.3.60 Suit. See 3.3.70.

3.3.61 Suit Closure. The component that allows the wearer to enter (don) and exit (doff) the vapor-protective suit element.

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

3.3.63 Suit Material. The principal material used in the construction of the vapor-protective suit.

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

3.3.65 Vapor-Protective Ensemble with Optional Chemical Flash Fire Escape and Liquefied Gas Protection. A compliant

vapor-protective ensemble that is also certified as compliant with the optional requirements for both *limited* protection against chemical flash fire *for escape only* and for protection against liquefied gases.

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

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

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

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

3.3.70* Vapor-Protective Suit. The ensemble garment element of the protective ensemble that provides chemical protection to the upper and lower torso, head, arms, and legs.

3.3.71 Visor Material. The transparent chemical-protective material that allows the wearer to see outside the protective ensemble hood.

Chapter 4 Certification

4.1 General.

4.1.1 The process of certification for protective ensembles and ensemble elements as being compliant with NFPA 1991 shall meet the requirements of Section 4.1 through Section 4.8.

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

4.1.3 All certification shall be performed by a certification organization that meets at least the requirements specified in Section 4.2 and that is accredited for personal protective equipment in accordance with ISO/IEC 17065, *Conformity assessment — Requirements for bodies certifying products, processes and services.* The accreditation shall be issued by an accreditation body operating in accordance with ISO 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 1991, in any statements about their respective product(s) unless the product(s) is certified as compliant to this standard.

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

4.1.6 All compliant ensembles and ensemble elements shall also have a product label that meets the requirements specified in Section 5.1.

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

4.1.8 The certification organization shall not issue any new certifications to the 2005 edition of this standard on or after the NFPA effective date for the 2016 edition, which is December 4, 2015.

4.1.9 The certification organization shall not permit any manufacturer to continue to label any ensembles or ensemble elements that are certified as compliant with the 2005 edition of this standard on or after December 4, 2016.

4.1.10 The certification organization shall require manufacturers to remove all certification labels and product labels indicating compliance with the 2005 edition of this standard from all ensembles and ensemble elements that are under the control of the manufacturer on December 4, 2016, and the certification organization shall verify this action is taken.

4.2 Certification Program.

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

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

4.2.3 The certification organization shall be accredited for personal protective equipment in accordance with ISO/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 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.

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.

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

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

4.2.8 The certification organization and the manufacturer shall evaluate any changes affecting the form, fit, or function of 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, that address report(s) of situation(s) 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 protective ensembles and ensemble elements, the certification organization shall conduct both inspection and testing as specified in this section.

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

4.3.2.1 The certification organization's testing laboratory's scope of accreditation to ISO 17025, *General requirements for the competence of testing and calibration laboratories*, shall encompass testing of personal protective equipment.

4.3.2.2 The accreditation of a certification organization's testing laboratory shall be issued by an accreditation body operating in accordance with ISO 17011, *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 17025, *General requirements for the competence of testing and calibration laboratories*.

4.3.3.2 The manufacturer's testing laboratory's scope of accreditation to ISO 17025, *General requirements for the competence of testing and calibration laboratories*, shall encompass testing of personal protective equipment.

4.3.3.3 The accreditation of a manufacturer's testing laboratory shall be issued by an accreditation body operating in accordance with ISO 17011, *Conformity assessment — 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 for the ensemble and ensemble elements in Section 5.1.

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 permit-

ted by 5.1.1.5, 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 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.

4.3.9 Inspection and evaluation 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 protective ensemble and ensemble element.

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 to 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 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* 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.

4.3.17 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.

4.3.18 The certification organization shall ensure that the manufacturer tests each vapor-protective ensemble for gastight integrity as specified in ASTM F1052, *Standard Test Method for Pressure Testing of Vapor-Protective Ensembles*. Each ensemble shall show an ending pressure of at least 797 Pa (3.2 in. water gauge) pressure. The date of the test shall be placed on the product label as specified in 5.1.1.8(5). The manufacturer shall provide the result with each ensemble.

4.4 Annual Verification of Product Compliance.

4.4.1 All vapor-protective ensemble models and all individual element models that are labeled as being compliant with this standard shall undergo recertification on an annual basis. This recertification shall include inspection and evaluation to all design requirements and testing to all performance requirements as required by this standard on all manufacturer's models and components as required by 4.4.3.

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

4.4.1.2 For the purpose of this standard, models shall include each unique pattern, style, or design of the individual element.

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 inspection program. For recertification, the certification organization shall acquire at least one complete vapor-protective ensemble sample outfitted with all manufacturer-provided external fittings. The certification organization shall also acquire a sufficient quantity of component samples to be tested for recertification as required by 4.4.3.

4.4.3 Sample vapor-protective ensembles and components shall be inspected, evaluated, and tested as follows.

4.4.3.1 Each vapor-protective ensemble shall be inspected and evaluated to each of the design requirements specified in Chapter 6.

4.4.3.2 A single specimen of each vapor-protective ensemble shall be tested for overall performance as specified in Section 7.1 using the following sequence of tests:

(1) The vapor-protective ensemble specimen shall be tested for gastight integrity in accordance with Section 8.2.
(2) The vapor-protective ensemble specimen shall then be tested for liquidtight integrity as specified in Section 8.3.
(3) The vapor-protective ensemble specimen shall then be tested for overall function and integrity as specified in Section 8.4.
(4) The vapor-protective ensemble specimen shall then be tested for airflow capacity as specified in Section 8.5.
(5) A new vapor-protective ensemble specimen shall be tested for overall inward leakage as specified in Section 8.8.
(6) If certified for optional chemical flash fire protection as specified in Section 7.7, a new vapor-protective ensemble specimen shall then be tested for overall ensemble flash protection as specified in Section 8.25.

4.4.3.3 All suit, visor, glove, footwear, optional chemical flash fire protection, and optional liquefied gas protection performance requirements shall be evaluated as specified in Chapter 7 with the following modifications:

(1) Chemical permeation and chemical penetration resistance testing shall be limited to the testing specified in 7.2.1, 7.3.1, 7.4.1, and 7.5.1 and shall be limited to the following chemicals:
    (a) Acrylonitrile
    (b) Carbon disulfide
    (c) Dichloromethane
    (d) Diethylamine
    (e) Methanol
    (f) Tetrahydrofuran
(2) Chemical permeation resistance testing specified in 7.6.2 shall be limited to ammonia.
(3) If the number of specimens is greater than two in the initial testing, a total of two specimens shall be permitted for annual testing requirements.
(4) If testing is specified for both directions of a material, a total of two specimens per material direction shall be permitted for testing requirements.

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

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

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

4.5.3.1 Registration to the requirements of ISO 9001, *Quality management systems — Requirements*, shall be conducted by a registrar that is accredited for personal protective equipment in accordance with ISO 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* as specified in 3.3.44 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.

4.6 Hazards Involving Compliant Product.

4.6.1* The certification organization shall establish procedures to be followed where situation(s) are reported in which a compliant product is subsequently found to be hazardous. These procedures shall comply with the provisions of ISO 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 product 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.

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) Removal of the mark of certification from the product.
(4) Where a hazardous condition exists and it is not practical to implement 4.6.11(1), 4.6.11(2), or 4.6.11(3); or the responsible parties refuse to take corrective action, the certification organization shall notify relevant governmental and regulatory agencies and issue a notice to the user community about the hazard.

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

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

4.7 Manufacturers' Investigation of Complaints and Returns.

4.7.1 Manufacturers shall provide corrective action in accordance with ISO 9001, *Quality management systems — Requirements*, or an equivalent ISO quality management system for investigating written complaints and returned products.*(See also A.4.5.3.)*

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 conduct a product recall.

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

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

Chapter 5 Labeling and Information

5.1 Product Label Requirements.

5.1.1 General.

5.1.1.1 Each vapor protective ensemble shall have a product label permanently and conspicuously attached to the innermost surface of the ensemble when the ensemble is properly assembled with all layers, components, and parts in place.

5.1.1.2 Each glove and footwear element shall have a product label attached to the element, or printed upon or inserted in the smallest unit of packaging of that element.

5.1.1.3 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.

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

5.1.1.5 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.

5.1.1.6 The certification organization's label, symbol, or identifying mark shall be legibly printed on the product label. All letters shall be at least 2.5 mm ($\frac{3}{32}$ in.) high.

5.1.1.7 The compliance statements and information specified in 5.1.2 and 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 3 mm ($\frac{1}{8}$ in.) high.

5.1.1.8 In addition to the compliance statements and information specified in 5.1.1.6, at least the following information shall also be printed legibly on the product label(s). All letters shall be at least 2 mm ($\frac{1}{16}$ in.) high.

(1) Manufacturer's name, identification, or designation
(2) Manufacturer's address
(3) Country of manufacture
(4) Suit model, style, or serial number
(5) Date of compliance testing to ASTM F1052, *Standard Test Method for Pressure Testing of Vapor-Protective Ensembles*
(6) Size
(7) Suit, glove, footwear material(s), as applicable
(8) Visor material(s) for suits
(9) Glove component for ensemble
(10) Footwear component for ensemble

5.1.1.9 Where detachable components of a vapor-protective ensemble element, including but not limited to, such components as supplemental garments, gloves, or boots, must be worn with a vapor-protective ensemble element in order to be compliant with the optional requirements of this standard, at least the following statement and information shall also be printed legibly on the product label of the ensemble element. All letters shall be at least 2.5 mm (3/32 in.) high. The appropriate term ensemble or 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.

"FOR COMPLIANCE WITH NFPA 1991, AND (insert 'OPTIONAL LIMITED CHEMICAL FLASH FIRE PROTECTION FOR ESCAPE ONLY IN THE EVENT OF A CHEMICAL FLASH FIRE' or 'LIQUEFIED GAS PROTECTION' or both), THE FOLLOWING COMPONENTS MUST BE WORN IN CONJUNCTION WITH THIS VAPOR-PROTECTIVE (insert the term ENSEMBLE or ENSEMBLE ELEMENT here):
(List detachable components here.)**"**

5.1.1.10 Detachable components specified in 5.1.1.9 shall meet the label requirements specified in ASTM F1301, *Standard Practice for Labeling Chemical Protective Clothing*. The label shall also meet the requirements of 5.1.1 through 5.1.1.5.

5.1.2 Ensemble Compliance Statements.

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

"THIS VAPOR-PROTECTIVE ENSEMBLE MEETS THE REQUIREMENTS OF NFPA 1991, STANDARD ON VAPOR-PROTECTIVE ENSEMBLES FOR HAZARDOUS MATERIALS EMERGENCIES, 2016 EDITION, AND ANY ADDITIONAL REQUIREMENTS NOTED BELOW.

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

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

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

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

5.1.3 Ensemble Element Compliance Statements.

5.1.3.1 Each ensemble element shall have at least the following compliance statement and information on the product label. The appropriate term "glove" or "footwear" shall be inserted where indicated in the label text.

"THIS (insert the element name 'GLOVE' or 'FOOTWEAR' here) ELEMENT MEETS THE REQUIREMENTS OF NFPA 1991, STANDARD ON VAPOR-PROTECTIVE ENSEMBLES FOR HAZARDOUS MATERIALS EMERGENCIES, 2016 EDITION, AND ANY ADDITIONAL REQUIREMENTS AS NOTED BELOW.

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

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

5.1.3.2 Where the ensemble element provides one or both optional additional protection, the YES or NO box shall be marked as appropriate for the additional requirement.

5.1.3.3 Where the ensemble element does not provide any optional additional protection above the basic requirements of this standard, the NO boxes shall be marked for both additional requirements.

5.2* User Information.

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

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

5.2.3 The required user information, or packaging containing the user information, shall be attached to the vapor-protective ensemble or ensemble element so that a deliberate action is necessary to remove it. The manufacturer shall provide notice that the user information is to be removed ONLY by the end user.

5.2.4 The manufacturer shall provide at least the following instructions and information with each vapor-protective ensemble and each element:

(1) Pre-use information as follows:
   (a) Safety considerations
   (b) Limitations of use
   (c) Marking recommendations and restrictions

(d) A statement that most performance properties of the vapor-protective ensemble or ensemble element cannot be tested by the user in the field
(e) Closure lubricants, if applicable
(f) Suit visor antifog agents or procedures
(g) Recommended undergarments
(h) Storage life and storage conditions
(i) Warranty information

(2) Preparation for use as follows:
(a) Sizing/adjustment
(b) Recommended storage practices

(3) Inspection frequency and details

(4) Don/doff information as follows:
(a) Donning and doffing procedures
(b) Sizing and adjustment procedures

(5) Procedures for completing interfaces with detachable components, including but not limited to detachable gloves, detachable boots, and detachable overcovers

(6) Proper use consistent with NFPA 1500 and 29 CFR 1910.132

(7) Maintenance and cleaning information as follows:
(a) Cleaning instructions and precautions with a statement advising users not to use garments that are not thoroughly cleaned and dried
(b) Inspection details
(c) Maintenance criteria and methods of repair, where applicable
(d) Decontamination procedures for both chemical and biological contamination

(8) Retirement and disposal criteria and consideration

(9) Instructions for removal and reinsertion of hand from gloves

(10) Instructions for removal and replacement of gloves and other user-replaceable components

(11)* A statement that "The closure has not been tested for permeation resistance."

5.2.4.1 The storage life shall be stated in years following the date of manufacture, and the rationale for this determination shall be provided.

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

5.2.6 The manufacturer shall state the storage life for each vapor-protective ensemble and each element.

5.2.7* The manufacturer shall state the model(s) and cylinder(s) size of NFPA 1981–compliant open-circuit SCBA worn during certification of the garment.

5.3 Technical Data Package.

5.3.1 General.

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

5.3.1.2* The technical data package shall contain all documentation required by this standard and the values obtained from the initial certification showing compliance with the requirements of Chapter 7 in the current edition of this standard using the reporting formats provided in Table 5.3.1.2(a) and Table 5.3.1.2(b). The technical data package information shall indicate "Pass" for those requirements that have no reported quantitative values and "Not applicable" for specific requirements that do not apply to the vapor-protective ensemble.

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

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

5.3.2 Material and Component Descriptions.

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

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

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

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

Table 5.3.1.2(a) Format for Reporting Certification Test Data in Technical Data Package

Ensemble or Element	Performance Requirement	Test Method	Requirement	Result
Base Requirements				
Ensemble	Liquidtight integrity	ASTM F1359 (Section 8.3)	No liquid penetration No liquid accumulation in outer gloves No liquid accumulation in outer boots	
	Overall ensemble function and integrity	ASTM F1154/ ASTM F1052 (Section 8.4)	Ending suit pressure ≥ 80 mm water gauge Test subject completes task Test subject has visual acuity of 20/35 or better through face piece lens and visor Time to remove and reinsert hands in gloves 5times ≤ 2 minutes	
	Air flow capacity	Section 8.5	Internal suit pressure ≤150 mm water gauge Ending suit pressure ≥80 mm water gauge	
	Overall inward leakage	Section 8.8	$PPDF_{sys}$ ≥ 488 $PPDF_i$ (local) ≥ 1071	Indicate lowest average value and its location
Exhaust valve	Exhaust valve mounting strength	Section 8.9	Strength > 135 N	
	Exhaust valve inward leakage	Section 8.24	Leakage rate ≤ 30 ml/min	
External fitting	External fitting installation effect on integrity	ASTM F1052 (Section 8.2)	Ending suit pressure ≥80 mm water gauge	
	External fitting pull-out strength	Section 8.13	Strength > 1000 N	
Suit material	Flame resistance	ASTM F1358 (Section 8.7)	Afterflame time ≤ 2 seconds No melting and dripping	
	Burst strength	ASTM D751 (Section 8.10)	Strength > 200 N	
	Puncture propagation tear resistance	ASTM D2582 (Section 8.11)	Tear resistance ≥ 49 N	
	Cold temperature performance	ASTM D747 (Section 8.12)	Bend moment ≤ 0.057 Nm	
Suit seam	Breaking strength	ASTM D751 (Section 8.22)	Strength > 67 N/25 mm	
Suit closure	Chemical penetration resistance	ASTM F903 (Section 8.23)	No penetration of 15 liquid chemicals	
	Breaking strength	ASTM D751 (Section 8.22)	Strength > 67 N/25 mm	
Visor material	Flame resistance	ASTM F1358 (Section 8.7)	Afterflame time ≤ 2 seconds No melting and dripping	
	Visor high-mass impact resistance	Section 8.29	No full-thickness cracks, holes, or fractures	
Visor seam	Breaking strength	ASTM D751 (Section 8.22)	Strength > 67 N/25 mm	
Glove material	Flame resistance	ASTM F1358 (Section 8.7)	Afterflame time ≤ 2 seconds No melting	
	Cut resistance	ASTM F1790 (Section 8.15)	Blade travel distance ≥20 mm at 150 grams	
	Puncture resistance	ASTM F1342 (Section 8.16)	Puncture force ≥ 22 N	
	Cold temperature performance	ASTM D747 (Section 8.12)	Bend moment ≤ 0.057 Nm	

(continues)

Table 5.3.1.2(a) *Continued*

Ensemble or Element	Performance Requirement	Test Method	Requirement	Result
Gloves	Dexterity	ASTM F2010 (Section 8.17)	Percent increase in bare handed control >600 percent	
Footwear upper material	Flame resistance	ASTM F1358 (Section 8.7)	Afterflame time ≤ 2 seconds No melting and dripping	
	Cut resistance	ASTM F1790 (Section 8.15)	Blade travel distance ≥20 mm at 350 grams	
	Puncture resistance	ASTM F1342 (Section 8.16)	Puncture force ≥ 36 N	
Footwear toe sections	Impact resistance	ASTM F2412 (Section 8.31)	Impact resistance ≥ 101.7 J	
	Compression resistance	ASTM F2412 (Section 8.31)	Compression resistance ≥11,121 N	
Footwear soles and heels	Abrasion resistance	ISO 4649 (Section 8.19)	Relative volume loss ≤250 mm^3	
	Slip resistance	ASTM F2913 (Section 8.21)	Coefficient ≥ 0.40	
Footwear puncture resistant device	Puncture resistance	ASTM F2412 (Section 8.30)	No puncture	
Footwear soles or ladder shanks	Bending resistance	Section 8.20	Deflection ≤ 6 mm	
Optional Flash Fire Requirements				
Ensemble	Overall flash fire protection	Section 8.25	Afterflame time ≤ 2 seconds Ending suit pressure ≥13 mm water gauge Test subject has visual acuity of 20/100 or better through face piece lens and visor	
Garment material	Heat transfer performance	ASTM F2700 (Section 8.18)	HTP Rating ≥ 12 cal/cm^2	
	Flame resistance	ASTM F1358 (Section 8.7)	Afterflame time ≤ 2 seconds Burn distance ≤ 100 mm No melting and dripping	
Visor material	Heat transfer performance	ASTM F2700 (Section 8.18)	HTP Rating ≥ 12 cal/cm^2	
	Flame resistance	ASTM F1358 (Section 8.7)	Afterflame time ≤ 2 seconds Burn distance ≤ 100 mm No melting and dripping	
Glove material	Heat transfer performance	ASTM F2700 (Section 8.18)	HTP Rating ≥ 12 cal/cm^2	
	Flame resistance	ASTM F1358 (Section 8.7)	Afterflame time ≤ 2 seconds Burn distance ≤ 100 mm No melting and dripping	
Footwear material	Heat transfer performance	ASTM F2700 (Section 8.18)	HTP Rating ≥ 12 cal/cm^2	
	Flame resistance	ASTM F1358 (Section 8.7)	Afterflame time ≤ 2 seconds Burn distance ≤ 100 mm	

Table 5.3.1.2(b) Format for Reporting Certification Permeation Test Data in Technical Data Package

Material or Seam Tested	**[insert material or seam description]**				
	Cumulative Permeation (μg/cm²) over Test Period Interval				
Test Period Interval	0–15 min	15–30 min	30–45 min	45–60 min	1-hour total
Chemical/Requirement	≤ 2.0	≤ 2.0	≤ 2.0	≤ 2.0	≤ 6.0
Acetone					
Acetonitrile					
Acrolein					
Acrylonitrile					
Anhydrous ammonia (gas)					
1,3-Butadiene (gas)					
Carbon disulfide					
Chlorine (gas)					
Dichloromethane					
Diethyl amine					
Dimethyl formamide					
Dimethyl sulfate					
Ethyl acetate					
Ethylene oxide (gas)					
Hexane					
Hydrogen chloride (gas)					
Methanol					
Methyl chloride (gas)					
Nitrobenzene					
Sodium hydroxide, 50% w/w					
Sulfuric acid, 96.1% w/w					
Tetrachloroethylene					
Tetrahydrofuran					
Chemical Warfare Agents					
Blister Agent Requirements	≤ 1.33	≤ 1.33	≤ 1.33	≤ 1.33	≤ 4.00
Distilled Mustard					
Nerve Agent Requirements	≤ 0.40	≤ 0.40	≤ 0.40	≤ 0.40	≤ 1.25
Soman					
Optional Liquefied Gases*	≤ 6.0				≤ 6.0
Ammonia (liquefied)					
Chlorine (liquefied)					
Ethylene oxide (liquefied)					

*Liquefied chemical gases are only evaluated over 15-minute exposure period.

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

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

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

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

Chapter 6 Design Requirements

6.1 Vapor-Protective Ensemble Design Requirements.

6.1.1* Vapor-protective ensembles shall be designed and configured to protect the wearer's torso, head, arms, legs, hands, and feet and shall completely enclose the wearer and the wearer's respiratory equipment.

6.1.2 Vapor-protective ensembles shall consist of a suit with hood, gloves, and footwear.

6.1.2.1 The suit hood shall be provided with a visor that is designed to allow the wearer to see outside the vapor-protective ensemble.

6.1.2.2 The visor shall be constructed of a transparent material that qualifies as a chemical-protective layer.

6.1.2.3* Vapor-protective ensembles shall only be permitted to be constructed using an outer garment designed to be worn over the suit element where such additional garments are necessary to meet the optional liquefied gas protection performance requirements specified in Section 7.6 or the optional chemical flash fire protection performance requirements specified in Section 7.7.

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

6.1.2.5 Vapor-protective ensembles shall be permitted to be constructed using an outer glove designed to be worn over the glove element where such additional gloves are necessary to meet the glove element requirements of this standard.

6.1.2.6 Vapor-protective ensembles shall be permitted to be constructed using an outer boot designed to be worn over a footwear element or bootie where such additional boots are necessary to meet the footwear element requirements of this standard.

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

6.1.4 Adhesive tape shall not be used to secure or to seam components of the ensemble in order to comply with the performance requirements of the standard.

6.1.5 Vapor-protective ensembles shall be offered in at least four unique and different sizes.

6.1.6* Vapor-protective ensembles shall be equipped with an exhaust valve(s).

6.1.6.1 Exhaust valves shall be one-way valves.

6.1.6.2 The one-way valves shall be designed to release exhaust air from the inside of the vapor-protective ensemble to the outside environment through the exhaust valve, and shall prevent entry of contaminated air into the vapor-protective ensemble from the outside environment through the exhaust valve.

6.1.7 The mounting mechanism of exhaust valves shall be designed to allow their removal and reinstallation or replacement, for inspection, from the vapor-protective ensemble.

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

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

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

6.1.9.2 The chemical-protective layer shall be permitted to depend on the other primary material to provide the physical protection.

6.1.10* Protective cover(s) constructed using a material that meets all the applicable performance criteria in Section 7.2 shall be provided to protect the suit closure assembly from direct chemical splashes. The cover(s) shall allow access to the closure(s) for donning, doffing, and inspection.

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

6.1.12* Only open-circuit SCBA that is certified to NFPA 1981 shall be specified to be worn with NFPA 1991–compliant ensembles.

6.1.13* The interface of and integration of the selected respiratory equipment with the protective ensemble shall not invalidate the NIOSH certification of the respective respiratory equipment.

6.2 Vapor-Protective Glove Element Design Requirements.

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

6.2.2 Glove elements shall provide protection from the finger tips to at least 25 mm (1 in.) beyond the wrist crease.

6.2.3 Glove elements shall be constructed using primary material that shall provide the protection from chemical and physical hazards. The primary material shall include the chemical-protective layer that can be configured as a separate layer or as a composite.

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

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

6.2.4.2 The glove chemical-protective layer shall be permitted to depend on the other primary material to provide the physical protection.

6.2.5 Glove elements shall be permitted to be constructed using an outer glove designed to be worn over the primary glove where such additional gloves are necessary to meet the glove element requirements of this standard.

6.2.5.1 Where the glove consists of multiple layers to meet the glove element requirements, all layers shall extend to at least the suit sleeve interface connection.

6.2.6 The interface of glove element to vapor-protective suit sleeve interface shall be designed to permit removal and replacement of the gloves attached to each suit sleeve within 30 minutes.

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

6.3 Vapor-Protective Footwear Element Design Requirements.

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

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

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

6.3.4 Footwear elements shall be constructed using primary material that shall provide the protection from chemical and physical hazards. The primary material shall include the chemical-protective layer that can be configured as a separate layer or as a composite.

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

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

6.3.5.2 The footwear chemical-protective layer shall be permitted to depend on the other primary material to provide the physical protection.

6.3.6 Footwear elements shall be permitted to be constructed using an outer boot designed to be worn over the primary footwear or bootie where such additional boots are necessary to meet the footwear element requirements of this standard.

6.3.7 Heel breast shall not be less than 13 mm (½ in.) nor more than 25 mm (1 in.).

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

6.3.9 Metal parts shall not penetrate from the outside into the lining or insole at any point.

6.3.10 No metal parts, 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.

6.3.11 Toe impact–resistant, compression-resistant, and sole puncture–resistant components shall be integral and nonremovable parts of the footwear.

6.3.12 Footwear shall meet the performance requirements as specified in ASTM F2413, *Standard Specification for Performance Requirements for Protective (Safety) Toe Cap Footwear*, for impact-resistant, compression-resistant, and puncture-resistant footwear with the exception that flex resistance to cracking shall not be evaluated.

Chapter 7 Performance Requirements

7.1 Vapor-Protective Ensemble Performance Requirements.

7.1.1 Vapor-protective ensembles shall be tested for overall liquid integrity as specified in Section 8.3, and ensembles shall allow no liquid penetration; where outer gloves are designed to be worn in conjunction with gloves attached to the ensemble, the outer gloves shall not collect liquid; and where outer boots are designed to be worn in conjunction with garment booties, the outer boots shall not collect liquid.

7.1.2 Ensembles shall be tested for overall function and integrity as specified in Section 8.4 and shall meet the following performance criteria:

(1) Ensembles shall have an ending pressure of at least 80 mm (3 5⁄32 in.) water gauge pressure upon completion of the functional test.
(2) Ensembles shall allow the test subject to complete all tasks while wearing a head-protective device.
(3) Ensembles shall permit the test subject to see through the combination of respiration and ensemble visor with a visual acuity of 20/35 or better.
(4) Ensembles shall permit the test subject to remove and reinsert their hand into the glove system five times sequentially within a period of 2.5 minutes or less.

(5) Ensembles shall permit the test subject to properly identify three of the four numbers on the NFPA 704-based placard at each of the following angles:

(a) Upwards: 36 degrees
(b) Downward: 30 degrees
(c) Right and Left: 60 degrees

7.1.3 Ensembles shall be tested for airflow capacity as specified in Section 8.5 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 (3 5/32 in.) water gauge pressure after subsequent testing for gastight integrity as specified in Section 8.2.

7.1.4 Ensembles on which external fittings are installed that penetrate any primary materials shall be tested for gastight integrity as specified in Section 8.2 and shall show an ending pressure of at least 80 mm (3 5/32 in.) water gauge.

7.1.5 Exhaust valves installed in vapor-protective ensembles shall be tested for mounting strength as specified in Section 8.9 and shall have a failure force greater than 135 N (30 lbf).

7.1.6 External fittings installed in vapor-protective ensembles shall be tested for pull-out strength as specified in Section 8.13 and shall have a failure force greater than 1000 N (225 lbf).

7.1.7 Exhaust valves installed in vapor-protective ensembles shall be tested for inward leakage as specified in Section 8.24 and shall not exhibit a leakage rate exceeding 30 ml/min (1.83 $in.^3$/min).

7.1.8 Vapor-protective ensembles shall be tested for overall inward leakage as specified in Section 8.8 and shall have an average local physiological protective dosage factor ($PPDF_i$) value at each PAD location for the four ensembles tested of no less than 1071 and an average systemic physiological protective dosage factor ($PPDF_{sys}$) value for each of the four tested ensembles of no less than 488.

7.2 Vapor-Protective Suit Element Performance Requirements.

7.2.1 Suit materials and seams shall be tested for permeation resistance as specified in Section 8.6 and shall have a cumulative permeation that does not exceed 6.0 $\mu g/cm^2$ for the 1-hour test period and a cumulative permeation that does not exceed 2.0 $\mu g/cm^2$ for each 15-minute interval within the 1-hour test period for each chemical tested.

7.2.1.1 Suit materials and seams shall be tested for permeation resistance as specified in Section 8.26 and shall not exceed a cumulative permeation of 1.25 $\mu g/cm^2$ for the chemical warfare agent Soman (GD or O-Pinacolyl methylphosphonofluoridate).

7.2.1.2 Suit materials and seams shall be tested for permeation resistance as specified in Section 8.26 and shall not exceed a cumulative permeation of 4.0 $\mu g/cm^2$ for the chemical warfare agent sulfur mustard, distilled [HD or bis (2-chloroethyl) sulfide].

7.2.1.3 Suit materials and seams shall be tested for permeation resistance as specified in Section 8.6 and shall have a cumulative permeation that does not exceed 6.0 $\mu g/cm^2$ for the 1-hour test period and a cumulative permeation that does not exceed 2.0 $\mu g/cm^2$ for each 15-minute interval within the 1-hour test period for each additional chemical or specific chemical mixture for which the manufacturer is certifying the ensemble.

7.2.2 Suit materials shall be tested for resistance to flame impingement as specified in Section 8.7 and shall have an afterflame time of not greater than 2.0 seconds and shall not melt and drip.

7.2.3 Suit material shall be tested for bursting strength as specified in Section 8.10 and shall have a bursting strength greater than 200 N (45 lbf).

7.2.4 Suit materials shall be tested for puncture propagation tear resistance as specified in Section 8.11 and shall have a puncture propagation tear resistance greater than 49 N (11 lbf).

7.2.5 Suit materials shall be tested for cold weather performance as specified in Section 8.12 and shall have a bending moment of less than 0.057 N·m (0.5 in.-lbf) at an angular deflection of 60 degrees at –25°C (–13°F).

7.2.6 Suit seams shall be tested for seam strength as specified in Section 8.22 and shall have a breaking strength greater than 67 N/25 mm (15 lbf/1 in.).

7.2.7 Suit closure assemblies shall be tested for penetration resistance as specified in Section 8.23 and shall show no penetration of the test liquids for at least 1 hour.

7.2.7.1 Suit closure assemblies shall be tested for chemical penetration resistance as specified in Section 8.23 and shall show no penetration of the test liquids for at least 1 hour and for any additional chemicals or specific chemical mixtures for which the manufacturer is certifying the suit.

7.2.8 Suit closure assemblies shall be tested for closure strength as specified in Section 8.22 and shall have a breaking strength greater than 67 N/25 mm (15 lbf/1 in.).

7.3 Vapor-Protective Suit Element Visor Performance Requirements.

7.3.1 Visor materials and visor material seams shall be tested for permeation resistance as specified in Section 8.6 and shall have a cumulative permeation that does not exceed 6.0 $\mu g/cm^2$ for the 1-hour test period and a cumulative permeation that does not exceed 2.0 $\mu g/cm^2$ for each 15-minute interval within the 1-hour test period for each chemical tested.

7.3.1.1 Visor materials and visor material seams shall be tested for permeation resistance as specified in Section 8.26 and shall not exceed a cumulative permeation of 1.25 $\mu g/cm^2$ for the chemical warfare agent Soman (GD or O-Pinacolyl methylphosphonofluoridate).

7.3.1.2 Visor materials and visor material seams shall be tested for permeation resistance as specified in Section 8.26 and shall not exceed a cumulative permeation of 4 $\mu g/cm^2$ for the chemical warfare agent sulfur mustard, distilled [HD or bis (2-chloroethyl) sulfide].

7.3.1.3 Visor materials and visor material seams shall be tested for permeation resistance as specified in Section 8.6, and shall have a cumulative permeation that does not exceed 6.0 $\mu g/cm^2$ for the 1-hour test period and a cumulative permeation that does not exceed 2.0 $\mu g/cm^2$ for each 15-minute interval within the 1-hour test period for each additional chemical or specific chemical mixture for which the manufacturer is certifying the ensemble.

7.3.2 Visor materials shall be tested for resistance to flame impingement as specified in Section 8.7 and shall have an afterflame time of not greater than 2.0 seconds and shall not melt and drip.

7.3.3 Visor materials shall be tested for high mass impact as specified in Section 8.27 and shall not have full-thickness cracks, holes, or fractures.

7.3.4 Visor material shall be tested for cold temperature bending as specified in Section 8.14 and shall not crack or show evidence of visible damage.

7.3.5 Visor material seams shall be tested for seam strength as specified in Section 8.22 and shall have a breaking strength of not less than 67 N/25 mm (15 lbf/1 in.).

7.4 Vapor-Protective Glove Element Performance Requirements.

7.4.1 Glove materials and glove seams shall be tested for permeation resistance as specified in Section 8.6 and shall have a cumulative permeation that does not exceed 6.0 $\mu g/cm^2$ for the 1-hour test period and a cumulative permeation that does not exceed 2.0 $\mu g/cm^2$ for each 15-minute interval within the 1-hour test period for each chemical tested.

7.4.1.1 Glove materials shall be tested for permeation resistance as specified in Section 8.26 and shall not exceed a cumulative permeation of 1.25 $\mu g/cm^2$ for the chemical warfare agent Soman (GD or O-Pinacolyl methylphosphonofluoridate).

7.4.1.2 Glove materials shall be tested for permeation resistance as specified in Section 8.26 and shall not exceed a cumulative permeation of 4 $\mu g/cm^2$ for the chemical warfare agent sulfur mustard, distilled [HD or bis (2-chloroethyl) sulfide].

7.4.1.3 Glove materials and glove seams shall be tested for permeation resistance as specified in Section 8.6 and shall have a cumulative permeation that does not exceed a cumulative permeation of 6.0 $\mu g/cm^2$ for the 1-hour test period and a cumulative permeation that does not exceed 2.0 $\mu g/cm^2$ for each 15-minute interval within the 1-hour test period for each additional chemical or specific chemical mixture for which the manufacturer is certifying the ensemble.

7.4.2 Glove materials shall be tested for resistance to flame impingement as specified in Section 8.7 and shall have an afterflame time of not greater than 2.0 seconds and shall not melt and drip.

7.4.3 Glove materials shall be tested for cut resistance as specified in Section 8.15 and shall have a blade travel distance of not less than 20 mm (0.8 in.).

7.4.4 Glove materials shall be tested for puncture resistance as specified in Section 8.16 and shall have a puncture resistance of not less than 22 N (5 lbf).

7.4.5 Glove materials shall be tested for cold weather performance as specified in Section 8.12 and shall have a bending moment of less than 0.057 N·m (0.5 in.-lbf) at an angular deflection of 60 degrees and –25°C (–13°F).

7.4.6* Gloves shall be tested for dexterity as specified in Section 8.17 and shall have an average percent increase of bare-hand control of less than 600 percent.

7.5 Vapor-Protective Footwear Element Performance Requirements.

7.5.1 Footwear upper materials shall be tested for permeation resistance as specified in Section 8.6 and shall have a cumulative permeation that does not exceed 6.0 $\mu g/cm^2$ for the 1-hour test period and a cumulative permeation that does not exceed 2.0 $\mu g/cm^2$ for each 15-minute interval within the 1-hour test period for each chemical tested.

7.5.1.1 Footwear upper materials shall be tested for permeation resistance as specified in Section 8.26 and shall not exceed a cumulative permeation of 1.25 $\mu g/cm^2$ for the chemical warfare agent Soman (GD or O-Pinacolyl methylphosphonofluoridate).

7.5.1.2 Footwear upper materials shall be tested for permeation resistance as specified in Section 8.26 and shall not exceed a cumulative permeation of 4 $\mu g/cm^2$ for the chemical warfare agent sulfur mustard, distilled [HD or bis (2-chloroethyl) sulfide].

7.5.1.3 Footwear upper materials shall be tested for permeation resistance as specified in Section 8.6 and shall have a cumulative permeation that does not exceed 6.0 $\mu g/cm^2$ for the 1-hour test period and a cumulative permeation that does not exceed 2.0 $\mu g/cm^2$ for each 15-minute interval within the 1-hour test period for each additional chemical or specific chemical mixture for which the manufacturer is certifying the ensemble.

7.5.2 Footwear upper materials shall be tested for resistance to flame impingement as specified in Section 8.7 and shall have an afterflame time of not greater than 2.0 seconds and shall not melt and drip.

7.5.3 Footwear upper materials shall be tested for cut resistance as specified in Section 8.15 and have a blade travel distance of not less than 20 mm (0.8 in.).

7.5.4 Footwear upper materials shall be tested for puncture resistance as specified in Section 8.16 and have a puncture resistance of not less than 36 N (8 lbf).

7.5.5 Footwear heels and soles shall be tested for abrasion resistance as specified in Section 8.19, and the relative volume loss shall not be greater than 250 mm^3.

7.5.6 Footwear soles or ladder shanks shall be tested for bending resistance as specified in Section 8.20 and shall not deflect more than 6 mm (¼ in.).

7.5.7 Footwear soles and heels shall be tested for slip resistance as specified in Section 8.21 and shall have a coefficient of 0.40 or greater.

7.5.8 Footwear toes shall be tested for impact and compression resistance as specified in Section 8.29, and shall have an impact resistance of not less than 101.7 J (75 ft-lb) and shall have a compression resistance of not less than 11,121 N (2500 lbf).

7.5.9 Footwear soles and heels shall be tested for puncture resistance as specified in Section 8.28 and shall show no puncture.

7.6 Optional Liquefied Gas Protection Performance Requirements for Vapor-Protective Ensembles and Ensemble Elements.

7.6.1 Vapor-protective ensembles and ensemble elements that will be certified as compliant with the additional *optional* crite-

ria for liquefied gas protection for escape only shall also meet all applicable requirements in Sections 7.1 through 7.5.

7.6.2 Primary suit, glove, and footwear element materials shall be tested for liquefied gas permeation resistance as specified in Section 8.6 and shall not show signs of damage and shall not exceed a cumulative permeation of 6.0 $\mu g/cm^2$ for the following list of gaseous industrial chemicals:

(1) Ammonia
(2) Chlorine
(3) Ethylene oxide

7.7 Optional Chemical Flash Fire Protection Performance Requirements for Vapor-Protective Ensembles and Ensemble Elements.

7.7.1 Vapor-protective ensembles and ensemble elements that will be certified as compliant with the additional *optional* criteria for chemical flash fire protection for escape only shall also meet all applicable requirements in Sections 7.1 through 7.5.

7.7.2 Vapor-protective ensembles and elements shall be tested for overall ensemble flash protection as specified by Section 8.25, and shall not have any afterflame times longer than 2 seconds, shall show an ending pressure of at least 13 mm (½ in.) water gauge in the subsequent gastight integrity testing, and shall permit visual acuity through the visor of 20/100 or better.

7.7.3 Suit materials, visor materials, glove materials, and footwear upper materials shall be tested for heat transfer performance (HTP) as specified in Section 8.18 and shall have an average HTP rating of not less than 12 cal/cm^2.

7.7.4 Primary suit, visor, glove, and footwear element materials shall be tested for resistance to flame impingement as specified in Section 8.7 and shall have afterflame time not greater than 2.0 seconds, shall not burn a distance greater than 100 mm (4 in.), and shall not melt and drip.

Chapter 8 Test Methods

8.1 Sample Preparation Procedures.

8.1.1 Application.

8.1.1.1 The sample preparation procedures contained in this section shall apply to each test method in this chapter, as specifically referenced in the sample preparation section of each test method.

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

8.1.2 Room Temperature Conditioning Procedure.

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

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

8.1.3 Flexural Fatigue Procedure for Suit Materials.

8.1.3.1 Samples shall be subjected to flexural fatigue in accordance with ASTM F392, *Standard Test Method for Flex Durability of Flexible Barrier Materials*, with the following modifications:

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

8.1.3.2 The preconditioning shall be performed according to the sequence specified in the test methods of this chapter.

8.1.4 Abrasion Procedure for Suit Materials.

8.1.4.1 Samples shall be abraded in accordance with ASTM D4157, *Standard Test Method for Abrasion Resistance of Textile Fabrics (Oscillatory Cylinder Method)*, under the following conditions:

(1) A 2.3 kg (5 lb) tension weight shall be used.
(2) A 1.6 kg (3½ lb) head weight shall be used.
(3) If the ensemble does not employ a separable inner and outer layer, the outer surface shall be abraded with an 80 grit abradant trimite open coat, or equivalent.
(4) If the ensemble employs a separable inner and outer layer, the following shall apply:
    (a) The abradant of the outer surface of the inner suit shall be the inner surface of the outer layer.
    (b) The abradant of the outer surface of the outer layer shall be 80 grit trimite open coat, or equivalent.
(5) The specimen shall be abraded for 25 continuous cycles for (3) and (4)(b) and 200 continuous cycles for (4)(a).

8.1.5 Flexural Fatigue Procedure for Gloves. Sample gloves shall be subjected to one full cycle of dexterity testing as specified in Section 8.17.

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 flexing equipment is capable of providing the angle of flex as described in FIA 1209.
    (b) The flexing equipment is capable of a flex speed of 60 ± 2 cycles per minute.
    (c) The 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.

8.1.8 Embrittlement Procedure for Suit, Visor and Faceshield, Glove, and Footwear Materials. Sample suit, visor and faceshield, glove, and footwear materials shall be embrittled in accordance with ASTM D2136, *Standard Test Method for Coated Fabrics — Low Temperature Bend Test*, with the following modifications:

(1) Embrittlement shall be conducted in a freezer having a temperature no higher than –25°C (–13°F).
(2) The material sample shall first be placed on a flat sheet of dry ice with outer surface of the material in contact with the dry ice for a period of 15 minutes under a pressure of 3.5 kPa (½ psi).
(3) The material sample shall be removed from the dry ice after 15 minutes of contact and immediately placed in the test apparatus.
(4) The bending action of the test apparatus shall be immediately activated while the sample is still in the freezer.

8.1.9 Elevated Temperature and Humidity Conditioning Procedure.

8.1.9.1 Samples or specimens shall be conditioned at a temperature of 32°C, ±2°C (90°F, ±4°F) and a relative humidity of 80 percent, ±5 percent until equilibrium is reached, as specified in ASTM D1776, *Standard Practice for Conditioning and Testing Textiles*, or for at least 24 hours.

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

8.2 Gastight Integrity Test.

8.2.1 Application.

8.2.1.1 This test method shall apply to vapor-protective ensembles and to glove and footwear elements.

8.2.1.2 Modifications to this test method for testing vapor-protective ensembles shall be as specified in 8.2.7.

8.2.1.3 Modifications to this test method for testing glove elements shall be as specified in 8.2.8.

8.2.1.4 Modifications to this test method for testing footwear elements shall be as specified in 8.2.9.

8.2.2 Sample Preparation.

8.2.2.1 Samples shall be complete vapor-protective ensemble, glove elements, or footwear elements.

8.2.2.2 Samples shall be conditioned as specified in 8.1.2.

8.2.3 Specimens.

8.2.3.1 Specimens shall be complete vapor-protective ensemble, glove elements, and footwear elements.

8.2.3.2 At least 3 specimens shall be tested.

8.2.3.3 Where the vapor-protective ensemble consists of multiple separate layers, and outer layers are not considered gastight, then only the portion of the vapor-protective suit that is considered gastight shall be tested.

8.2.4 Procedure.

8.2.4.1 Specimens shall be tested in accordance with ASTM F1052, *Standard Test Method for Pressure Testing of Vapor-Protective Ensembles*.

8.2.4.2 The following pressures shall be used during testing:

(1) Pre-test expansion pressure of 125 mm (5 in.) water gauge
(2) Test pressure of 100 mm (4 in.) water gauge

8.2.5 Report. The ending pressure shall be recorded and reported for each specimen.

8.2.6 Interpretation.

8.2.6.1 The pressure upon completion of the inflation test shall be used to determine pass or fail performance.

8.2.6.2 Any one specimen failing the test shall constitute failure of the test.

8.2.7 Specific Requirements for Testing Vapor-Protective Ensembles.

8.2.7.1 A minimum of one vapor-protective ensemble shall be tested.

8.2.7.2 Where the vapor-protective suit consists of multiple separate layers, and outer layers are not considered gastight, then only the portion of the vapor-protective suit that is considered gastight shall be tested.

8.2.7.3 Ensembles failing the test shall be permitted to be repaired. A report indicating the repairs made shall be provided by the manufacturer.

8.2.8 Specific Requirements for Testing Glove Elements.

8.2.8.1 A minimum of one pair of gloves shall be tested.

8.2.8.2 A test fixture that provides a gastight seal with the cuff of the glove shall be utilized.

8.2.8.3 The fixture shall have a valved port to allow air introduction and pressure measurement.

8.2.8.4 The test fixture shall be permitted to be a vapor-protective suit.

8.2.8.5 Gloves failing this test shall not be permitted to be repaired.

8.2.9 Specific Requirements for Testing Footwear Elements.

8.2.9.1 A minimum of one pair of footwear shall be used.

8.2.9.2 A test fixture that provides a gastight seal with the footwear shall be utilized.

8.2.9.3 The fixture shall have valved port to allow air introduction and pressure measurement.

8.2.9.4 The test fixture shall be permitted to be a vapor-protective suit.

8.2.9.5 Repairs to footwear failing this test shall not be permitted.

8.3 Liquidtight Integrity Test.

8.3.1 Application.

8.3.1.1 This test method shall apply to complete vapor-protective ensembles.

8.3.2 Sample Preparation.

8.3.2.1 Samples shall be complete ensembles.

8.3.2.2 Samples shall be conditioned as specified in 8.1.2.

8.3.3 Specimens.

8.3.3.1 Specimens shall be complete ensembles with all layers assembled that are required for the ensemble to be compliant.

8.3.3.2 At least one specimen shall be tested.

8.3.3.3 Where the vapor-protective ensemble consists of multiple separate layers, and outer layers are not considered gastight, then only the portion of the vapor-protective suit that is considered gastight shall be tested.

8.3.4 Apparatus. The apparatus and supplies for testing shall be those specified in ASTM F1359, *Standard Test Method for Liquid Penetration Resistance of Protective Clothing or Protective Ensembles Under a Shower Spray While on a Mannequin*, using the following modifications:

(1) The surface tension of the water used in testing shall be 34 dynes/cm, ±2 dynes/cm.
(2) The manikin used in testing shall have straight arms and legs, with arms positioned at the manikin's side.
(3) The absorptive garment shall cover all portions of the manikin that are covered by the test specimen.

8.3.5 Procedure. Liquidtight integrity testing of garments shall be conducted in accordance with ASTM F1359, *Standard Test Method for Liquid Penetration Resistance of Protective Clothing or Protective Ensembles Under a Shower Spray While on a Mannequin*, with the following modifications:

(1) The method used for mounting the manikin in the spray chamber shall not interfere with the water spray.
(2) The suited manikin shall be exposed to the liquid spray for a total of 1 hour, 15 minutes in each of the four specified manikin orientations.
(3) At the end of the liquid spray exposure period, excess liquid shall be removed from the surface of the specimen.
(4) The specimen shall be inspected within 5 minutes of the end of the liquid spray exposure period for evidence of liquid penetration.

8.3.6 Report.

8.3.6.1 A diagram shall be prepared for each test.

8.3.6.2 The diagram shall identify, record, and report the locations of any liquid leakage as detected on the interior of the vapor-protective ensemble or the liquid-absorptive suit.

8.3.7 Interpretation.

8.3.7.1 Water penetration into the interior of the ensemble shall be based on any evidence of liquid inside the specimen or on the interior of the vapor-protective ensemble, as determined by visual or tactile means, or absorbent toweling.

8.3.7.2 Water penetration between layers of the gloves shall be determined if outer gloves are to be worn in conjunction with chemical-protective suit gloves and if the outer gloves partially or completely fill with liquid.

8.3.7.3 Water penetration between layers of foot protection shall be determined if outer boots are to be worn in conjunction with suit booties to meet the foot protection requirements and if the outer boots partially or completely fill with liquid.

8.4 Overall Ensemble Function and Integrity Test.

8.4.1 Application. This test method shall apply to vapor-protective ensembles.

8.4.2 Sample Preparation.

8.4.2.1 Samples shall be complete vapor-protective ensembles.

8.4.2.2 Samples shall be conditioned as specified in 8.1.2.

8.4.3 Specimens.

8.4.3.1 Specimens shall be complete vapor-protective ensembles.

8.4.3.2 At least three specimens shall be tested using a different test subject for each specimen.

8.4.3.3 Where the vapor-protective ensemble consists of multiple separate layers, and outer layers are not considered gastight, then only the portion of the vapor-protective suit that is considered gastight shall be tested.

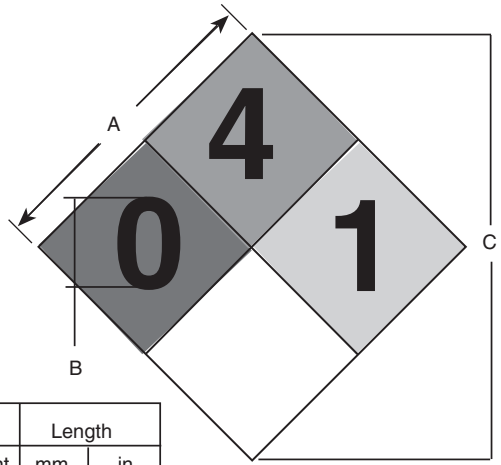
8.4.4 Apparatus. The equipment and supplies specified in ASTM F1154, *Standard Practices for Qualitatively Evaluating the Comfort, Fit, Function, and Durability of Protective Ensembles and Ensemble Components*, shall be used along with the following additional items:

(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 an NFPA 704 placard relative to the test subject
(4) NFPA 704-based placard as seen in Figure 8.4.4

8.4.5 Procedure.

8.4.5.1 Suit 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 exercise procedures A and B shall be used.
(2) Ensembles tested shall meet the sizing range of the test subject as determined in 5.3.1.4. The suit shall be donned in accordance with the manufacturer's instructions.
(3) Testing shall be conducted at 25°C, ±7°C (77°F, ±10°F) and relative humidity of 50 percent, ±20 percent.
(4) Test subjects shall wear head protection meeting the dimensional requirements of Type I, Class G helmets of ANSI Z89.1, *Standard for Industrial Head Protection,* while carrying out the exercise protocols.



	Length	
Measurement	mm	in.
A	64	2.5
B	25	1
C	90	3.5

FIGURE 8.4.4 NFPA 704 Placard.

(5) Test subjects shall wear underclothing in accordance with the manufacturer's recommendations, or in lieu of a detailed recommendation, a full-body coverall.
(6) Test subjects shall wear a self-contained breathing apparatus (SCBA) that is compliant with NFPA 1981

8.4.5.2 Visual acuity testing shall be conducted using the eye chart, with a normal lighting range of 100 through 150 footcandles (fc) at the chart and with the test subject positioned at a distance of 6.1 m (20 ft) from the chart.

8.4.5.2.1 The test subject shall have a minimum visual acuity of 20/20 in each eye, uncorrected or corrected, as determined in a visual acuity test or doctor's examination.

8.4.5.2.2 The test subject shall read the standard eye chart through the lens of the SCBA facepiece and suit visor to determine the ensemble visor's impact on the test subject's visual acuity.

8.4.5.3 The field of vision for the test subject shall be assessed for the up, down, left, and right orientation angles using 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) off of the ground/–0.1 m away from the eye of the test subject and perpendicular to field of view line of sight being measured.

8.4.5.4 At the end of all testing, the test subject shall be instructed to remove his or her hands from each of the gloves while still wearing the suit, touch the bypass valve on 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 a total of five times. The time for completing this action shall be timed using a stopwatch or other suitable timing device.

8.4.5.5 Gastight integrity shall be measured as specified in Section 8.2 upon completion of the exercise protocols.

8.4.6 Report.

8.4.6.1 The end suit pressure shall be recorded and reported.

8.4.6.2 The ability of the test subject to satisfactorily complete all exercises while wearing head protection meeting the dimensional requirements of Type I, Class G helmets of ANSI Z89.1, *Standard for Industrial Head Protection*, shall be recorded and reported.

8.4.6.3 The visual acuity of the test subject when in and out of the suit shall be recorded and reported.

8.4.6.4 The angular degree for the up, down, left, and right defining the field of vision shall be measured and reported. The average angular degree for each direction for all test subjects shall be calculated and reported.

8.4.6.5 The time for each test subject to completely remove his or her hands from the gloves and reinsert his or her hands into the gloves five times sequentially shall be recorded and reported. The average time for all test subjects shall be calculated and reported.

8.4.7 Interpretation.

8.4.7.1 Following the test subject exercises, an ending suit pressure after inflation testing in accordance with Section 8.2 shall be used to determine pass or fail performance.

8.4.7.2 The ability of the test subject to satisfactorily complete all exercises while wearing head protection meeting the dimensional requirements of Type I, Class G helmets of ANSI Z89.1, *Standard for Industrial Head Protection*, shall be used to determine pass or fail performance.

8.4.7.3 The visual acuity of the test subject when inside the suit shall be used for determining pass or fail performance.

8.4.7.4 The average angular field of vision shall be used to determine pass or fail performance in each direction.

8.4.7.5 The average time for all test subjects to completely remove their hands from the gloves and reinsert their hands into the gloves five times sequentially shall determine pass or fail performance.

8.5 Maximum Suit Ventilation Rate Test.

8.5.1 Application. This test method shall apply to vapor-protective ensembles.

8.5.2 Sample Preparation.

8.5.2.1 Samples shall be complete vapor-protective ensembles.

8.5.2.2 Samples shall be conditioned as specified in 8.1.2.

8.5.3 Specimens.

8.5.3.1 Specimens shall be complete vapor-protective ensembles.

8.5.3.2 At least one specimen shall be tested.

8.5.3.3 The test specimen shall include all outer wear and other items required for the vapor-protective ensemble to be compliant with this standard.

8.5.4 Apparatus.

8.5.4.1 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 vapor-protective suit to be tested as indicated in Figure 8.5.4.1. 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.

8.5.4.2 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.

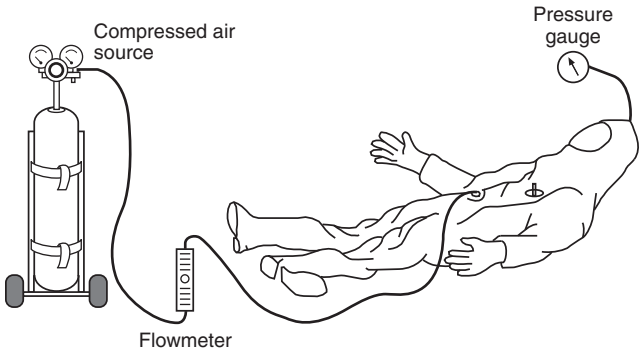


FIGURE 8.5.4.1 Configuration of Whole Suit Maximum Airflow Test.

8.5.4.3 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 vapor-protective suit.

8.5.5 Procedure.

8.5.5.1 Following the attachment of the two connectors, the gastight integrity of the suit shall be tested as specified in Section 8.2.

8.5.5.2 During the test, the pressure gauge specified in 8.5.5.3 shall be attached to one bulkhead connector; the other bulkhead connector shall be plugged.

8.5.5.2.1 During the test, a soapy water solution shall be applied around the edges of the connectors to assure that no leakage occurs through the installed suit wall connectors.

8.5.5.2.2 The remaining steps of this procedure shall be completed only if the sample suit shows an ending pressure of 80 mm (3 3/16 in.) water column gauge or higher.

8.5.5.3 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.

8.5.5.4 Beginning at time zero, air shall be flowed into the suit at a rate of 500 L/min.

8.5.5.5 After a period of 5 minutes, the pressure at the head connector shall be measured.

8.5.5.6 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 8.2.

8.5.6 Report.

8.5.6.1 The maximum internal suit pressure during the airflow period shall be recorded and reported.

8.5.6.2 The ending suit pressure for the gastight integrity tests before and after the airflow period shall be recorded and reported.

8.5.7 Interpretation.

8.5.7.1 The maximum internal suit pressure shall be used to determine pass or fail performance.

8.5.7.2 The ending pressure after suit inflation testing subsequent to the maximum suit ventilation test shall be used to determine compliance.

8.6 Chemical Permeation Resistance Test One.

8.6.1 Application.

8.6.1.1 This test method shall apply to suit, visor, glove, and footwear element materials, and shall apply to selected elements' seams.

8.6.1.2 Modifications to this test method for testing suit materials after flexing and abrading shall be as specified in 8.6.7.

8.6.1.3 Modifications to this test method for testing glove materials after abrading shall be as specified in 8.6.8.

8.6.1.4 Modifications to this test method for testing footwear materials after abrading shall be as specified in 8.6.9.

8.6.1.5 Modifications to this test method for testing seams shall be as specified in 8.6.10.

8.6.1.6 Modifications to this test for testing primary materials against liquefied gases shall be as specified in 8.6.11.

8.6.2 Sample Preparation.

8.6.2.1 Samples shall be either vapor-protective ensembles or suit materials, visor materials, gloves, and footwear of the sizes specified in the modifications.

8.6.2.2 Samples shall be conditioned as specified in 8.1.9 after the conditioning specified in the modifications.

8.6.3 Specimens.

8.6.3.1 Specimens shall be the size specified in ASTM F739, *Standard Test Method for Permeation of Liquids and Gases Through Protective Clothing Materials Under Conditions of Continuous Contact*.

8.6.3.2 At least three specimens shall be tested per chemical challenge.

8.6.3.3 For composite materials, only the chemical protection layer shall be the sample for testing for chemical permeation resistance.

8.6.4 Procedures.

8.6.4.1* Permeation resistance shall be measured in accordance with ASTM F739, *Standard Test Method for Permeation of Liquids and Gases Through Protective Clothing Materials Under Conditions of Continuous Contact*, with the following modifications:

(1) Total cumulative permeation shall be measured for a period of 1 hour, +1 minute, –0 minutes, and each 15-minute interval of the 1-hour exposure.
(2) Testing shall be performed at a temperature of 32°C, ±2°C (90°F, ±4°F).
(3) The minimum detectable cumulative permeation mass shall be determined for each chemical tested and shall be at least 0.6 μg/cm^2 or lower.

8.6.4.2 Permeation resistance shall be measured for each of the following chemicals at ≥95 percent concentration unless noted otherwise, with gases at a concentration of 99.0 percent or greater, except as indicated in the following list:

(1) Acetone
(2) Acetonitrile
(3) Acrolein
(4) Acrylonitrile
(5) Anhydrous ammonia (gas)
(6) 1,3-Butadiene (gas)
(7) Carbon disulfide
(8) Chlorine (gas)
(9) Dichloromethane
(10) Diethyl amine
(11) Dimethyl formamide
(12) Dimethyl sulfate
(13) Ethyl acetate
(14) Ethylene oxide (gas)
(15) Hexane
(16) Hydrogen chloride (gas)
(17) Methanol
(18) Methyl chloride (gas)
(19) Nitrobenzene

(20) Sodium hydroxide, 50 percent w/w
(21) Sulfuric acid, 96.1 percent w/w
(22) Tetrachloroethylene
(23) Tetrahydrofuran
(24) Toluene

8.6.5 Report.

8.6.5.1 The following information and results shall be recorded and reported:

(1) Material type or name
(2) Chemical or chemical mixture (volume composition of mixture)
(3) Cumulative permeation mass ($\mu g/cm^2$) for each 15-minute interval and for the entire 1-hour test period
(4) Minimum detectable cumulative permeation mass ($\mu g/cm^2$)
(5) Detection method
(6) Date of test
(7) Testing laboratory

8.6.5.2 The average cumulative permeation mass shall be determined for each chemical for each 15-minute exposure interval and for the entire 1-hour test period.

8.6.5.2.1 If no chemical is detected for any replicate permeation resistance test, then the cumulative permeation mass used for that replicate shall be the minimum detectable cumulative permeation mass for purposes of calculating the average cumulative permeation mass.

8.6.5.2.2 If no chemical is detected for all replicates in a specific chemical test, then the average cumulative permeation mass shall be reported as a value less than the minimum detectable cumulative permeation mass.

8.6.5.3 The manufacturer shall report the average cumulative permeation masses for each 15-minute exposure interval and for the entire 1-hour test period in the technical data package.

8.6.6 Interpretation. The average cumulative permeation mass for each 15-minute exposure interval and for the total 1-hour exposure period shall be used in determining compliance for the particular material/chemical combination.

8.6.7 Specific Requirements for Testing Suit Materials After Flexing and Abrading.

8.6.7.1 Samples for conditioning shall be 200 mm × 280 mm (8 in. × 11 in.) rectangles and shall consist of all layers as configured in the suit.

8.6.7.2 Two samples shall first be conditioned by flexing as specified in 8.1.3.

8.6.7.2.1 One sample shall be flexed with the longitudinal axis parallel to the machine direction of the material, and the second sample shall be flexed with the longitudinal axis parallel to the cross-machine direction of the material.

8.6.7.2.2 Following flexing, two samples for abrasion conditioning, each measuring 45 mm × 230 mm (1 ¾ in. × 9 in.), shall be cut from the center of the flexed samples.

8.6.7.2.3 At least one specimen for abrasion conditioning shall be taken from a sample flexed in the machine direction, and at least one specimen for abrasion conditioning shall be taken from a sample flexed in the cross-machine direction for each chemical tested.

8.6.7.3 These new samples for abrasion conditioning shall then be conditioned by abrading as specified in 8.1.4.

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

8.6.7.3.2 The permeation test specimen shall be taken from the exact center of the abraded sample so that the center of the permeation test and the center of the abraded sample coincide.

8.6.8 Specific Requirements for Testing Glove Materials After Abrading.

8.6.8.1 Samples for conditioning shall be whole glove components or whole glove individual elements.

8.6.8.2 Three samples for abrasion conditioning, each measuring 45 mm × 230 mm (1 ¾ in. × 9 in.), shall be cut from the gauntlet portion of the sample.

8.6.8.3 These new samples for abrasion conditioning shall then be conditioned by abrading as specified in 8.1.4.

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

8.6.8.3.2 The permeation test specimen shall be taken from the exact center of the abraded sample so that the center of the permeation test and the center of the abraded sample coincide.

8.6.9 Specific Requirements for Testing Footwear Materials After Abrading.

8.6.9.1 This test shall apply to all types of footwear configurations. Where the footwear incorporates a bootie constructed of suit material, the suit material flex fatigue resistance test shall be permitted to be substituted for this test.

8.6.9.2 Samples for conditioning shall be whole footwear components or whole footwear individual elements.

8.6.9.3 Samples for abrasion conditioning, each measuring 45 mm × 230 mm (1 ¾ in. × 9 in.), shall be cut from the center of the footwear upper.

8.6.9.4 The samples for abrasion conditioning shall then be conditioned by abrading as specified in 8.1.4.

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

8.6.9.4.2 The permeation test specimen shall be taken from the exact center of the abraded sample so that the center of the permeation test and the center of the abraded sample coincide.

8.6.10 Specific Requirements for Testing Seams.

8.6.10.1 Seam specimens shall be prepared from seam samples that have a minimum of 150 mm (6 in.) of material on each side of the seam center.

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

8.6.10.3 Seam specimens shall be prepared representing each different seam or shall be taken from each different type of

seam found in the vapor-protective suit, including as a minimum the suit-to-suit material seams and the suit-to-visor material seams.

8.6.10.4 Samples for conditioning shall be 600 mm (23 $^{9}/_{16}$ in.) lengths of prepared seam or cut from vapor-protective ensembles.

8.6.11 Specific Requirements for Testing Primary Materials Against Liquefied Gases.

8.6.11.1 Samples for conditioning shall be suit material, visor material, glove material from the glove gauntlet, and footwear material from the footwear upper.

8.6.11.1.1 Glove material specimens shall include all layers used in construction of the glove system.

8.6.11.1.2 Where the footwear consists of a bootie and outer boot, the footwear specimens shall include all layers in the footwear system.

8.6.11.2 Specimens shall be conditioned as specified in 8.1.8. Specimens shall be exposed on their normal outside surface.

8.6.11.3 Only one specimen for permeation resistance testing shall be taken from each sample subjected to embrittlement conditioning. The permeation test specimen shall be taken from the exact center of the folded sample so that the center of the permeation test and the center of the folded sample coincide.

8.6.11.4 The test cell and test chemical shall be maintained at a temperature sufficient to keep the test chemical as a liquid at ambient pressure such that a 13 mm (½ in.) liquid layer is maintained at all times during the test.

8.6.11.5 Cumulative permeation shall be measured for a period of 15 minutes, +1 minute, –0 minutes.

8.7 Flammability Resistance Test.

8.7.1 Application.

8.7.1.1 This test method shall be applied to suit, visor, glove, and footwear element materials.

8.7.1.2 Modifications to this test method for base ensemble performance shall be as specified in 8.7.7.

8.7.1.3 Modifications to this test method for optional chemical flash fire protection performance shall be as specified in 8.7.8.

8.7.2 Sample Preparation.

8.7.2.1 Samples for conditioning shall be at least 1 m (1 yd) squares of material.

8.7.2.2 Samples shall be conditioned as specified in 8.1.2.

8.7.3 Specimens.

8.7.3.1 Specimens shall be the size specified in ASTM F1358, *Standard Test Method for Effects of Flame Impingement on Materials Used in Protective Clothing Not Designated Primarily for Flame Resistance.*

8.7.3.2 Five specimens in each of the warp directions, machine or coarse, and the filling directions, cross-machine or wale, shall be tested.

8.7.3.3 Where the material is isotropic, 10 specimens shall be tested.

8.7.4 Procedure. Flame resistance testing shall be conducted in accordance with ASTM F1358, *Standard Test Method for Effects of Flame Impingement on Materials Used in Protective Clothing Not Designated Primarily for Flame Resistance,* with the following modifications:

(1) The test apparatus shall include the test cabinet and accessories, burner, and gas regulation system, as specified in Sections 6.1, 6.2, and 6.3 of ASTM D6413, *Standard Test Method for Flame Resistance of Textiles (Vertical Test).*
(2) Specimens shall be observed for the combination of both melting and dripping.

8.7.5 Report.

8.7.5.1 Afterflame times shall be recorded and reported for each specimen and as the average for each material direction.

8.7.5.2 Burn distances shall be recorded and reported for each specimen and as the average for each material direction.

8.7.5.3 Ignition during the initial 3-second exposure shall be recorded and reported for each specimen.

8.7.5.4 Evidence of both melting and dripping during the 12-second exposure period shall be recorded and reported for each specimen.

8.7.6 Interpretation.

8.7.6.1 Ignition of any individual specimen during the initial 3-second exposure shall be used to determine compliance with the ignition requirements.

8.7.6.2 The average afterflame time in any direction shall be used to determine compliance with the afterflame requirements.

8.7.6.3 The average burn distance in any direction shall be used to determine compliance with burn distance requirements.

8.7.6.4 Evidence of both melting and dripping of any specimen shall be used to determine compliance with melting and dripping requirements.

8.7.7 Specific Requirements for Testing Base Ensemble Materials.

8.7.7.1 Only the 3-second flame exposure shall be used.

8.7.7.2 Burn distances and afterflame times shall only be determined for the 3-second exposure.

8.7.8 Specific Requirements for Testing Optional Chemical Flash Fire Protection Ensemble Materials.

8.7.8.1 Only the 12-second flame exposure shall be used.

8.7.8.2 Burn distances and afterflame times shall be determined only for the 12-second exposure.

8.8 Man-in-Simulant Test (MIST).

8.8.1 Application. This test shall apply to complete vapor-protective ensembles.

8.8.2 Samples.

8.8.2.1 Samples for conditioning shall be complete ensembles.

8.8.2.2 Samples shall be conditioned as specified in 8.1.2.

8.8.3 Specimens.

8.8.3.1 The specimens shall be a complete ensemble with gloves and footwear.

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

8.8.3.3 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.

8.8.3.4 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.

8.8.3.5* 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.

8.8.3.6 Underclothing and socks shall be permitted to be reused, provided they have been laundered with a detergent that has been demonstrated not to cause interference with the analytical method.

8.8.4 Apparatus.

8.8.4.1 Test Facility.

8.8.4.1.1 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.

8.8.4.1.2 The test shall be conducted in a test chamber with a minimum volume of sufficient dimensions to permit free movement of the test subject(s) when fully dressed in the ensemble and for the test subject(s) to carry out the physical exercise routine specified in 8.8.5.8.

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

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

8.8.4.2 Test Chemical and Analytical Equipment.

8.8.4.2.1 The test simulant shall be methyl salicylate (MeS; $C_8H_8O_3$) 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).

8.8.4.2.2* The standard concentration of MeS in the vapor chamber shall be 150 mg/m^3, ±10 mg/m^3, as measured by a real-time infrared analysis of the chamber air or other validated real-time analytical technique.

8.8.4.2.3 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.

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

8.8.4.2.5 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.

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

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

8.8.4.4 Test Subjects.

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

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

8.8.5 Procedure.

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

8.8.5.2 PADs shall be placed on test subjects at the body region locations shown in Figure 8.8.5.2.

8.8.5.2.1 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.

8.8.5.2.2 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.

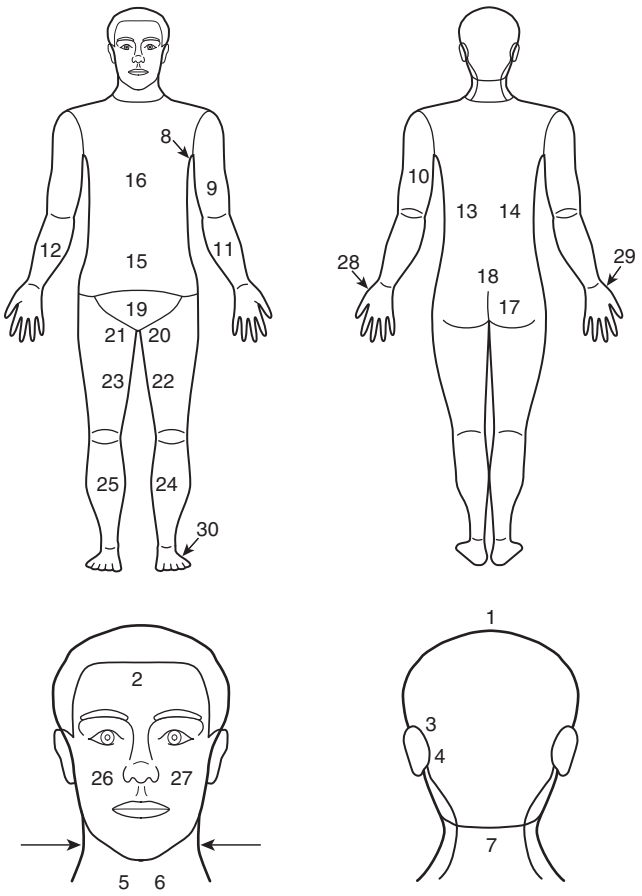
8.8.5.3 Three additional PADs shall be used to conduct background sampling and for quality control during the trial. These PADs shall be located in the dressing area, the stage 1 undress area, and the stage 2 undress area.

8.8.5.4 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.

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

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

8.8.5.7 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.



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 8.8.5.2 Locations of PADs on Test Subjects.

8.8.5.8 Physical Exercise Routine.

8.8.5.8.1 Once the chamber concentration has been established, the test subject(s) shall perform the following physical activity protocol and 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.

8.8.5.8.2 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.

8.8.5.8.3 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.

8.8.5.8.4 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.

8.8.5.8.5 For activities 8.8.5.8.1(7) (walking in place) and 8.8.5.8.1(8) (crawling in place), the test subject shall rotate 90 degrees on 15-second intervals during the 1-minute period.

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

8.8.5.9 Decontamination and Doffing.

8.8.5.9.1 After completion of the 30-minute MIST exposure, the test 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.

8.8.5.9.2 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.

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

8.8.5.9.2.2 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.

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

8.8.5.9.4 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.

8.8.5.9.5 As soon as all items of clothing, except the underwear, are removed, the decontaminated test subject shall proceed to the second stage undressing room and the background PADs shall be collected and handled as specified in 8.8.5.9.7. The exposure time for the first stage undressing room background PADs shall be recorded.

8.8.5.9.6 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 8.8.5.9.7. The exposure time for the second stage undressing room PADs shall be recorded.

8.8.5.9.7 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 minutes, ±5 minutes, immediately after exposure.

8.8.6 PAD Qualification and Analysis.

8.8.6.1 The uptake rate for each lot of PADs shall be determined in accordance with 8.8.6.2 using a minimum of seven PADs selected randomly from the lot.

8.8.6.2* Measurement of PAD Uptake Rate.

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

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

8.8.6.2.2 The PAD uptake rate shall be calculated in accordance with the procedures provided in 8.8.6.4. The average of all PAD uptake rates shall be calculated and used in the calculation of MeS dosage on the test subject PADs.

8.8.6.3 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.

8.8.6.3.1 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 minutes, +5 minutes, –0 minutes. After this exposure, the PADs shall be covered in foil and each placed in a sealed container and stored at 25°C, ±3°C (77°F, ±5°F) for 30 minutes, ±5 minutes. Four of these PADs shall be packed in dry ice for 24 hours, four placed in the proposed cold storage temperature for 24 hours, and four extracted 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.

8.8.6.3.2 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.

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

[8.8.6.4]

$$u = m / ACt$$

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

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

8.8.6.5.1 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 4 MeS concentration standards accounting for the proper density of the extraction solvent.

8.8.6.6 For the test results to be considered valid for a given ensemble, no more than one PAD from each of the body region locations tested (i.e., no more than one PAD out of the four replicates for any particular region) shall be permitted to be lost to analysis over the course of the four test subjects.

8.8.7 Calculations.

8.8.7.1 The dosage measured by each PAD ($Ct_{inside,i}$) shall be determined using the average uptake rate determined for the PAD lot used in the evaluation of a specific ensemble using the following equation:

[8.8.7.1]

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

where:
$Ct_{inside,i}$ = the MeS vapor dosage at the specific PAD in mg/min/cm^3

m_i = the total mass of MeS measured on the specific PAD in mg
u_{avg} = the average uptake of the PAD lot in cm/min
A = the average active area of the PA in cm^2

8.8.7.1.1 The protection factor at each PAD location shall be calculated using the following equation:

[8.8.7.1.1]

$$PF_i = Ct_{outside} / Ct_{inside.i}$$

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 MeS concentration readings taken during the course of the test subject exposure period.

8.8.7.1.2 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.

8.8.7.2 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:

[8.8.7.2]

$$Local\ PPDF_i = (OSED_i / 25) * PF$$

where:
OSED = onset of symptoms exposure dosages
PF = protection factor

8.8.7.2.1* 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 8.8.7.2.1.

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

8.8.7.3 A systemic *PPDF* shall also be calculated from the PAD data. The systemic protection analysis shall use the systemic weighting body region hazard analysis values from the Defense Research Establishment Suffield Report and National Research Council Report to calculate the systemic physiological protective dosage factor for each ensemble test ($PPDF_{sys}$). The $PPDF_{sys}$ for each specimen is calculated as follows, where each of the terms is calculated using the information in Table 8.8.7.3.

Table 8.8.7.2.1 Site-Specific OSED by PAD Location

Body Region	PAD Location	OSED (mg·min·m^{-3})
Head/neck	1, 2, 3, 4, 5, 6, 7, 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

[8.8.7.3]

$$PPDF_{sys} = \sum_1 (dz_i / ED_{50i}) / \sum_i (dz_i / ED_{50i} * PF_i)$$

8.8.7.3.1 The average $PPDF_{sys}$ for all specimens tested shall be calculated.

8.8.7.3.2* The protection factor PF_i used in the calculation of $PPDF_{sys}$ shall be the average *PF* of all PADs in a specific body region.

8.8.8 Report.

8.8.8.1 The individual specimen and average local $PPDF_i$ values for each PAD location shall be recorded and reported.

Table 8.8.7.3 ED_{50i} Values by PAD and Body Location

Body Region *i* for BRHA Model	PADs Mapped to This Region (Average Dosage from Each PAD, Then Calculate PF_i)	Area of Body Region (dz_i, cm^2)	ED_{50i} for Severe Effects (VX) for Body Region (mg/Individual)
Scalp	1, 2	350	0.76
Ears	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

8.8.8.2 The $PPDF_{sys}$ value for each specimen and the average $PPDF_{sys}$ value for the ensemble tested shall be recorded and reported.

8.8.8.3 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) Each individual and the average PAD uptake rate
(5) The measured MeS mass on each PAD used in the dressing room, stage 1 undressing room, and stage 2 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

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

8.9 Exhaust Valve Mounting Strength Test.

8.9.1 Application. This test method shall apply to exhaust valves mounted in vapor-protective ensembles.

8.9.2 Sample Preparation.

8.9.2.1 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 vapor-protective ensemble.

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 complete exhaust valve assemblies mounted into a piece of vapor-protective ensembles material.

8.9.3.2 At least three specimens shall be tested.

8.9.4 Apparatus.

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

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

8.9.4.1.2 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.

8.9.4.1.3 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.

8.9.4.2 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.

8.9.4.3 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 loading 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.

8.9.5 Procedure.

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

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

8.9.5.3 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.

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

8.9.6 Report.

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

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

8.9.7 Interpretation. The average mounting strength shall be used to determine pass or fail performance.

8.10 Burst Strength Test.

8.10.1 Application.

8.10.1.1 This test shall apply to vapor-protective suit elements.

8.10.1.2 Where vapor-protective suits are constructed of several separable layers, then all layers, assembled in the order in which they appear in the suit, shall be tested as a composite.

8.10.2 Sample Preparation.

8.10.2.1 Samples shall be at least 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 the size specified in ASTM D751, *Standard Methods of Testing Coated Fabrics*.

8.10.3.2 At least 10 specimens shall be tested.

8.10.4 Procedure. Material burst strength shall be measured in accordance with ASTM D751, *Standard Methods of Testing*

Coated Fabrics, using the tension testing machine with ring clamp.

8.10.5 Report. The burst strength of each specimen shall be recorded and reported to the nearest 1 N (¼ lbf). The average burst strength of all specimens shall be calculated, recorded, and reported.

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

8.11 Puncture Propagation Tear Resistance Test.

8.11.1 Application.

8.11.1.1 This test shall apply to vapor-protective suit elements and visor materials.

8.11.1.2 Where the suit element is constructed of several layers, then all layers, assembled in the order in which they appear in the suit, shall be tested as a composite.

8.11.2 Sample Preparation.

8.11.2.1 Samples shall be at least 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 the size specified in ASTM D2582, *Standard Test Method for Puncture Propagation Tear Resistance of Plastic Film and Thin Sheeting*.

8.11.3.2 A minimum of five specimens in each of the warp, machine or coarse, and the filling, cross-machine or wale, directions shall be tested.

8.11.3.3 If the material is isotropic, then 10 specimens shall be tested.

8.11.4 Procedure. Specimens shall be tested in accordance with ASTM D2582, *Standard Test Method for Puncture Propagation Tear Resistance of Plastic Film and Thin Sheeting*.

8.11.5 Report.

8.11.5.1 The puncture propagation tear resistance of each specimen shall be recorded and reported to the nearest 1 N (¼ lbf).

8.11.5.2 An average puncture propagation tear resistance shall be calculated, recorded, and reported for the warp and filling directions.

8.11.6 Interpretation.

8.11.6.1 Pass or fail performance shall be based on the average puncture propagation tear resistance in the warp and filling directions.

8.11.6.2 Failure in any one direction constitutes failure for the material.

8.12 Cold Temperature Performance Test One.

8.12.1 Application. This test method shall apply to vapor-protective suit element and glove element materials.

8.12.2 Sample Preparation.

8.12.2.1 Samples for conditioning shall be at least 1 m (1 yd) squares of material.

8.12.2.2 Samples shall be conditioned as specified in 8.1.2.

8.12.3 Specimens.

8.12.3.1 Specimens shall be the size specified in ASTM D747, *Standard Test Method for Apparent Bending Modulus of Plastics by Means of a Cantilever Beam*.

8.12.3.2 A minimum of five specimens consisting of all layers in each of the warp, machine or coarse, and filling, cross-machine or wale, directions shall be tested.

8.12.3.3 If the material is isotropic, then 10 specimens shall be tested.

8.12.4 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 that applied when the specimen is bent to a 60 degree angular deflection and shall be calculated in inch-pounds as follows:

[8.12.4]

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

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

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

8.13 Fitting Pull Out Strength Test.

8.13.1 Application. This test method shall apply to each type of external fitting used in vapor-protective ensembles.

8.13.2 Sample Preparation.

8.13.2.1 Samples shall be an external fitting and the suit element material assembly representative of the construction practices used to fabricate the vapor-protective suit.

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 an external fitting and suit material assembly representative of the construction practices used to fabricate the vapor-protective suit.

8.13.3.2 At least three specimens shall be tested.

8.13.4 Apparatus.

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

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

8.13.4.1.2 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.

8.13.4.1.3 The mounting ring shall be designed such that a means is provided for affixing it to the fixed (bottom) arm of a tensile testing machine.

8.13.4.2 A set of tensile machine jaws shall be used to pull the external fitting perpendicular to the surface of the suit material in which the external fitting is mounted.

8.13.4.3 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 loading range.
(5) It shall be outfitted with a load cell. The testing machine shall be configured with the compression cell on either the lower or upper arm.

8.13.5 Procedure.

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

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

8.13.5.3 The tensile testing machine shall be set in operation but shall stop when the external fitting has pulled from the material or when the material breaks along the specimen mounting ring. The tensile testing machine jaws shall have a velocity of 500 mm/min (20 in./min) under load conditions and shall be uniform at all times.

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

8.13.6 Report.

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

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

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

8.14 Cold Temperature Performance Test Two.

8.14.1 Application. This test method shall apply to visor component materials.

8.14.2 Sample Preparation.

8.14.2.1 Samples shall be at least 1 m (1 yd) squares of material consisting of all layers.

8.14.2.2 Samples shall be conditioned as specified in 8.1.2.

8.14.3 Specimens.

8.14.3.1 Specimens shall be the size specified in ASTM D2136, *Standard Test Method for Coated Fabrics — Low Temperature Bend Test.*

8.14.3.2 At least five specimens consisting of all layers shall be tested.

8.14.4 Procedure.

8.14.4.1 Specimens shall be tested in accordance with ASTM D2136, *Standard Test Method for Coated Fabrics — Low Temperature Bend Test*, at a test temperature of –25°C (–13°F).

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

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

8.14.6 Interpretation.

8.14.6.1 Damage of any one specimen shall constitute failing performance.

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

8.15 Cut Resistance Test.

8.15.1 Application.

8.15.1.1 This test method shall apply to vapor-protective glove element materials and to vapor-protective footwear element upper materials.

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

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

8.15.2 Sample Preparation.

8.15.2.1 Samples shall be whole gloves or footwear uppers.

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 the size specified in ASTM F1790, *Standard Test Methods for Measuring Cut Resistance of Materials Used in Protective Clothing.*

8.15.3.2 At least three specimens, consisting of all layers, shall be tested.

8.15.4 Procedure. Specimens shall be evaluated in accordance with ASTM F1790, *Standard Test Methods for Measuring Cut Resistance of Materials Used in Protective Clothing*, with the modification that the specimens shall be tested to a specific load with the measurement of distance of blade travel.

8.15.5 Report.

8.15.5.1 The distance of blade travel shall be recorded and reported to the nearest 1 mm (3/64 in.) for each sample specimen.

8.15.5.2 The average distance of blade travel in millimeters (inches) shall be recorded and reported for all specimens tested.

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

8.15.7 Specific Requirements for Testing Glove Materials.

8.15.7.1 Specimens shall be taken from the glove and shall not include seams.

8.15.7.2 Specimens shall consist of each composite of the glove used in the actual ensemble glove configuration, with layers arranged in the proper order.

8.15.7.3 Where a composite is identical to another composite except for additional reinforcement layer(s), the composite with no reinforcement layers shall be tested.

8.15.7.4 Cut resistance testing shall be performed under a load of 150 g (5.5 oz).

8.15.8 Specific Requirements for Testing Footwear Upper Materials.

8.15.8.1 Specimens shall be taken from the footwear upper up to the minimum height specified in 6.3.2 and shall not include seams.

8.15.8.2 Specimens shall consist of each composite of the footwear upper used in the actual ensemble footwear configuration, with layers arranged in the proper order.

8.15.8.3 Where a composite is identical to another composite except for additional reinforcement layer(s), the composite with no reinforcement layers shall be tested.

8.15.8.4 Cut resistance testing shall be performed under a load of 350 g (12.5 oz).

8.16 Puncture Resistance Test One.

8.16.1 Application.

8.16.1.1 This test shall be applied to vapor-protective glove element materials and to vapor-protective footwear element upper materials.

8.16.1.2 Modifications to this test method for testing glove materials shall be as specified in 8.16.7.

8.16.1.3 Modifications to this test method for testing footwear upper materials shall be as specified in 8.16.8.

8.16.2 Sample Preparation.

8.16.2.1 Samples shall be complete gloves or footwear upper sections.

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 at least 150 mm (6 in.) square.

8.16.3.2 At least three specimens shall be tested.

8.16.4 Procedure. Specimens shall be tested in accordance with ASTM F1342, *Standard Test Method for Resistance of Protective Clothing Materials to Puncture*, Test Method A, conducting three punctures per specimen with the modifications listed in 8.16.4.1and8.16.4.2.

8.16.4.1 Puncture probes shall be qualified first before use in testing.

8.16.4.2 The compression load cell shall be capable of discerning 0.5 N (0.1 lbf) of force in the range suitable for the material being tested. The upper limit of the load cell shall not be more than 10 times the actual puncture resistance measured for the specimens.

8.16.5 Report.

8.16.5.1 The puncture force shall be recorded and reported for each specimen to the nearest 0.5 N (0.125 lbf) of force.

8.16.5.2 The average puncture force shall be recorded and reported for all specimens tested.

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

8.16.7 Specific Requirements for Testing Glove Materials.

8.16.7.1 Specimens shall be taken from the glove and shall not include seams.

8.16.7.2 Specimens shall consist of each composite of the glove used in the actual ensemble glove configuration, with layers arranged in the proper order.

8.16.7.3 Where a composite is identical to another composite except for additional reinforcement layer(s), the composite with no reinforcement layers shall be tested.

8.16.8 Specific Requirements for Testing Footwear Upper Materials.

8.16.8.1 Specimens shall be taken from the footwear upper up to the minimum height specified in 6.3.2 and shall not include seams.

8.16.8.2 Specimens shall consist of each composite of the footwear upper used in the actual ensemble footwear configuration, with layers arranged in proper order.

8.16.8.3 Where a composite is identical to another composite except for additional reinforcement layer(s), the composite with no reinforcement layers shall be tested.

8.17 Glove Hand Function Test.

8.17.1 Application. This test shall apply to vapor-protective glove elements.

8.17.2 Sample Preparation.

8.17.2.1 Samples shall be whole glove pairs.

8.17.2.2 Samples shall be conditioned as specified in 8.1.2.

8.17.2.3 Samples shall be in new, as distributed, condition.

8.17.2.4 Samples shall not receive special softening or flexing treatments prior to testing.

8.17.3 Specimens.

8.17.3.1 Specimens shall be whole glove pairs.

8.17.3.2 At least one specimen shall be tested for each glove size.

8.17.4 Procedures. Testing shall be conducted in accordance with ASTM F2010, *Standard Test Method for Evaluation of Glove Effects on Wearer Hand Dexterity Using a Modified Pegboard Test*, using the following modifications:

(1) Each available size of gloves shall be evaluated with at least one separate test subject with the same pair of gloves.

(2) A minimum of three different glove pairs shall be evaluated.
(3) Test subjects shall be selected such that their hand dimensions are as close as possible.

8.17.5 Report. The average percent of barehanded control for all tests shall be calculated, recorded, and reported.

8.17.6 Interpretation. The average percent of barehanded control for all tests shall be used to determine pass or fail performance.

8.18 Heat Transfer Performance (HTP) Test.

8.18.1 Application. This test method shall apply to suit materials, visor materials, glove materials, and footwear upper materials.

8.18.2 Sample Preparation.

8.18.2.1 Samples shall be 150 mm × 150 mm, ±5 mm (6 in. × 6 in., ±¼ in.) and shall consist of all layers representative of the element materials to be tested, excluding any areas with special reinforcements or seams.

8.18.2.2 Samples shall be conditioned as specified in 8.1.2.

8.18.3 Specimens.

8.18.3.1 Samples shall be 150 mm × 150 mm, ±5 mm (6 in. × 6 in., ±¼ in.) and shall consist of all layers representative of the element materials to be tested, excluding any areas with special reinforcements or seams.

8.18.3.2 At least three specimens shall be tested.

8.18.3.3 Specimens shall not be stitched to hold individual layers together.

8.18.4 Apparatus. The test apparatus specified in ASTM F2700, *Standard Test Method for Unsteady-State Heat Transfer Evaluation of Flame Resistant Materials for Clothing with Continuous Heating*, shall be used.

8.18.5 Procedure. Heat transfer performance testing shall be performed in accordance with ASTM F2700, *Standard for Test Method for Unsteady-State Heat Transfer Evaluation of Flame Resistant Materials for Clothing with Continous Heating*, with the following modifications:

(1) The optional spacer shall not be used.
(2) The heat transfer performance value shall be used with calculations made using the heat flux in calories per square centimeter per second and reported as the HTP rating.

8.18.6 Report.

8.18.6.1 The individual test HTP rating of each specimen shall be recorded and reported.

8.18.6.2 The average HTP rating shall be calculated, recorded, and reported.

8.18.6.3 Where a HTP rating is greater than 60, then the HTP rating shall be reported as ">60."

8.18.7 Interpretation.

8.18.7.1 Pass or fail determinations shall be based on the average reported HTP rating of all specimens tested.

8.18.7.2 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.

8.19 Abrasion Resistance Test.

8.19.1 Application. This test method shall apply to vapor-protective footwear element soles and heels.

8.19.2 Samples.

8.19.2.1 Samples for conditioning shall be uniform cylinders of footwear soles and heel material.

8.19.2.2 Samples shall be conditioned as specified in 8.1.2.

8.19.3 Specimens.

8.19.3.1 A minimum of three specimens of the footwear soles and heel material shall be tested.

8.19.4 Procedure. Abrasion resistance shall be performed in accordance with ISO 4649, *Rubber, vulcanized or thermoplastic — Determination of abrasion resistance using a rotating cylindrical drum device,* Method A, with a vertical force of over 10 N over an abrasion distance of 40 m.

8.19.5 Report. The relative loss volume of each specimen shall be recorded and reported.

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

8.20 Ladder Shank Bend Resistance Test.

8.20.1 Application. This test method shall apply to vapor-protective footwear element ladder shanks.

8.20.2 Sample Preparation.

8.20.2.1 Samples shall be footwear ladder shanks.

8.20.2.2 Samples shall be conditioned as specified in 8.1.2.

8.20.3 Specimens.

8.20.3.1 Specimens shall be footwear ladder shanks.

8.20.3.2 At least three specimens shall be tested.

8.20.4 Apparatus.

8.20.4.1 The apparatus shall consist of a tensile testing machine, such as an Instron® or equivalent, that challenges a specimen with a simulated ladder rung.

8.20.4.2 A 32 mm diameter × 50 mm long (1¼ in. diameter × 2 in. long) noncompressible probe shall be mounted on the movable arm.

8.20.4.3 The specimen support assembly shall consist of two 50 mm × 25 mm × 25 mm (2 in. × 1 in. × 1 in.) noncompressible blocks placed 50 mm (2 in.) apart as shown in Figure 8.20.4.3.

8.20.5 Procedure. The ladder shank shall be placed on mounting blocks as it would be oriented toward the ladder when affixed into the protective footwear and subjected to force on its center with the test probe operated at 50 mm/min (2 in./min).

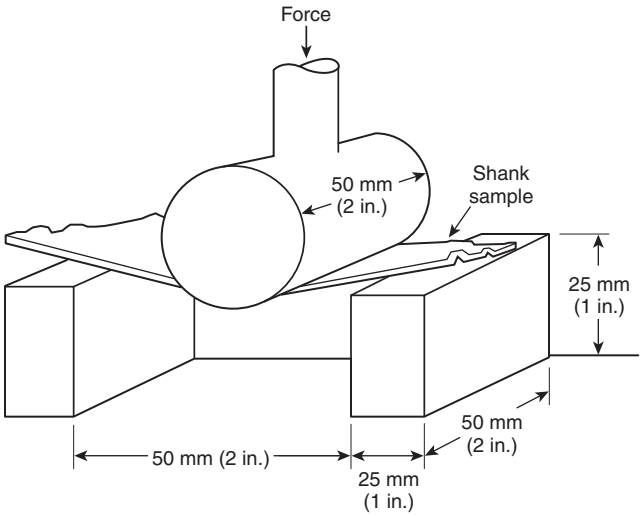


FIGURE 8.20.4.3 Ladder Shank Bend Test Set-Up.

8.20.6 Report.

8.20.6.1 Deflection at 1779 N (400 lbf) shall be recorded and reported to the nearest 1 mm (1/32 in.).

8.20.6.2 The average deflection shall be calculated, recorded, and reported to the nearest 1 mm (1/32 in.).

8.20.7 Interpretation. Pass or fail performance shall be determined using the average deflection for all specimens tested.

8.21 Slip Resistance Test.

8.21.1 Application. This test method shall apply to footwear.

8.21.2 Samples.

8.21.2.1 Samples shall be complete footwear.

8.21.2.2 Samples shall be conditioned as specified in ASTM F2913, *Standard Test Method for Measuring the Coefficient of Friction for Evaluation of Slip Performance of Footwear and Test Surfaces/Flooring Using a Whole Shoe Tester.*

8.21.3 Specimens.

8.21.3.1 Specimens shall be complete footwear elements in men's size 9D, medium width, or equivalent.

8.21.3.2 At least three specimens shall be tested.

8.21.4 Procedure. Slip resistance testing shall be performed in accordance with ASTM F2913, *Standard Test Method for Measuring the Coefficient of Friction for Evaluation of Slip Performance of Footwear and Test Surfaces/Flooring Using a Whole Shoe Tester*, in the following configurations, and references to any other flooring or contaminate within ASTM F2913 shall not apply:

(1) Footwear shall be tested in both the forepart and heel positions.
(2) Footwear shall be tested in the wet condition.
(3) Footwear shall be tested on a quarry tile surface that meets the specifications of ASTM F2913 and shall not be calibrated in accordance with ASTM F2913. The calibration frequency of 10 tests specified in ASTM F2913 shall be equivalent to 50 test runs.

8.21.5 Report.

8.21.5.1 The coefficient of friction for each specimen shall be recorded and reported.

8.21.5.2 The average coefficient of friction for all specimens for each configuration shall be calculated, recorded and reported.

8.21.6 Interpretation. The average coefficient of friction for each configuration shall be used to determine pass/fail performance.

8.22 Seam/Closure Breaking Strength Test.

8.22.1 Application.

8.22.1.1 This test shall be applied to vapor-protective suit element seams and closure assembly used in the construction of the vapor-protective suit, including at least suit and suit–visor seams. Where the suit element consists of multiple separable layers, the test shall be applied to the seams and closure assemblies of each separable layer.

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

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

8.22.2 Sample Preparation.

8.22.2.1 Samples shall be 0.5 m (18 in.) lengths of material seam or closure assembly representative of each seam or closure assembly type used in the suit.

8.22.2.2 A straight seam shall be permitted to be cut from the finished suit or shall be permitted to be prepared by joining two pieces of the suit material in a manner representing the actual seam construction in the finished vapor-protective ensemble.

8.22.2.3 Closure samples shall be permitted to be individual samples cut to specimen width.

8.22.2.4 Samples shall be conditioned as specified in 8.1.2.

8.22.3 Specimens.

8.22.3.1 Specimens shall be the size specified in ASTM D751, *Standard Test Methods for Coated Fabrics.*

8.22.3.2 Closure specimens shall be permitted to be 25 mm ±6 mm (1 in., ±1/4 in.) larger than the required specimen size. The specimen edges of the closure shall be permitted to be secured.

8.22.3.3 At least five specimens of each seam or closure assembly type shall be tested.

8.22.4 Procedure. All seams and closure assemblies shall be tested in accordance with ASTM D751, *Standard Test Methods for Coated Fabrics.* The test machine shall be operated at a rate of 305 mm/min (12 in./min).

8.22.5 Report.

8.22.5.1 The breaking strength for each seam or closure assembly specimen shall be recorded and reported.

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

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

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

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

8.22.8 Specific Procedures for Testing Closure Assemblies. Samples for conditioning shall include 150 mm (6 in.) of material on either side of the closure.

8.23 Closure Penetration Resistance Test.

8.23.1 Application. This test method shall apply to vapor-protective ensemble closure assemblies.

8.23.2 Sample Preparation.

8.23.2.1 Samples shall be complete vapor-protective ensembles.

8.23.2.2 Samples shall be conditioned as specified in 8.1.7.

8.23.3 Specimens.

8.23.3.1 Specimens shall be the suit closure assembly consisting of the closure in combination with the seam attaching the closure to the suit.

8.23.3.2 At least three specimens shall be tested.

8.23.4 Procedure. Penetration resistance testing of suit closure assemblies shall be conducted in accordance with ASTM F903, *Standard Test Method for Resistance of Materials Used in Protective Clothing to Prevent Penetration by Liquids*, Procedure C, using the following modifications:

(1) All tests shall be conducted at 25°C, ±3°C (77°F, ±5°F).
(2) The test cell shall be modified to accommodate the shape of the suit closure assembly without affecting other parts of the test procedure. The Plexiglas® shield shall be omitted from the test cell.
(3) Use of blotting paper at the end of the test shall be permitted to assist in the visual observation of liquid penetration. Visually observed chemical on the blotting paper shall constitute failure of this test.
(4) An observation to determine specimen penetration shall be made at the end of the chemical contact period.
(5) Testing shall be conducted against the 15 liquid chemicals specified in ASTM F1001, *Standard Guide for Selection of Chemicals to Evaluate Protective Clothing Materials*.

8.23.5 Report.

8.23.5.1 The pass or fail results for each chemical tested shall be recorded and reported.

8.23.5.2 The identification of the locations where penetration occurs, if discernible, shall be recorded and reported.

8.23.6 Interpretation. Observed liquid penetration at the end of the test for any specimen shall constitute failure of this test.

8.24 Exhaust Valve Inward Leakage Test.

8.24.1 Application. This test method shall apply to vapor-protective suit exhaust valves.

8.24.2 Sample Preparation.

8.24.2.1 Samples shall be individual vapor-protective suit exhaust valves including mounting means.

8.24.2.2 Samples shall be conditioned as specified in 8.1.2.

8.24.3 Specimens.

8.24.3.1 Specimens shall be individual vapor-protective suit exhaust valves including mounting means.

8.24.3.2 At least 10 specimens shall be tested.

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 an 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 column gauge.
(4) The fixture shall allow for the measurement of flow into the valve (valve exterior to valve interior sides) with a flow-measuring device capable of measuring flow rates from at least 0 ml/min to 100 ml/min, ±1 ml/min (0 $in.^3$/min to 6.1 $in.^3$/min, ±0.6 $in.^3$/min).

8.24.5 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.

8.24.6.1 The inward leakage flow rate shall be recorded and reported for each specimen.

8.24.6.2 The average inward leakage of all specimens shall be calculated, recorded, and reported.

8.24.7 Interpretation. The average inward leakage shall be used to determine pass or fail performance.

8.25 Overall Ensemble Flash Test.

8.25.1 Application. This test method shall apply to vapor-protective ensembles.

8.25.2 Sample Preparation.

8.25.2.1 Samples shall be complete vapor-protective ensembles.

8.25.2.2 Samples shall include any additional protective clothing components and equipment that are necessary to provide full-body flash protection to the wearer and shall be tested in conjunction with the vapor-protective ensemble.

8.25.2.3 Samples shall be conditioned as specified in 8.1.2.

8.25.3 Specimens.

8.25.3.1 Specimens shall be complete vapor-protective ensembles.

8.25.3.2 Specimens shall include any additional protective clothing components and equipment that are necessary to provide full-body flash protection to the wearer and shall be tested in conjunction with the vapor-protective ensemble.

8.25.3.3 At least three specimens shall be tested.

8.25.4 Apparatus.

8.25.4.1 A human-form manikin shall be used to support the protective suit during chemical flash fire testing. The manikin shall be coated with a suitable flame-retardant coating.

8.25.4.2 A one-piece flame-retardant coverall shall be placed over the manikin.

8.25.4.3 The protective ensemble to be tested shall be placed on the manikin, over the flame-resistant clothing, in accordance with the manufacturer's instructions.

8.25.4.4 A flash chamber shall be constructed as illustrated in Figure 8.25.4.4 and shall include the following:

(1) It shall have an internal width and depth of 2 m, ±100 mm (6½ ft, ±4 in.) and a height of 2.5 m, ±200 mm (8 ft, ±8 in.).
(2) It shall be constructed of 50 mm × 100 mm (2 in. × 4 in.) framing lumber or other suitable structural material. Firewall, 20 mm (¾ in.), or other suitable flame-resistant paneling, shall be used on the chamber walls. A piece of 13 mm (½ in.) heat-tempered safety glass of sufficient size shall be used on opposite chamber walls for multiple viewing points during testing.
(3) The chamber shall be sealed with a suitable flame-resistant material to provide a gastight seal when the door is closed..
(4) It shall have a port for filling the chamber with propane gas located as shown in Figure 8.25.4.4. The port shall allow isolation of the propane source through a valve. The port shall be leakfree with respect to the outside environment.
(5) It shall have a minimum of two ports for electric igniters located on one wall of the chamber. The ports shall be positioned at heights on the chamber wall such that the propane will ignite immediately once triggered. The port shall be leakfree with respect to the outside environment.
(6) It shall have a top that allows containment of propane gas within the chamber during filling and venting of flash pressure after ignition.
(7) A suitable stand that allows the manikin to be positioned 305 mm, ±25 mm (1 ft, ±1 in.) above the chamber floor shall be constructed.
(8) The flash fire chamber shall be located so that testing is performed at a temperature of 24°C, ±11°C (75°F, ±20°F) and a relative humidity of 70 percent, ±25 percent. Tests shall not be conducted outdoors during precipitation.

8.25.4.5 Verification of Flash Exposure.

8.25.4.5.1 Prior to testing each day, two Schmidt-Boelter heat flux gauges shall be mounted in a thermally insulated fixture with the face of the gauges situated perpendicular to the floor, oriented toward the ignition source, and mounted in the center of the chamber.

8.25.4.5.2 The sensors shall be located 122 cm (48 in.) and 152 cm (60 in.) from the chamber floor.

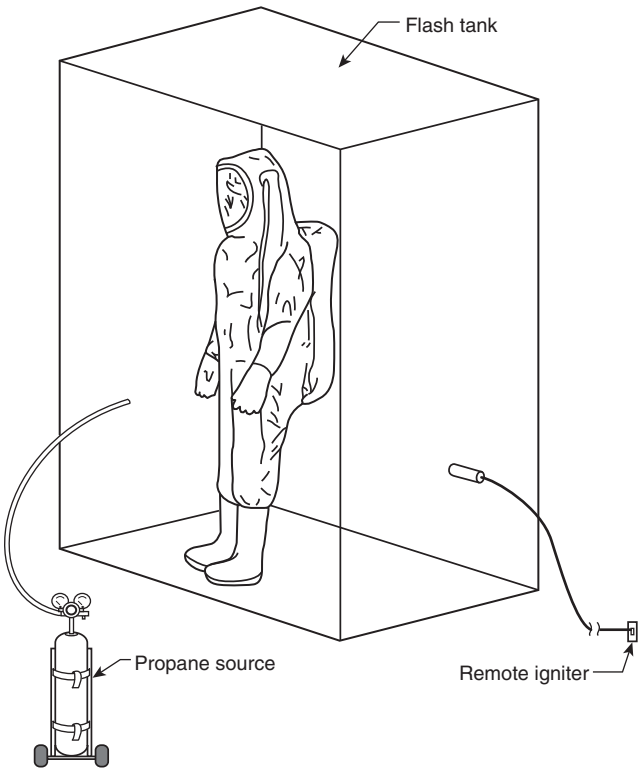


FIGURE 8.25.4.4 Overall Ensemble Chemical Flash Chamber.

8.25.4.5.3 A data acquisition system shall be used to collect heat flux readings during the verification exposure and shall be sufficient to provide at least one heat flux reading every tenth of a second.

8.25.4.5.4 Propane gas, at 99 percent purity or better, shall be metered into the chamber at a delivery pressure of 172.3 kPa, ±13.8 kPa (25 psi, ±2 psi) and a rate of 0.16 m^3/min, ±0.01 m^3/min (5½ ft^3/min, ±½ ft^3/min) for 2 minutes, ±1 minute.

8.25.4.5.4.1 An initial calibration exposure shall be conducted to verify that the propane gas conditions produce a visible chemical flash fire lasting 7 seconds, ±1 second.

8.25.4.5.4.2 If not achieved, the fill time shall be adjusted with a subsequent calibration exposure to verify performance.

8.25.4.5.4.3 The exact fill time required to produce a visible chemical flash fire lasting 7 seconds, ±1 second, shall be recorded.

8.25.4.5.4.4 The concentration of the propane shall be permitted to be checked by a combustible gas meter or similar detector.

8.25.4.5.5 After determining the time required to produce a flash fire exposure lasting 7 seconds, ±1 second, the data collected from the heat flux sensors shall be recorded.

8.25.5 Procedure.

8.25.5.1 A gastight integrity test shall be performed on the ensemble in accordance with Section 8.2 prior to the chemical flash fire exposure.

8.25.5.2 The suited manikin shall be placed on the stand in the center of the flash chamber in an upright stationary position.

8.25.5.3 Propane gas, at 99 percent purity or better, shall be metered into the chamber at a delivery pressure of 172.3 kPa, ±13.8 kPa (25 psi, ±2 psi) and a rate of 0.16 m^3/min, ±0.01 m^3/min (5½ ft^3/min, ±½ ft^3/min) for 2 minutes, ±1 minute, to produce a visible chemical flash fire lasting 7 seconds, ±1 second.

8.25.5.3.1 The exact time required to produce a visible chemical flash fire lasting 7 seconds, ±1 second, shall be recorded.

8.25.5.3.2 The concentration of the propane shall be permitted to be checked by a combustible gas meter or similar detector.

8.25.5.4 The flash chamber shall be viewed at both vantage points, front and back, throughout the test. Video documentation shall also be conducted from the front vantage point.

8.25.5.5 The chamber atmosphere shall be remotely ignited at 30 seconds, ±5 seconds after the chamber has been filled with propane gas.

8.25.5.6 The suited manikin shall not be removed until all surfaces have cooled to ambient temperature.

8.25.5.7 The protective ensemble shall be removed from the manikin and examined visually for physical signs of damage from thermal exposure.

8.25.5.8 A gastight integrity test shall be performed on the ensemble in accordance with Section 8.2 following the chemical flash fire exposure.

8.25.5.9 Following gastight integrity testing, the ensemble shall be donned by a test subject and evaluated for visual acuity.

8.25.5.9.1 The test subject shall have a minimum visual acuity of 20/20 in each eye, uncorrected or corrected with contact lenses, as determined in a visual acuity test or doctor's examination.

8.25.5.9.2 Visual acuity testing from within the ensemble shall be conducted using a standard 6.1 m (20 ft) eye chart with a normal lighting range of 100 to 150 foot-candles (fc) at the chart and with the test subject positioned at a distance of 6.1 m (20 ft) from the chart.

8.25.5.9.3 The test subject shall then read the standard eye chart through the lens of the SCBA facepiece and ensemble visor(s) to determine his or her visual acuity.

8.25.6 Report.

8.25.6.1 The before and after gastight integrity test results, afterflame time, visor clarity, relative humidity, and ambient temperature shall be recorded and reported for each test specimen.

8.25.6.2 An illustration of the protective ensemble, as shown in Figure 8.25.6.2, shall be prepared, and the location of any damage shall be recorded and reported. Damage shall include but not be limited to charring, blistering, evidence of material melting, delamination, or destruction of any ensemble components.

8.25.6.3 The verification burn visible chemical flash fire time shall be recorded and reported.

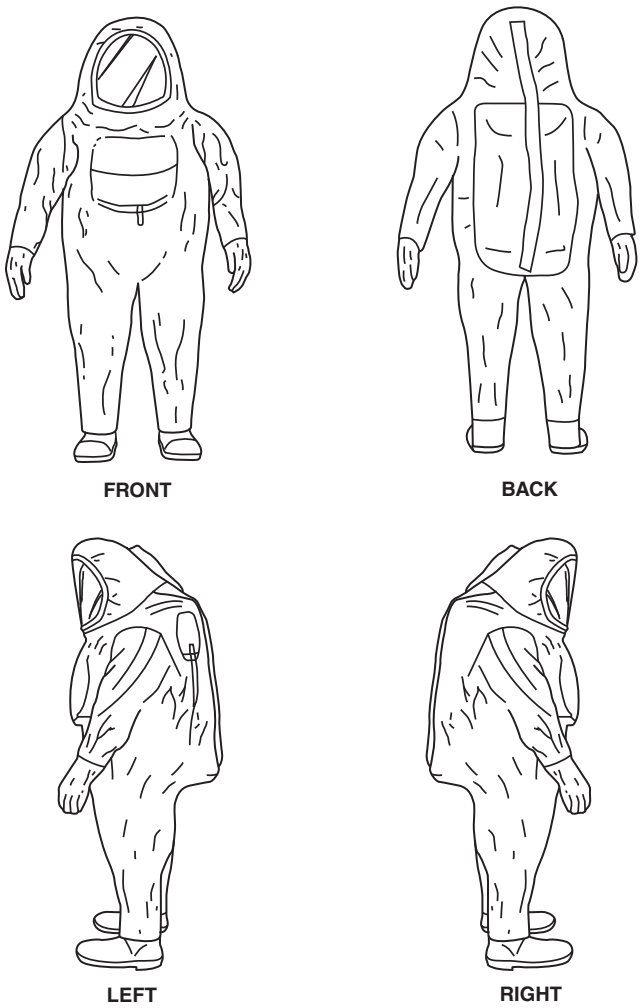


FIGURE 8.25.6.2 Suit Diagram (for noting damage locations).

8.25.6.4 Separate illustrations shall be prepared for overcovers if tested with the protective ensemble.

8.25.7 Interpretation.

8.25.7.1 The maximum of afterflame time among all specimens shall be used to determine compliance with the afterflame requirement.

8.25.7.2 The lowest ending inflation test pressure shall be used to determine compliance to the post flash fire simulation inflation test requirements.

8.25.7.3 The visual acuity of the test subject inside the ensemble shall be used for determining pass or fail compliance with the post flash fire simulation visual acuity requirements.

8.26 Chemical Permeation Resistance Test Two.

8.26.1 Application.

8.26.1.1 This method shall apply to the suit, visor, glove, and footwear element materials, and to the selected elements' seams.

8.26.1.2 Specific requirements for testing suit materials after flexing and abrading shall be as specified in 8.26.10.

8.26.1.3 Specific requirements for testing glove materials after abrading shall be as specified in 8.26.11.

8.26.1.4 Specific requirements for testing footwear materials after abrading shall be as specified in 8.26.12.

8.26.1.5 Specific requirements for testing seams shall be as specified in 8.26.13.

8.26.2 Samples. Samples shall be either vapor-protective ensembles or suit materials, visor materials, gloves, and footwear of the sizes specified in the modifications.

8.26.3 Specimens.

8.26.3.1 Specimens shall be of a size required to fit the permeation test cell.

8.26.3.2 A minimum of three specimens shall be tested against each challenge chemical.

8.26.3.3 For composite materials, only the chemical protection layer shall be the sample for testing for chemical permeation resistance.

8.26.3.4 Following any sample preparation, the specimens shall be conditioned as specified in 8.1.9.

8.26.4 Apparatus.

8.26.4.1 A controlled environmental chamber shall be used to maintain the test cell, air flow control system, and reagent chemicals within ±2.0°C (±4.0°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, to test cells when not in use, to challenge chemicals and other test apparatus prior to testing, as well as for holding the test cells horizontally during use while connected to the air delivery system manifold and to the effluent sampling mechanism.

8.26.4.2* 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 8.26.4.2(a) and individual part detail shown in Figure 8.26.4.2(b) through Figure 8.26.4.2(f).

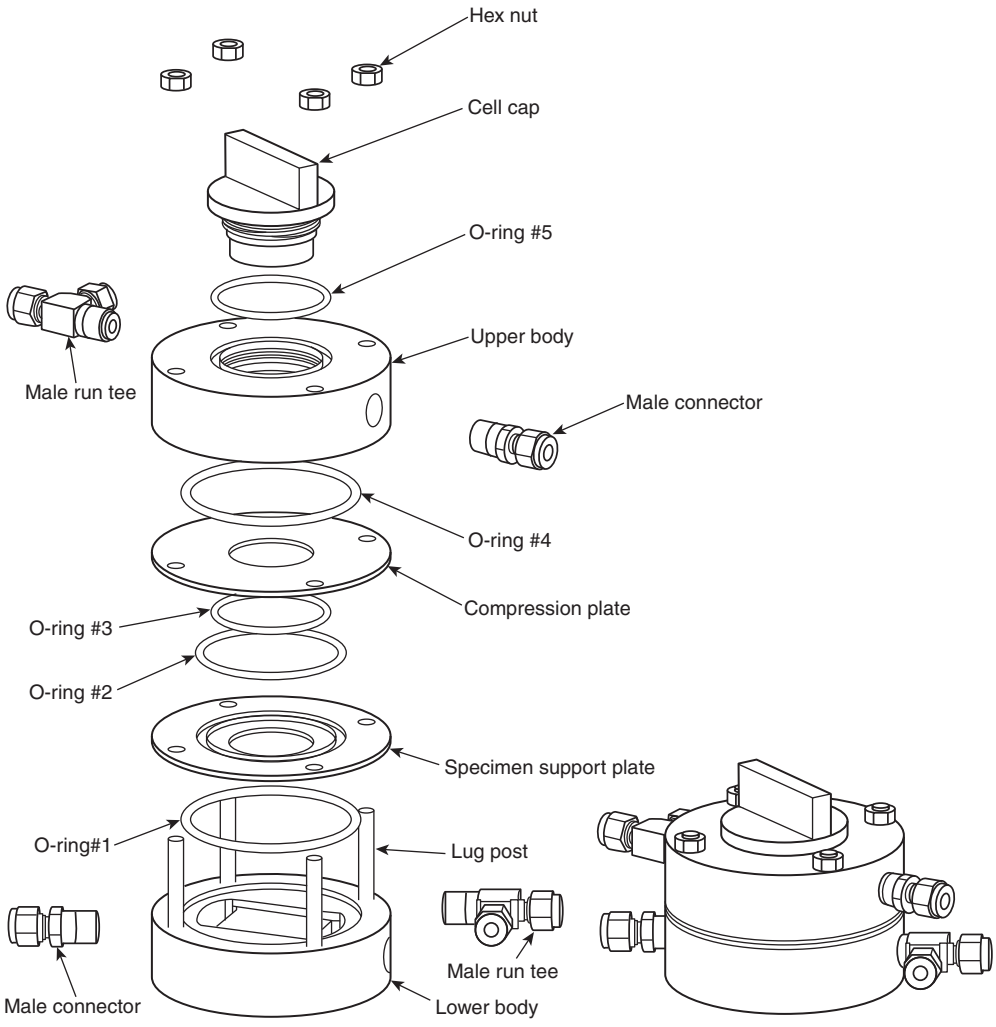


FIGURE 8.26.4.2(a) Diffusion Test Cell Assembly. ***(Source: W. L. Gore & Associates, Inc.)***

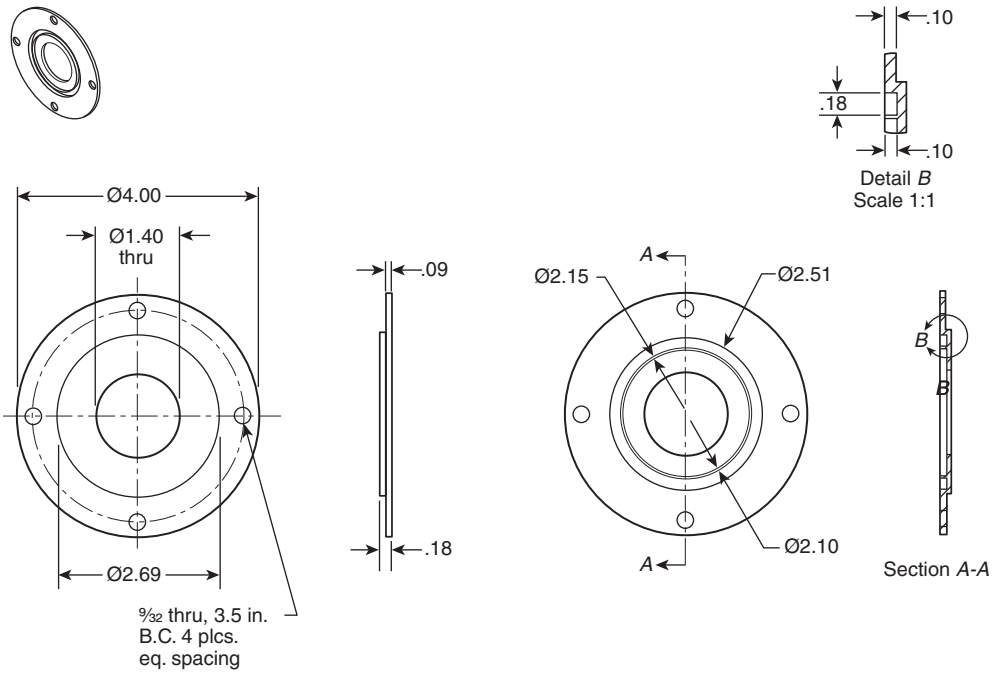


FIGURE 8.26.4.2(b) Sample Support Plate. ***(Source: W. L. Gore & Associates, Inc.)***

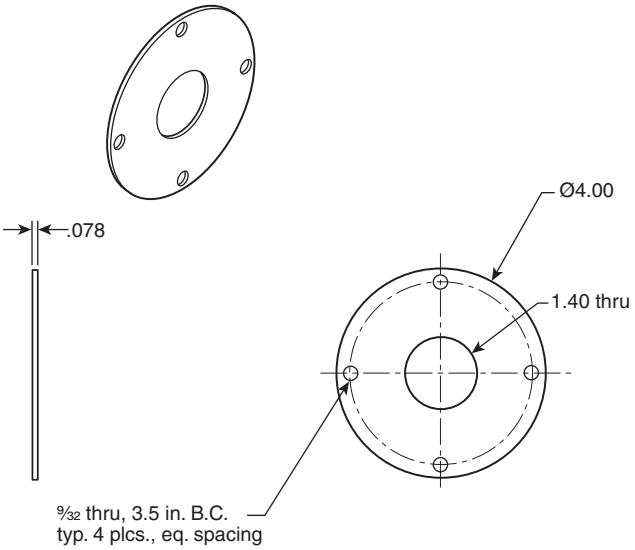


FIGURE 8.26.4.2(c) Compression Plate. ***(Source: W. L. Gore & Associates, Inc.)***

8.26.4.3* 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.

8.26.4.4 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 the test exposure period. The analytical system shall be permitted to include a bubbler tube, solid sorbent, or real-time chemical analyzer. Effluent sampling shall be permitted to be taken discretely or cumulatively; however, the selected analytical system shall be able to determine all of the challenge chemical permeating through the specimen in 60 minutes.

8.26.4.5* 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.

8.26.4.6* A manometer or pressure gage 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.

8.26.5 Supplies.

8.26.5.1 Syringes, capable of delivering the challenge chemical, shall be used for dispensing liquid challenge chemical onto the surface of the specimen in the test cell.

8.26.5.2* Replacement O-rings shall be available for use in the permeation test cell.

8.26.5.2.1* If unknown, the compatibility of the O-ring material with the challenge chemical shall be verified before use.

8.26.5.2.2 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.

8.26.5.3* An inert impermeable surrogate material shall be used as a negative control during validation tests.

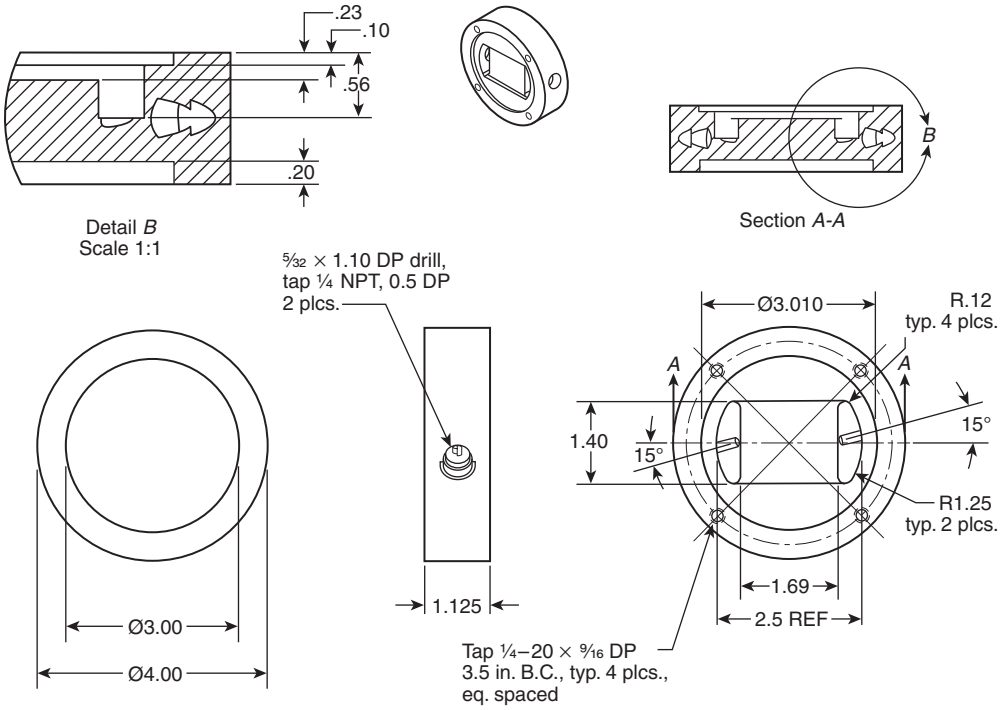


FIGURE 8.26.4.2(d) Lower Body (Collection Side). ***(Source: W. L. Gore & Associates, Inc.)***

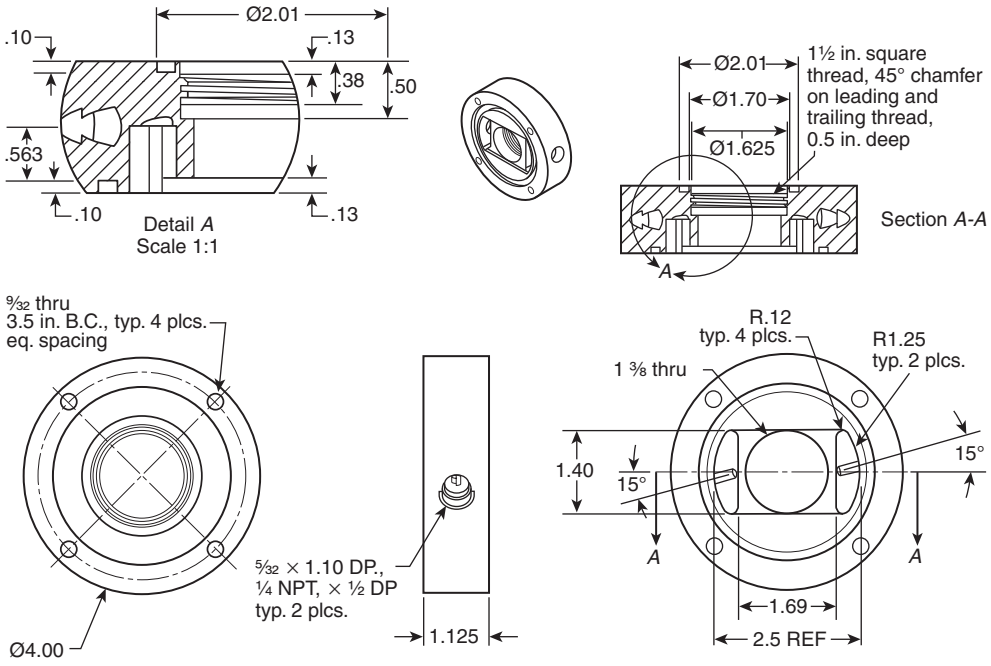


FIGURE 8.26.4.2(e) Upper Body (Challenge Side). ***(Source: W. L. Gore & Associates, Inc.)***

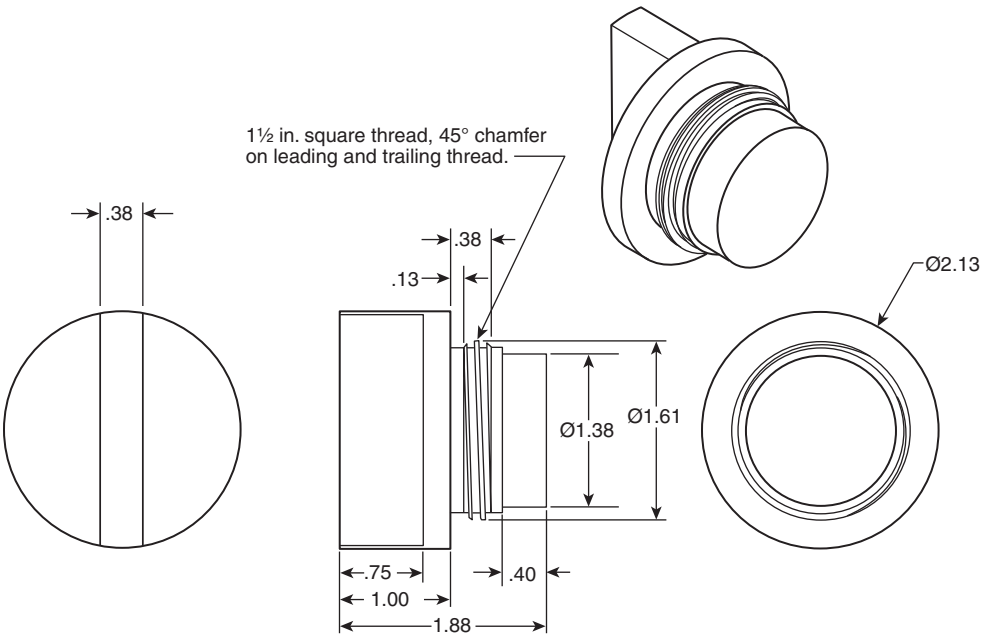


FIGURE 8.26.4.2(f) Top Cap. ***(Source: W. L. Gore & Associates, Inc.)***

8.26.6 Chemicals.

8.26.6.1 The following challenge chemicals shall be tested as liquids:

(1) Sulfur mustard, distilled [HD or bis (2-chloroethyl) sulfide, CAS 505-60-2]
(2) Soman [GD or O-Pinacolyl methylphosphonofluoridate, CAS 96-64-0]

8.26.6.2 Process for Determining the Mass of Liquid Chemical Challenge Applied.

8.26.6.2.1 Prior to assembling the test cell and conducting the test, the mass of the applied challenge chemical shall be determined using the procedure in 8.26.6.2.2 through 8.26.6.2.7.

8.26.6.2.2* The challenge chemical shall be applied to an inert impermeable surrogate specimen in the pattern described in 8.26.7.4.

8.26.6.2.3* After application, the inert impermeable surrogate specimen shall be visually inspected to verify that the liquid chemical challenge was correctly applied.

8.26.6.2.4 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 8.26.6.2.5 through 8.26.6.2.7.

8.26.6.2.5 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.

8.26.6.2.6 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.

8.26.6.2.7 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 100 g/m^2 (+1.0/–0.0 g/m^2).

8.26.7 Procedures.

8.26.7.1 Preconditioning.

8.26.7.1.1 The challenge chemicals, test specimen, test equipment, and test cell assembly shall be placed in the environmental chamber for a minimum of 24 hours at 32°C, ±2°C (90°F, ±4°F) and at a relative humidity of 80 percent, ±5 percent, prior to testing.

8.26.7.2 Test Cell Assembly.

8.26.7.2.1 The test cell shall be assembled in the environmental chamber at 32°C, ±2°C (90°F, ±4°F) and at a relative humidity of 80 percent, ±5 percent.

8.26.7.2.2 O-ring #1 shall be placed on the lower body (collection side) of the test cell.

8.26.7.2.3 The sample support plate shall be placed on the lower body (collection side) of the test cell.

8.26.7.2.4 O-ring #2 (outer) and O-ring #3 (inner) shall be placed in the respective grooves on the sample support plate.

8.26.7.2.5 The specimen shall be removed from the conditioning location in the environmental chamber and shall be placed on top of the sample support plate.

8.26.7.2.6 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.

8.26.7.2.7 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.

8.26.7.2.8 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.

8.26.7.2.9 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.

8.26.7.2.10 The integrity of the test cell assembly shall be verified using the procedure in 8.26.7.3.

8.26.7.2.11 Each test cell shall be labeled with the challenge chemical to be used in it.

8.26.7.3 Verification of Test Cell Integrity.

8.26.7.3.1 Test cell integrity shall be performed in the environmental chamber at 32°C, ±2°C (90°F, ±4°F) and at a relative humidity of 80 percent, ±5 percent.

8.26.7.3.2 Valves on the outlet ports of the upper and lower body of the test cell shall be closed.

8.26.7.3.3 Both the upper and lower body inlet ports of the test cell shall be connected to a manometer.

8.26.7.3.4 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.

8.26.7.3.5 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 8.26.7.2.

8.26.7.3.6 Only test cells that have passed this integrity test shall be used for testing.

8.26.7.4 Procedure for Liquid Chemical Challenge.

8.26.7.4.1 The test cell shall be mounted horizontally and connected to the air delivery system in the environmental chamber at 32°C, ±2°C (90°F, ±4°F) and at a relative humidity of 80 percent, ±5 percent. All connections shall be secured.

8.26.7.4.2 The calibrated analytical detection system shall be assembled and initiated according to its instructions.

8.26.7.4.2.1 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.

8.26.7.4.2.2 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.

8.26.7.4.3 The air delivery shall be flowing filtered air at a temperature of 32°C, ±2°C (90°F, ±4°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.

8.26.7.4.4 After placing the liquid challenge chemical on the specimen in the test cell, the cell top cap shall be sealed within 5 seconds.

8.26.7.4.5 Filtered air at a temperature of 32°C, ±2°C (90°F, ±4°F) and at a relative humidity of 80 percent, ±5 percent, shall be flowed only to the collection side of the test cell a rate of 1.0 LPM, ±0.1 LPM. No air shall be flowed across the challenge side of the test cell.

8.26.7.4.6 The challenge chemical in the effluent air stream shall be collected, measured, and analyzed using either discrete or cumulative methods for 60 minutes, +1.0 /–0 minutes.

8.26.7.4.7 The collection media for the challenge chemical shall be analyzed using an appropriate analytical procedure.

8.26.7.4.8 At least one test shall be conducted with a specimen, but without the challenge chemical, as a negative control.

8.26.7.4.9* At least one test shall be conducted with an inert impermeable surrogate specimen as a negative control.

8.26.7.4.10 The results from tests accompanied by unsuccessful negative controls shall not be used and the test shall be repeated.

8.26.7.5 Test Conclusion, Test Cell Cleaned, and Specimen Disposal.

8.26.7.5.1 At the conclusion of the test, the test cell shall be purged and the air delivery and analytical system shall be shut down.

8.26.7.5.2 Each cell shall be disassembled one at a time.

8.26.7.5.3 The tested specimen shall be inspected for degradation or other obvious abnormalities; these observations shall be recorded with the test results.

8.26.7.5.4 Disposal of tested specimens and other supplies shall be handled according to local, state, federal, or other applicable regulations.

8.26.7.5.5 Each component of the test cell shall be rinsed with acetone or other appropriate solvent to remove residual chemicals.

8.26.7.5.6 The cell shall be allowed to air dry in a clean area for 24 hours before reuse.

8.26.8 Report.

8.26.8.1 The cumulative permeation in one hour shall be calculated, recorded, and reported in $\mu g/cm^2$ for each specimen for each challenge chemical.

8.26.8.1.1 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.

8.26.8.2 The average cumulative permeation shall be calculated and reported by averaging the results from all specimens for each challenge chemical.

8.26.8.2.1 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.

8.26.8.2.2 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.

8.26.8.3 Any observations of degradation or other abnormalities shall be reported at the conclusion of the testing of each specimen.

8.26.9 Interpretation. The average cumulative permeation for each challenge chemical shall be used to determine pass or fail performance.

8.26.10 Specific Requirements for Testing Suit Materials After Flexing and Abrading.

8.26.10.1 Samples for conditioning shall be 200 mm × 280 mm (8 in. × 11 in.) rectangles and shall consist of all layers as configured in the suit.

8.26.10.2 Two samples shall first be conditioned by flexing as specified in 8.1.3.

8.26.10.2.1 One sample shall be flexed with the longitudinal axis parallel to the machine direction of the material, and the second sample shall be flexed with the longitudinal axis parallel to the cross-machine direction of the material.

8.26.10.2.2 Following flexing, two samples for abrasion conditioning, each measuring 45 mm × 230 mm (1¾ in. × 9 in.), shall be cut from the center of the flexed samples.

8.26.10.2.3 At least one specimen for abrasion conditioning shall be taken from a sample flexed in the machine direction, and at least one specimen for abrasion conditioning shall be taken from a sample flexed in the cross-machine direction for each chemical tested.

8.26.10.3 These new samples for abrasion conditioning shall then be conditioned by abrading as specified in 8.1.4.

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

8.26.10.3.2 The permeation test specimen shall be taken from the exact center of the abraded sample so that the center of the permeation test and the center of the abraded sample coincide.

8.26.11 Specific Requirements for Testing Glove Materials After Abrading.

8.26.11.1 Samples for conditioning shall be whole glove components or whole glove individual elements.

8.26.11.2 Three samples for abrasion conditioning, each measuring 45 mm × 230 mm (1 ¾ in. × 9 in.), shall be cut from the center of the gauntlet portion of the sample.

8.26.11.3 These new samples for abrasion conditioning shall then be conditioned by abrading as specified in 8.1.4.

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

8.26.11.3.2 The permeation test specimen shall be taken from the exact center of the abraded sample so that the center of the permeation test and the center of the abraded sample coincide.

8.26.12 Specific Requirements for Testing Footwear Materials After Flexing.

8.26.12.1 This test shall apply to all types of footwear configurations. Where the footwear incorporates a bootie constructed of suit material, the suit material flex fatigue resistance test shall be permitted to be substituted for this test.

8.26.12.2 Samples for conditioning shall be whole footwear components or whole footwear individual elements.

8.26.12.3 Samples for abrasion conditioning, each measuring 45 mm × 230 mm (1 ¾ in. × 9 in.), shall be cut from the center of the footwear upper.

8.26.12.4 The samples for abrasion conditioning shall then be conditioned by abrading as specified in 8.1.4.

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

8.26.12.4.2 The permeation test specimen shall be taken from the exact center of the abraded sample so that the center of the permeation test and the center of the abraded sample coincide.

8.26.13 Specific Requirements for Testing Seams.

8.26.13.1 Seam specimens shall be prepared from seam samples that have a minimum of 150 mm (6 in.) of material on each side of the seam center.

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

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

8.26.13.4 Samples for conditioning shall be 600 mm (23$^{9}/_{16}$ in.) lengths of prepared seam or cut from vapor-protective ensembles.

8.27 Visor High-Mass Impact Resistance Test.

8.27.1 Application.

8.27.1.1 This test shall apply to visor materials.

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

8.27.2 Sample Preparation.

8.27.2.1 Samples shall be at least 2 m^2 (2 yd^2) of material.

8.27.2.2 Samples shall be conditioned as specified in 8.1.2.

8.27.3 Specimens.

8.27.3.1 Specimens shall be 450 mm × 305 mm.

8.27.3.2 A minimum of five specimens shall be tested.

8.27.4 Procedure. Specimens shall be tested in accordance with Section 9.11 of ANSI Z87.1, *American National Standard for Occupational and Educational Eye and Face Protection*, with the following modifications:

(1) Visor material shall be securely mounted to the test fixture.
(2) The sample number shall be indicated.
(3) The impact location shall be in the center apex of the visor between the frame members.

(4) Testing shall be performed on samples conditioned for a minimum of 4 hours at –25°C, ±2 °C (–13°F, ±4 °F).
(5) Testing shall commence between 60 seconds and 90 seconds after removal from the cold chamber.
(6) The sample shall not be allowed to move more than 6 mm (0.25 in.). If a sample moves more than 6 mm (0.25 in.), the sample shall be discarded and a new sample shall be tested.

8.27.5 Report.

8.27.5.1 Visible penetration or full-thickness cracks shall be recorded and reported.

8.27.6 Interpretation.

8.27.6.1 Penetration or full-thickness cracking on any single impact shall be used to determine compliance.

8.28 Puncture Resistance Test Two.

8.28.1 Application. This test method shall apply to the puncture-resistant device of vapor-protective footwear.

8.28.2 Sample Preparation.

8.28.2.1 Samples shall be footwear puncture-resistant devices.

8.28.2.2 Samples shall be conditioned as specified in 8.1.2.

8.28.3 Specimens.

8.28.3.1 Specimens shall be footwear puncture-resistant devices.

8.28.3.2 At least three specimens shall be tested.

8.28.4 Procedure.

8.28.4.1 Puncture resistance shall be performed in accordance with Section 11 of ASTM F2412, *Standard Test Methods for Footwear Protection.*

8.28.4.2 The test shall be performed under an applied force of 1200 N (270 lbf).

8.28.4.3 The penetration of the test pin tip shall be viewed at a 90-degree angle to determine if the tip penetrates the puncture-resistant device.

8.28.4.4 The observation shall be made if the test pin tip penetrates the puncture-resistant device.

8.28.5 Report. Whether or not the test pin tip is observed shall be reported for each specimen.

8.28.6 Interpretation. One or more footwear specimens showing penetration of the test pin tip shall constitute failing performance.

8.29 Impact and Compression Test.

8.29.1 Application. This test method shall apply to the toe section of vapor-protective footwear elements.

8.29.2 Sample Preparation.

8.29.2.1 Samples shall be complete footwear toes.

8.29.2.2 Samples shall be conditioned as specified in 8.1.2.

8.29.3 Specimens.

8.29.3.1 Specimens shall be complete footwear toes.

8.29.3.2 At least three specimens shall be tested.

8.29.4 Procedure. Footwear specimens shall be tested in accordance with Sections 5 and 6 of ASTM F2412, *Standard Test Methods for Foot Protection.*

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

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

Annex A Explanatory Material

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

A.1.1 No single personal protective ensemble can currently protect the wearer from exposure to all hazards. OSHA/EPA Levels A, B, and C describe recommended personal protective ensembles. These levels are defined in the Hazardous Waste Operations and Emergency Response Standard (HAZWOPER), 29 CFR 1910.120, Appendix B, as follows:

Level A – To be selected when the greatest level of skin, respiratory and eye protection is required.

Level B – The highest level of respiratory protection is necessary but a lesser level of skin protection is needed.

Level C – The concentration(s) and type(s) of airborne substances is known and the criteria for using air-purifying respirators are met.

While these definitions provide guidelines and a framework for discussing PPE, the descriptive narrative in these levels does not set minimum performance criteria required for specific threats, such as chemical permeation resistance and physical property characteristics. Thus the use of these general "levels" of protection does not accurately describe the protective ability of such ensembles and does not assure that the wearer is adequately protected from any specific hazards. Relying solely on these nomenclatures could result in exposure above acceptable exposure limits, or an unnecessary reduction in operational effectiveness through lack of mobility, decreased dexterity, or reduced operational mission duration. Proper selection of Personal Protective Equipment (PPE) for emergency response should be based upon a careful assessment of two factors: 1) the expected hazards and anticipated exposures to be present at the scene, and 2) the probable impact of those hazards based upon the mission role of the emergency response organization.

Homeland Security Presidential Directive (HSPD) 8 defines personal protective equipment in terms of nationally-recognized standards and NIOSH standards. The NFPA standards require third-party certification of products; product manufacturers may not claim compliance with them unless their product is fully certified, and listed and labeled by an independent third party certification organization in accordance with the standard. The NIOSH standards require government certification and product manufacturers may not claim compliance with them unless their product is certified, listed and labeled by NIOSH. Several of these standards have already been officially adopted by the Department of Homeland Security.

The following information is provided to assist emergency response organizations in transitioning from Levels A, B, and C to compliant protection-based standards terminology. Because the OSHA/EPA Levels are expressed in more general terms than the standards and do not include testing to determine protection capability, it is not possible to "map" the Levels to specific standards. However, it is possible to look at specific configurations and suggest their OSHA/EPA Level based on the definitions provided above. Some examples of ensembles and the approximate corresponding levels are provided in the table below.

Ensemble Description Using Performance-Based Standard(s)	OSHA/EPA Level
NFPA 1991, 2005 edition [CBR(N) protection now included in mandatory requirements], worn with NIOSH CBRN SCBA	A
NFPA 1991, 2000 edition with C/B optional requirements, worn with NIOSH CBRN SCBA	A
NFPA 1994 Class 1 worn with NIOSH CBRN SCBA	A
NFPA 1994 Class 2 worn with NIOSH CBRN SCBA	B
NFPA 1994 Class 2 worn with NIOSH CBRN APR	C
NFPA 1994 Class 3 worn with NIOSH CBRN SCBA	C
NFPA 1994 Class 3 worn with NIOSH CBRN APR	C

Emergency response organizations are cautioned to examine their hazard and mission requirements closely, and select appropriate performance standards. All personal protective equipment should be employed in accordance with federal OSHA standards, including those contained in 29 CFR 1910, Subpart H — Hazardous Materials (including 29 CFR 1910.120 — Hazardous Waste Operations and Emergency Response); 29 CFR 1901, Subpart I — Personal Protective Equipment (including 29 CFR 1901.134 — Respiratory Protection) that include requirements for safety and health plans, medical evaluation, and training.

Types of personal protective equipment and information on related standards, certifications, and products are all available on the DHS-sponsored *Responder Knowledge Base* website https://www.llis.dhs.gov/knowledgebase?.

A.1.1.1 This standard does not include any specific design or performance requirements or test methods that demonstrate protection from particulates such as radiological particulates or particulate toxins. Protection from particulates is predicated on the performance provided by the overall ensemble leakage required and tested in 7.1.8 and Section 8.8.

Organizations responsible for specialized hazardous materials response functions including ionizing radiation, cryogenics, or fire fighting applications should use protective clothing and equipment specifically designed for protection for those operations.

A.1.1.2 At the time this standard was prepared, the characteristics of a dust or particulate flash fire had not been defined by this Committee and, therefore, the Committee has chosen not to assume that these exposures are similar to a chemical flash fire nor are the requirements for chemical flash fire protection adequate as minimum requirements for dust or particulate flash fire protection.

A.1.1.6 The appropriate respiratory protection for this ensemble is a self-contained breathing apparatus (SCBA) that is certified to NFPA 1981 and to NIOSH requirements for CBRN SCBA. The testing for this ensemble was performed using an NFPA 1981-compliant SCBA, which is designated in the technical data package. Any NFPA 1981-compliant SCBA can be considered for use by the authority having jurisdiction. However, it is the responsibility of the authority having jurisdiction to ensure that the ensemble is interoperable with the intended wearing configuration for that ensemble, which includes all items to be worn by the end user including SCBA.

A.1.2.1 The requirements of this standard were developed taking into consideration the needs of emergency response personnel for hazardous materials emergencies. This application can entail a variety of chemical, physical, and other hazards. Other protection needs, such as for routine industrial operations, should warrant a thorough review of the requirements in this standard to determine applicability.

There are no requirements in this standard that address reuse or multiple wearings of vapor-protective ensembles. Users are cautioned that exposure of vapor-protective ensembles to chemicals could require disposal, particularly if the effectiveness of decontamination cannot be assessed.

A.1.2.2 The testing requirements in Chapter 8 of this standard are intended to establish material performance, not the limitations of the working environment for technical rescue.

Users should be advised that if unusual conditions prevail, or if there are signs of abuse or mutilation of the protective ensemble or any element or component thereof, or if modifications or replacements are made or accessories are added without authorization of the protective ensemble element manufacturer, the margin of protection could be reduced.

Users should also be advised that the protective properties in new vapor-protective ensembles, as required by this standard, can diminish as the product is worn and ages.

It is strongly recommended that purchasers of vapor-protective ensembles consider the following circumstances:

(1) Emergency response personnel must wear many items of protective clothing and equipment. Any interference by one item of another item's use could result in inefficient operations or unsafe situations.
(2) Different breathing apparatus, communications systems, cooling devices, and other protective equipment might not be equally accommodated by each vapor-protective suit.