

NFPA 1994

Standard on Protective Ensembles for Chemical/Biological Terrorism Incidents

2001 Edition



NFPA, 1 Batterymarch Park, PO Box 9101, Quincy, MA 02269-9101
An International Codes and Standards Organization

NFPA License Agreement

This document is copyrighted by the National Fire Protection Association (NFPA), 1 Batterymarch Park, Quincy, MA 02269-9101 USA.
All rights reserved.

NFPA grants you a license as follows: The right to download an electronic file of this NFPA document for temporary storage on one computer for purposes of viewing and/or printing one copy of the NFPA document for individual use. Neither the electronic file nor the hard copy print may be reproduced in any way. In addition, the electronic file may not be distributed elsewhere over computer networks or otherwise. The hard copy print may only be used personally or distributed to other employees for their internal use within your organization.

Copyright ©
National Fire Protection Association, Inc.
One Batterymarch Park
Quincy, Massachusetts 02269

IMPORTANT NOTICE ABOUT THIS DOCUMENT

NFPA codes, standards, recommended practices, and guides, 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 its codes and 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 this document. The NFPA also makes no guaranty or warranty as to the accuracy or completeness of any information published herein.

In issuing and making this document 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 this document. 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.

NOTICES

All questions or other communications relating to this document 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 documents during regular revision cycles, should be sent to NFPA headquarters, addressed to the attention of the Secretary, Standards Council, National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

Users of this document should be aware that this document may be amended from time to time through the issuance of Tentative Interim Amendments, and that an official NFPA document at any point in time consists of the current edition of the document together with any Tentative Interim Amendments then in effect. In order to determine whether this document is the current edition and whether it has been amended through the issuance of Tentative Interim Amendments, 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 above.

A statement, written or oral, that is not processed in accordance with Section 5 of the Regulations Governing Committee Projects 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.

The NFPA does not take any position with respect to the validity of any patent rights asserted in connection with any items which are mentioned in or are the subject of this document, and the NFPA disclaims liability for the infringement of any patent resulting from the use of or reliance on this document. Users of this document are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, is entirely their own responsibility.

Users of this document should consult applicable federal, state, and local laws and regulations. NFPA does not, by the publication of this document, intend to urge action that is not in compliance with applicable laws, and this document may not be construed as doing so.

Licensing Policy

This document is copyrighted by the National Fire Protection Association (NFPA). By making this document available for use and adoption by public authorities and others, the NFPA does not waive any rights in copyright to this document.

1. Adoption by Reference—Public authorities and others are urged to reference this document in laws, ordinances, regulations, administrative orders, or similar instruments. Any deletions, additions, and changes desired by the adopting authority must be noted separately. Those using this method are requested to notify the NFPA (Attention: Secretary, Standards Council) in writing of such use. The term "adoption by reference" means the citing of title and publishing information only.

2. Adoption by Transcription—**A.** Public authorities with lawmaking or rule-making powers only, upon written notice to the NFPA (Attention: Secretary, Standards Council), will be granted a royalty-free license to print and republish this document in whole or in part, with changes and additions, if any, noted separately, in laws, ordinances, regulations, administrative orders, or similar instruments having the force of law, provided that: (1) due notice of NFPA's copyright is contained in each law and in each copy thereof; and (2) that such printing and republication is limited to numbers sufficient to satisfy the jurisdiction's lawmaking or rule-making process. **B.** Once this NFPA Code or Standard has been adopted into law, all printings of this document by public authorities with lawmaking or rule-making powers or any other persons desiring to reproduce this document or its contents as adopted by the jurisdiction in whole or in part, in any form, upon written request to NFPA (Attention: Secretary, Standards Council), will be granted a nonexclusive license to print, republish, and vend this document in whole or in part, with changes and additions, if any, noted separately, provided that due notice of NFPA's copyright is contained in each copy. Such license shall be granted only upon agreement to pay NFPA a royalty. This royalty is required to provide funds for the research and development necessary to continue the work of NFPA and its volunteers in continually updating and revising NFPA standards. Under certain circumstances, public authorities with lawmaking or rule-making powers may apply for and may receive a special royalty where the public interest will be served thereby.

3. Scope of License Grant—The terms and conditions set forth above do not extend to the index of this document.

(For further explanation, see the Policy Concerning the Adoption, Printing, and Publication of NFPA Documents, which is available upon request from the NFPA.)

Copyright © 2001, National Fire Protection Association, All Rights Reserved

NFPA 1994

Standard on

Protective Ensembles for Chemical/Biological Terrorism Incidents

2001 Edition

This edition of NFPA 1994, *Standard on Protective Ensembles for Chemical/Biological Terrorism Incidents*, was prepared by the Technical Committee on Hazardous Materials Protective Clothing and Equipment, released by the Technical Correlating Committee on Fire and Emergency Services Protective Clothing and Equipment, and acted on by NFPA at its May Association Technical Meeting held May 13–17, 2001, in Anaheim, CA. It was issued by the Standards Council on July 13, 2001, with an effective date of August 2, 2001.

This edition of NFPA 1994 was approved as an American National Standard on August 2, 2001.

Origin and Development of NFPA 1994

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

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

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

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

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

Technical Correlating Committee on Fire and Emergency Services Protective Clothing and Equipment (FAE-AAC)

Richard M. Duffy, *Chair*

International Association of Fire Fighters, DC [L]

William M. Lambert, *Secretary*

Mine Safety Appliances Co., Pittsburgh, PA [M]
Rep. Compressed Gas Association

Leslie Anderson, USDA Forest Service, MT [E]
Richard W. Blocker, Jr., The DuPont Company, VA [M]
Dennis W. Browner, Scott Aviation, NC [M]
Rep. Industrial Safety Equipment Association
Nicholas J. Curtis, Lion Apparel, Inc., OH [M]
Robert A. Freese, Globe Manufacturing Co., NH [M]
William L. Grilliot, TFG/Morning Pride Manufacturing, LLC, OH [M]
Rep. Fire and Emergency Manufacturers and Services Association Inc.
William E. Haskell, III, U.S. Army SBCCOM, MA [U]
Virgil Hathaway, San Diego Fire Department, CA [U]
Rep. Southern Area Fire Equipment Research
James S. Johnson, Lawrence Livermore National Labs, CA [RT]
Cy Long, Texas Commission on Fire Protection, TX [E]

David G. Matthews, United Kingdom Fire Brigades Association, England [SE]
Jim Minx, Oklahoma State Firefighters Association, OK [C]
Stephen R. Sanders, Safety Equipment Institute, VA [RT]
Denise N. Statham, Southern Mills, Inc., GA [M]
Jeffrey O. Stull, International Personnel Protection, Inc., TX [SE]
Robert D. Tutterow, Jr., Charlotte Fire Department, NC [U]
Rep. Fire Industry Equipment Research Organization
Bruce H. Varner, City of Carrollton Fire Department, TX [U]
Rep. International Fire Service Training Association
Harry Winer, U.S. Navy, MA [RT]
Thomas L. Wollan, Underwriters Laboratories Inc., NC [RT]

Alternates

Janice C. Bradley, Industrial Safety Equipment Association, VA [M]
(Alt. to D. W. Browner)
Patricia A. Freeman, Globe Manufacturing Co., NH [M]
(Alt. to R. A. Freese)
Patricia A. Gleason, Safety Equipment Institute, VA [RT]
(Alt. to S. R. Sanders)
Mary I. Grilliot, TFG/Morning Pride Manufacturing, LLC, OH [M]
Rep. Fire and Emergency Manufacturers and Services Association Inc.
(Alt. to W. L. Grilliot)

Tricia Hock, Springfield, LLC, SC [M]
(Alt. to D. N. Statham)
Steven B. Lumry, Oklahoma City Fire Department, OK [C]
Rep. Oklahoma State Firefighters Association
(Alt. to J. Minx)
Bob Montgomery, Celanese Corporation, NC [M]
(Alt. to R. W. Blocker, Jr.)
Daniel P. Ryan, Underwriters Laboratories Inc., NC [RT]
(Alt. to T. L. Wollan)
Frank P. Taylor, Lion Apparel, Inc., OH [M]
(Alt. to N. J. Curtis)

Nonvoting

Donna P. Brehm, Virginia Beach Fire Department, VA [U]
Don R. Forrest, United Firefighters of Los Angeles City, CA [L]
Bryan C. Heirston, Oklahoma City Fire Department, OK [L]
Rep. International Association of Fire Fighters

Richard Mangan, USDA Forest Service, MT [RT]
James S. Nee, ARFF Working Group, PA [U]
Rep. Aircraft Rescue & Fire Fighting Working Group
Kirk H. Owen, Plano Fire Department, TX [U]
Rep. NFPA Fire Service Section
Ray F. Reed, Dallas Fire Department, TX [U]

Bruce W. Teele, NFPA Staff Liaison

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 (FAE-HAZ)

Bryan C. Heirston, *Chair*

Oklahoma City Fire Department, OK [L]
Rep. International Association of Fire Fighters

Patricia A. Gleason, *Secretary*

Safety Equipment Institute, VA [RT]

William Alexander, Bata Shoe Co., MD [M]

Jeffrey B. Borkowski, Fire Department, City of New York, NY [U]

Wade G. DeHate, Hillsborough County Fire Rescue, FL [E]

Stephen L. Derynck, Underwriters Laboratories Inc., NC [RT]

Gerald J. Diskin, Eastman Kodak Co., NY [U]

Jan Dunbar, CA [E]

Rep. International Association of Fire Chiefs

Daniel Gohlke, W. L. Gore & Associates, MD [M]

William E. Haskell, III, U.S. Army SBCCOM, MA [U]

William G. Hatch, Hatch, Health and Safety Training, CA [SE]

Derek Jenkins, Ontario Hydro — Nanticoke, ON, Canada [U]

Glenn P. Jirka, University of Missouri Fire & Rescue Training Institute, MO [SE]

John D. Langley, Kappler Safety Group, Inc., AL [M]

Colin W. Lunas, Intertek Testing Services, NY [RT]

Robert R. Massie, Chemical, Biological Incident Response Force (CBIRF), MD [E]
Rep. U.S. Marine Corps

Louis V. Ott, Gentex Corporation, PA [M]

Rep. Industrial Safety Equipment Association

Kenneth A. Pever, Guardian Manufacturing Co., OH [M]

Jack R. Pryor, City of Plano Fire Department, TX [U]

Jack Sawicki, Geomet Technologies Inc., MD [M]

Mel Seng, TFG/Norcross Safety Products, IL [M]

Karen E. Strumlock, Lion Apparel, Inc., OH [M]

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

Robert West, Texas Instruments, TX [U]

John E. Wisner, Jr., Loudoun County Department of Fire/Rescue Services, VA [U]

James P. Zeigler, DuPont Nonwovens, VA [M]

Michael Ziskin, Field Safety Corporation, CT [RT]

Alternates

Nicholas J. Curtis, Lion Apparel, Inc., OH [M]

(Alt. to K. E. Strumlock)

John J. Fanning, Fire Department, City of New York, NY [U]

(Alt. to J. B. Borkowski)

Andy Gbur, Intertek Testing Services, OH [RT]

(Alt. to C. W. Lunas)

Dave Gilday, Bata Shoe Co., MD [M]

(Alt. to W. Alexander)

Angie S. Hill, Underwriters Laboratories Inc., NC [RT]

(Alt. to S. L. Derynck)

Philip C. Mann, Kappler Safety Group, Inc., AL [M]

(Alt. to J. D. Langley)

Thomas M. Pease, Gentex Corporation, PA [M]

Rep. Industrial Safety Equipment Association

(Alt. to L. V. Ott)

John Reilly, Total Fire Group, NY [M]

(Alt. to M. Seng)

Bruce W. Teele, NFPA Staff Liaison

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.

These lists represent the membership at the time the Committees were 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.

Contents

Chapter 1 Administration	1994- 5	Chapter 8 Test Methods	1994-20
1.1 Scope	1994- 5	8.1 Sample Preparation Procedures	1994-20
1.2 Purpose	1994- 5	8.2 Gas-Tight Integrity Test	1994-21
1.3 Units	1994- 5	8.3 Overall Ensemble Inward Leakage Test ...	1994-21
Chapter 2 Referenced Publications	1994- 6	8.4 Overall Ensemble Function and	
2.1 General	1994- 6	Integrity Test	1994-23
Chapter 3 Definitions	1994- 6	8.5 Maximum Ensemble Ventilation Rate	
3.1 General	1994- 6	Test	1994-24
3.2 NFPA Official Definitions	1994- 6	8.6 Liquid-Tight Integrity Test One	1994-25
3.3 General Definitions	1994- 7	8.7 Exhaust Valve Inward Leakage Test	1994-26
Chapter 4 Certification	1994- 9	8.8 Exhaust Valve Mounting Strength Test	1994-26
4.1 General	1994- 9	8.9 Fitting Pull-Out Strength Test	1994-27
4.2 Certification Program	1994- 9	8.10 Chemical Permeation Resistance Test	1994-27
4.3 Inspection and Testing	1994-10	8.11 Burst Strength Test	1994-29
4.4 Recertification	1994-10	8.12 Puncture Propagation Tear Resistance	
4.5 Manufacturer's Quality Assurance		Test	1994-29
Program	1994-11	8.13 Cold Temperature Performance Test	
4.6 ISO Registration for Manufacturers	1994-11	One	1994-30
Chapter 5 Labeling and Information	1994-12	8.14 Seam/Closure Breaking Strength Test	1994-30
5.1 Product Labeling Requirements	1994-12	8.15 Cold Temperature Performance Test	
5.2 User Information	1994-13	Two	1994-30
5.3 Technical Data Package	1994-14	8.16 Cut Resistance Test	1994-31
Chapter 6 Design Requirements	1994-14	8.17 Puncture Resistance Test One	1994-31
6.1 Protective Ensemble Requirements	1994-14	8.18 Glove Hand Function Test	1994-31
6.2 Garment Element Requirements	1994-15	8.19 Abrasion Resistance Test	1994-32
6.3 Glove Element Requirements	1994-15	8.20 Puncture Resistance Test Two	1994-32
6.4 Footwear Element Requirements	1994-15	8.21 Slip Resistance Test	1994-32
6.5 Accessory Requirements	1994-15	8.22 Impact and Compression Resistance	
Chapter 7 Performance Requirements	1994-15	Test	1994-33
7.1 Class 1 Ensembles	1994-15	8.23 Viral Penetration Resistance Test	1994-33
7.2 Class 2 Ensembles	1994-17	8.24 Liquid-Tight Integrity Test Two	1994-34
7.3 Class 3 Ensembles	1994-19	Annex A Explanatory Material	1994-34
		Annex B Informational References	1994-38
		Index	1994-39

NFPA 1994**Standard on****Protective Ensembles for
Chemical/Biological Terrorism Incidents****2001 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.

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 the minimum requirements for the design, performance, testing, documentation, and certification of protective ensembles designed to protect fire and emergency services personnel from chemical/biological terrorism agents.

1.1.1.1 The requirements for Class 1 ensembles shall apply to vapor-protective ensembles and liquid-protective ensembles designed to protect personnel at chemical/biological terrorism incidents where a risk analysis of the incident indicates one of the following:

- (1) The identity or concentration of the vapor or liquid is unknown.
- (2) Liquid contact is expected and no direct skin contact can be permitted, as exposure of personnel at these levels will result in the substantial possibility of immediate death or immediate serious injury or illness, or the ability to escape will be severely impaired.

1.1.1.2 The requirements for Class 2 ensembles shall apply to ensembles that provide protection from vapors and liquids and are designed to protect personnel at chemical/biological terrorism incidents where a risk analysis of the incident indicates the following:

- (1) Victims are not ambulatory and are symptomatic.
- (2) Potential for direct liquid droplet or aerosol contact is probable.

1.1.1.3 The requirements for Class 3 ensembles shall apply to ensembles that provide protection from liquids and are designed to protect personnel at chemical/biological terrorism incidents where a risk analysis of the incident indicates the following:

- (1) Victims are ambulatory and symptomatic.
- (2) Potential for direct liquid droplet or aerosol contact is possible.

1.1.2 This standard shall apply to the design, manufacturing, and certification processes for *new* protective ensembles for chemical/biological terrorism incidents. This edition of NFPA 1994 shall not apply to any protective ensembles for chemical/biological terrorism incidents manufactured prior to the effective date of this standard.

1.1.3* This standard shall establish requirements for a single exposure wearing of protective ensembles for chemical/biological terrorism incidents.

1.1.4 This standard shall not apply to any protective ensembles for chemical/biological terrorism incidents manufactured in accordance with other specifications or standards of other organizations.

1.1.5 This standard shall not establish requirements for respiratory protection for chemical/biological terrorism incidents. Appropriate respiratory protection for the specific chemical/biological exposure is a critical part of overall protection and shall be specified and provided by the authority having jurisdiction.

1.1.6* This standard shall not establish requirements for any fire-fighting applications or hazardous materials emergencies involving radiological, liquefied gas, or cryogenic liquid hazards; or against explosive atmospheres.

1.1.7 This standard shall not apply to use requirements for protective ensembles for chemical/biological terrorism incidents as these requirements are specified in NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program*.

1.1.8* Chemical/biological ensembles and ensemble elements that are certified as compliant with NFPA 1994 shall be permitted also to be certified to NFPA standards for hazardous materials emergencies protective ensembles and protective clothing or NFPA standards for emergency medical operations protective clothing.

1.1.9 The requirements of this standard shall not apply to accessories that might be attached to any ensemble or to any element of an ensemble, unless specifically addressed herein.

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

1.2 Purpose.

1.2.1* The purpose of this standard shall be to establish minimum levels of protection for fire and emergency services personnel assigned to chemical/biological terrorism agents including dual-use industrial chemicals, chemical terrorism agents, or biological terrorism agents.

1.2.1.1 To achieve this purpose, this standard shall establish minimum requirements for protective ensembles for fire and emergency services personnel responding to chemical/biological terrorism incidents, or for fire and emergency services personnel exposed to victims or materials during assessment, extrication, rescue, triage, and treatment operations at or involving chemical/biological terrorism incidents.

1.2.1.2 This standard shall establish three levels of protective ensembles that could be selected for protection of fire and emergency services personnel based on what the incident risk analysis indicates is necessary protection for the intended operations.

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 Units.

1.3.1 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.

1.3.2 Equivalent values in parentheses shall not be considered as the requirement as these values might be 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.

2.1.1 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program*, 1997 edition.

NFPA 1981, *Standard on Open-Circuit Self-Contained Breathing Apparatus for the Fire Service*, 1997 edition.

2.1.2 Other Publications.

2.1.2.1 ANSI Publications. American National Standards Institute, Inc., 11 West 42nd Street, 13th Floor, New York, NY 10036.

ANSI Z41, *Standard for Safety-Toe Footwear*, 1983.

ANSI Z89.1, *Standard for Industrial Head Protection*, 1997.

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

ASTM D 747, *Standard Test Method for Apparent Bending Modulus of Plastics by Means of a Cantilever Beam*, 1999.

ASTM D 751, *Standard Test Methods for Testing Coated Fabrics*, 1998.

ASTM D 1630, *Standard Test Method for Rubber Property — Abrasion Resistance (NBS Abrader)*, 1994.

ASTM D 2136, *Standard Test Method for Coated Fabrics — Low Temperature Bend Test*, 1998.

ASTM D 2582, *Standard Test Method for Puncture Propagation Tear Resistance of Plastic Film and Thin Sheeting*, 1993.

ASTM D 4157, *Standard Test Method for Abrasion Resistance of Textile Fabrics (Oscillatory Cylinder Method)*, 1992.

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

ASTM F 392, *Standard Test Method for Flex Durability of Flexible Barrier Materials*, 1998.

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

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

ASTM F 1052, *Standard Test Method for Pressure Testing Vapor Protective Ensembles*, 1997.

ASTM F 1154, *Standard Practice for Qualitatively Evaluating the Comfort, Fit, Function, and Integrity of Chemical Protective Suit Ensembles*, 1999.

ASTM F 1301, *Standard Practice for Labeling Chemical Protective Clothing*, 1999.

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

ASTM F 1359, *Standard Test Method for Measuring the Liquid Permeation Resistance of Protective Clothing or Protective Ensembles Under a Shower Spray While on a Mannequin*, 1999.

ASTM F 1671, *Standard Test Method for Resistance of Materials Used in Protective Clothing to Penetration by Blood-Borne Pathogens Using Ph-X174 Bacteriophage as a Test System*, 1995.

ASTM F 1790, *Standard Test Methods for Measuring Cut Resistance of Materials Used in Protective Clothing*, 1997.

2.1.2.3 CSA Publication. Canadian Standards Association, 178 Rexdale Boulevard, Rexdale, Ontario M9W 1R3, Canada.

Z195-M, *Standard for Protective Footwear, Occupational Health and Safety*, 1992.

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

FIA 1209, *Whole Shoe Flex.*

Shoe Size Conversion, Research Results and Recommendations.

2.1.2.5 GSA Publication. General Services Administration, Specifications Activity, Printed Materials Supply Division, Building 197, Naval Weapons Plant, Washington, DC 20407. U.S. Federal Test Method standards are also available from the U.S. Government Printing Office, Washington, DC 20402, or regional branches.

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

2.1.2.6 ISO Publications. International Standards Organization, 1 rue de Varembe, Case Postale 56, CH-1211 Geneve 20, Switzerland.

ISO Guide 17025, *General Requirements for the Competence of Calibration and Testing Laboratories*, 1999.

ISO Guide 65, *General Requirements for Bodies Operating Product Certification Systems*, 1996.

ISO 9001, *Quality Management Systems — Requirements*, 2000.

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

Title 29, *Code of Federal Regulations*, Part 1910, Subpart L, *Personal Protective Equipment*, 1994.

Title 42, *Code of Federal Regulations*, Part 84, *Respiratory Protective Devices, Tests for Permissibility*, 1997.

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 included, common usage of the terms shall apply.

3.2 NFPA Official Definitions.

3.2.1* Approved. Acceptable to the authority having jurisdiction.

3.2.2* Authority Having Jurisdiction. The organization, office, or individual responsible for approving equipment, materials, an installation, or a procedure.

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

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

3.2.5 Shall. Indicates a mandatory requirement.

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

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

3.3 General Definitions.

3.3.1* Accessory(ies). An item that is attached to an ensemble or ensemble element that is not necessary to meet the requirements of this standard.

3.3.2 Biological Terrorism Agents. Liquid or particulate agents that can consist of a biologically derived toxin or pathogen used to inflict lethal or incapacitating casualties.

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

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

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

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

3.3.7 Chemical/Biological Barrier Material. The layer or part of the composite that is intended to provide a barrier of protection against chemical/biological terrorism agents.

3.3.8 Chemical/Biological Terrorism Agents. The term used to refer to chemical terrorism agents, biological terrorism

agents, and dual-use industrial chemicals. (See also Biological Terrorism Agents, Chemical Terrorism Agents, and Dual-Use Industrial Chemicals.)

3.3.9* Chemical/Biological Terrorism Incident Protective Ensembles. Multiple elements, Categorized as Class 1, Class 2, or Class 3 ensembles, designed to provide minimum full body protection against exposure to chemical/biological terrorism agents occurring during chemical/biological terrorism emergencies. (See also Class 1 Ensemble, Class 2 Ensemble, and Class 3 Ensemble.)

3.3.10* Chemical/Biological Terrorism Incident Protective Footwear. An element of the chemical/biological terrorism incident protective ensemble designed to provide minimum protection to the foot, ankle, and lower leg.

3.3.11* Chemical/Biological Terrorism Incident Protective Garment(s). An element of the chemical/biological terrorism incident protective ensemble designed to provide minimum protection to the upper and lower torso, arms, and legs; excluding the head, hands, and feet.

3.3.12* Chemical/Biological Terrorism Incident Protective Glove(s). An element of the chemical/biological terrorism incident protective ensemble designed to provide minimum protection to the wearer's hands and wrists.

3.3.13 Chemical Terrorism Agents. Liquid, solid, gaseous, and vapor chemical agents and dual-use industrial chemicals used to inflict lethal or incapacitating casualties, generally on a civilian population as a result of a terrorist attack.

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

3.3.15 Class 1 Ensemble. A chemical/biological terrorism incident protective ensemble to protect fire and emergency services personnel at chemical/biological terrorism incidents where the identity or concentration of the vapor or liquid agent is unknown, or where it is necessary to provide vapor protection, or where liquid contact is expected and no direct skin contact can be permitted as exposure of personnel at these levels will result in the substantial possibility of immediate death, immediate serious incapacitation, or the ability to escape will be severely impaired.

3.3.16 Class 2 Ensemble. A chemical/biological terrorism incident protective ensemble to protect fire and emergency services personnel at chemical/biological terrorism incidents where it is necessary to provide sufficient vapor protection for the intended operation, where direct contact of liquid droplets is probable, and where victims are not ambulatory but symptomatic.

3.3.17 Class 3 Ensemble. A chemical/biological terrorism incident protective ensemble to protect fire and emergency services personnel at chemical/biological terrorism incidents where it is necessary to provide sufficient liquid protection for the intended operation, where direct contact of liquid droplets is possible, and where victims are impaired but ambulatory.

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

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

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

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

3.3.22 Dual-Use Industrial Chemicals. Highly-toxic industrial 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. Can be liquid, solid, or gas agents. [See also Chemical Terrorism Agents and Chemical Warfare (CW) Agents.]

3.3.23* Encapsulating. A type of ensemble that provides liquid-tight protection to the upper and lower torso, head, hands, and feet and completely covers the wearer and the wearer's respirator. (See also Chemical/Biological Terrorism Incident Protective Ensemble and Non-encapsulating.)

3.3.24 Ensemble. An abbreviated term for Chemical/Biological Terrorism Incident Protective Ensemble. (See also Chemical/Biological Terrorism Incident Protective Ensemble.)

3.3.25* Ensemble Elements. The parts or items that comprise the chemical/biological terrorism incident protective ensemble.

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

3.3.27 Fire and Emergency Services Personnel. Members of fire departments, other governmental agencies, or other organizations that have the public safety responsibilities and who would respond to terrorism incidents where a chemical terrorism agent(s), biological terrorism agent(s), or dual-use industrial chemical(s) has been or could be released.

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. An abbreviated term for Chemical/Biological Terrorism Incident Protective Footwear element. (See also Chemical/Biological Terrorism Incident Protective Footwear.)

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

3.3.31 Garment(s). An abbreviated term for Chemical/Biological Terrorism Incident Protective Garment(s) element. [See also Chemical/Biological Terrorism Incident Protective Garment(s)].

3.3.32 Garment Closure. The garment component designed and configured to allow the wearer to enter (don) and exit (doff) the chemical/biological terrorism incident protective ensemble.

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

3.3.34 Garment Material. The principal protective clothing material used in the construction of chemical/biological terrorism incident protective garments.

3.3.35 Glove(s). An abbreviated term for Chemical/Biological Terrorism Incident Protective Glove(s) element. [See also Chemical/Biological Terrorism Incident Protective Glove(s).]

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

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

3.3.38 Manufacturer. The entity that assumes the liability and provides the warranty for the compliant product.

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

3.3.40* Non-Encapsulating. A type of ensemble that provides protection to the upper and lower torso, head, hands, and feet but does not cover the wearer's respirator. (See also Chemical/Biological Terrorism Incident Protective Ensemble and Encapsulating.)

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

3.3.42 Outer Garment. A garment worn over another garment element to meet the requirements of this standard.

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

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

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

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

3.3.47 Protective Clothing Material. Any material or composite used in an ensemble or ensemble element for the purpose of protecting parts of the wearer's body against chemical/biological terrorism agents, or against physical hazards.

3.3.48 Protective Ensembles. An abbreviated term for Chemical/Biological Terrorism Incident Protective Ensembles. (See also Chemical/Biological Terrorism Incident Protective Ensembles.)

3.3.49 Protective Footwear. An abbreviated term for Chemical/Biological Terrorism Incident Protective Footwear. (See also Chemical/Biological Terrorism Incident Protective Footwear.)

3.3.50 Protective Garment(s). An abbreviated term for Chemical/Biological Terrorism Incident Protective Garment(s). [See also Chemical/Biological Terrorism Incident Protective Garment(s).]

3.3.51 Protective Glove(s). An abbreviated term for Chemical/Biological Terrorism Incident Protective Glove(s). [See also Chemical/Biological Terrorism Incident Protective Glove(s).]

3.3.52 Radiological Agents. Radiation associated with x-rays, alpha, beta, and gamma emissions from radioactive isotopes, or other materials in excess of normal background radiation levels.

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

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

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

3.3.56 Visor Material. The transparent chemical-protective clothing material that allows the wearer to see outside the chemical/biological terrorism incident protective ensemble.

Chapter 4 Certification

4.1 General.

4.1.1* All protective ensembles that are labeled as being compliant with this standard shall meet or exceed all applicable requirements specified in this standard and shall be certified. Manufacturers shall not claim compliance with a portion(s) or segment(s) of the requirements of this standard and shall not use the name or identification of this standard, NFPA 1994, in any statements about their respective products unless the product is certified to this standard.

4.1.2 All certification shall be performed by an approved 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 Guide 65, *General Requirements for Bodies Operating Product Certification Systems*.

4.1.3 Compliant chemical/biological terrorism incident protective ensembles and ensemble elements shall be labeled and listed. In addition, each compliant chemical/biological terrorism incident protective ensemble and ensemble element shall have a product label that meets the applicable requirements specified in Section 5.1, Product Labeling Requirements.

4.1.3.1 Glove elements and footwear elements that are provided, sold, or distributed as part of a specific ensemble shall not be required to be separately labeled and listed but shall be included as a part of the ensemble product label and listing. The designation of which elements are certified as compliant with a specific ensemble(s) shall be clearly indicated on the product labels of both the element and the ensemble.

4.1.3.2 Glove and footwear ensemble elements that are manufactured as separate items and are not intended to be provided, sold, or distributed as part of a complete ensemble shall be certified as ensemble elements.

4.1.4 Where protective ensembles and ensemble elements are certified for additional chemicals and mixtures, they shall

also meet or exceed all applicable requirements for the ensemble element specified in this standard.

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

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

4.2.3* 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. There shall be no conditional, temporary, or partial certifications. Manufacturers shall not be authorized to use any label or reference to the certification organization on products that are not manufactured in compliance with all applicable requirements of this standard.

4.2.4* The certification laboratory shall have laboratory facilities and equipment for conducting proper tests, a program for calibration of all instruments shall be in place and operating, and procedures shall be in use to ensure proper control of all testing. Good practice shall be followed regarding the use of laboratory manuals, form data sheets, documented calibration and calibration routines, performance verification, proficiency testing, and staff qualification and training programs.

4.2.5 The certification organization shall require the manufacturer to establish and maintain a program of production inspection and testing that at least meets the requirements of Section 4.5 or 4.6. 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.

4.2.6 The certification organization and the manufacturer shall evaluate any changes affecting the form, fit, or function of the certified product to determine its continual certification of this standard.

4.2.7* The certification organization shall have a follow-up inspection program of the manufacturing facilities of the certified product, with at least two random and unannounced visits per 12-month period.

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

4.2.7.2 The certification organization shall have a statistically validated process for determining the critical inspections and tests to be conducted through this follow-up program to verify the continued compliance of the product or component.

4.2.8 The certification organization shall have a program for investigating field reports alleging malperformance or failure of listed products.

4.2.9* The certification organization shall require the manufacturer to have a product recall system as part of the manufacturer's quality assurance program.

4.2.10 The operating procedures of the certification organization shall provide a mechanism for the manufacturer to ap-

peal decisions. The procedures shall include the presentation of information from both sides of a controversy to a designated appeals panel.

4.2.11 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 ensembles and ensemble elements, the certification organization shall conduct both inspection and testing as specified in this section.

4.3.1.1 The certification organization shall ensure that the manufacturer tests each Class 1 ensemble and each Class 1 ensemble element for gas-tight integrity as specified in Section 8.2, Gas-Tight Integrity Test. Each ensemble and ensemble element shall show an ending pressure of not less than 80 mm ($3\frac{1}{32}$ in.) water pressure.

4.3.1.2 The date of the test shall be printed on the product label.

4.3.2 All inspections, evaluations, conditioning, and testing for certification or for recertification shall be conducted by the certification organization or a facility accredited by the certification organization for inspections, evaluations, conditioning, and testing in accordance with all provisions pertaining to testing laboratories in ISO Guide 17025, *General Requirements for the Competence of Calibration and Testing Laboratories*.

4.3.3 All inspections, evaluations, conditioning, or testing conducted by a product manufacturer shall not be used in the certification or recertification process unless the facility for inspections, evaluations, conditioning, or testing has been accredited by the certification organization in accordance with all provisions pertaining to testing laboratories in ISO Guide 17025, *General Requirements for the Competence of Calibration and Testing Laboratories*.

4.3.4 Sampling levels for testing and inspection shall be established by the certification organization and the manufacturer to assure a reasonable and acceptable reliability at a reasonable and acceptable confidence level that products certified to this standard are compliant unless such samples 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 attachment, compliance statements, other statements, and other product information are at least as specified for the specific item in Section 5.1, Product Labeling Requirements.

4.3.6 Inspection by the certification organization shall include a review of any graphic representations used on product labels, as permitted by 5.1.1.6, to ensure that the graphics are consistent with the worded statements, readily understood, and clearly communicate the intended message.

4.3.7 Inspection by the certification organization shall include a review of the user information required by Section 5.2, User Information, to ensure that the information has been developed and is available.

4.3.8 The certification organization shall review the Technical Data Package to determine compliance with the requirements of Section 5.3, Technical Data Package.

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

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

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

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

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

4.3.11 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 products as being compliant with this standard.

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.

4.3.12.1 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.

4.3.12.2 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.

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

4.3.14 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.

4.4 Recertification.

4.4.1 All ensemble models and all ensemble element models that are labeled as being compliant with this standard shall undergo recertification on an annual basis.

4.4.1.1 This recertification shall include inspection and evaluation to 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.

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

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

4.4.2.1 For recertification, the certification organization shall acquire at least one complete ensemble sample outfitted with all manufacturer-provided external fittings.

4.4.2.2 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 Ensembles and ensemble elements shall be inspected, evaluated, and tested as specified in 4.4.3.1 through 4.4.3.3.

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

4.4.3.2 One sample of each ensemble shall be tested for overall performance as specified in Section 7.1, Class 1 Ensembles, using the following sequence of tests:

- (1) The ensemble shall be tested for inward leakage as specified in Section 8.3, Overall Ensemble Inward Leakage Test, and shall show no inward leakage greater than 0.02 percent for Class 1 garments, or 2.0 percent for Class 2 garments. This test shall not apply to Class 3 garments.
- (2) The ensemble shall then be tested for overall function and integrity as specified in Section 8.4, Overall Ensemble Function and Integrity Test, as follows:
 - (a) The ensemble shall allow no liquid penetration in subsequent liquid-integrity testing as specified in Section 8.6, Liquid-Tight Integrity Test One.
 - (b) The ensemble shall allow the test subject to complete all tasks.
 - (c) The ensemble shall accommodate head protection devices meeting the requirements for Type 1, Class G helmets of ANSI Z89.1, *Standard for Industrial Head Protection*.
 - (d) The ensemble shall permit the test subject to see through the visor or respirator facepiece lense with a visual acuity of 20/35 or better.

4.4.3.3 All ensemble material, visor, glove, and footwear performance requirements shall be evaluated as specified in Chapter 7 with the following modifications:

- (1) Permeation and penetration resistance testing specified in Chapter 7 shall be performed against each of the following chemicals:
 - (a) Distilled Sulfur Mustard (HD)
 - (b) Sarin (GB)
 - (c) Ammonia (NH₃) (CAS 7664-41-7)
- (2) A total of two specimens shall be permitted for physical testing requirements. If the testing is specified for both directions of a material, a total of two specimens per material direction shall be permitted for testing requirements. For gloves and footwear, the right- and left-hand components of a single pair shall be considered as separate specimens under this requirement.

4.4.4 The manufacturer shall maintain all design, inspection, performance, and test data from the certification organization produced during the recertification of manufacturers' mod-

els. The manufacturer shall provide such data, upon request, to the purchaser or to the authority having jurisdiction.

4.5 Manufacturer's Quality Assurance Program.

4.5.1 The manufacturer shall provide and maintain a quality assurance program that includes a documented inspection and product recall system. The manufacturer shall have an inspection system to substantiate conformance to this standard.

4.5.2 The manufacturer shall maintain written inspection and testing instructions.

4.5.2.1 The instructions shall prescribe inspection and test of materials, work in process, and completed articles.

4.5.2.2 Criteria for acceptance and rejection of materials, processes, and final product shall be part of the instructions.

4.5.3 The manufacturer shall maintain records of all pass/fail tests. Pass/fail records shall indicate the disposition of the failed material or product.

4.5.4 The manufacturer's inspection system shall provide for procedures that assure the latest applicable drawings, specifications, and instructions are used for fabrication, inspection, and testing.

4.5.5 The manufacturer shall, as part of the quality assurance program, maintain a calibration program of all instruments used to ensure proper control of testing. The calibration program shall be documented as to the date of calibration and performance verification.

4.5.6 The manufacturer shall maintain a system for identifying the appropriate inspection status of component materials, work in process, and finished goods.

4.5.7 The manufacturer shall establish and maintain a system for controlling nonconforming material, including procedures for the identification, segregation, and disposition of rejected material. All nonconforming materials or products shall be identified to prevent use, shipment, and intermingling with conforming materials or products.

4.5.8 The manufacturer's quality assurance program shall be audited by the third-party certification organization to determine that the program is sufficient to ensure continued product compliance with this standard.

4.5.9 The manufacturer's quality assurance program shall describe how the quality assurance method used ensures that each item of production complies with the requirements of Chapters 6 and 7 of this standard.

4.6 ISO Registration for Manufacturers.

4.6.1 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 4.2.9.

4.6.2 The manufacturer shall be registered to ISO 9001, *Quality Management Systems — Requirements*.

4.6.3 The ISO registration requirements shall have an effective date of 1 March 2003.

4.6.4 Until 1 March 2003, or until the date the manufacturer becomes ISO registered, whichever date occurs first, the manufacturer shall comply with Section 4.5.

Chapter 5 Labeling and Information

5.1 Product Labeling Requirements.

5.1.1 General.

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

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

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

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

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

5.1.1.6 Symbols and other pictorial graphic representations shall be permitted to be used to supplement worded statements on the product label(s).

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

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

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

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

5.1.1.10 Where detachable components including, but not limited to, outer garments, outer gloves, or outer boots must

be worn with an ensemble or ensemble element in order for the ensemble or ensemble element to be compliant with this standard, at least the following statement and information shall also be printed legibly on the product label of the ensemble or ensemble element that requires an additional component. All letters shall be at least 2.5 mm ($\frac{3}{32}$ in.) high. The appropriate term *ensemble* or *ensemble element* shall be inserted where indicated in the label text. The statement shall be followed by the detachable component(s) type and identification and instructions for proper wear.

“TO BE COMPLIANT WITH NFPA 1994, THE FOLLOWING ADDITIONAL COMPONENTS MUST BE WORN IN CONJUNCTION WITH THIS CHEMICAL OR BIOLOGICAL INCIDENT (insert the term ENSEMBLE or ENSEMBLE ELEMENT here):”

[The detachable component(s) information shall appear here.]

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

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

“SEE TECHNICAL DATA PACKAGE FOR A LIST OF DETACHABLE COMPONENTS.”

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

5.1.2 Ensemble Compliance Statements.

5.1.2.1 Each protective ensemble shall have at least the following compliance statement on the product label. The appropriate numeral for the class of the ensemble, 1, 2, or 3, and the appropriate term for the type of ensemble, *encapsulating* or *non-encapsulating*, shall be inserted where indicated in the label text.

“THIS CLASS (insert 1, 2, or 3 here) (insert ENCAPSULATING or NON-ENCAPSULATING here) CHEMICAL/BIOLOGICAL PROTECTIVE ENSEMBLE MEETS THE REQUIREMENTS OF NFPA 1994, STANDARD ON PROTECTIVE ENSEMBLES FOR CHEMICAL/BIOLOGICAL TERRORISM INCIDENTS, 2001 EDITION, FOR THE ABOVE-NOTED CLASS.”

5.1.2.2 Each Class 1 protective ensemble shall have at least the following additional statement immediately following the compliance statement, specified in 5.1.2.1, on the product label:

“This Class 1 ensemble is designed for use at incidents where the identity or concentration of the vapor or liquid agent is unknown, or where it is necessary to provide vapor protection, or where liquid contact is expected and no direct skin contact can be permitted.”

5.1.2.3 Each Class 2 protective ensemble shall have at least the following additional statement immediately following the compliance statement, specified in 5.1.2.1, on the product label:

“This Class 2 ensemble is designed for use at incidents where it is necessary to provide sufficient vapor protection for the intended operation, where direct contact of liquid droplets is probable; and where victims are symptomatic and nonambulatory.”

5.1.2.4 Each Class 3 protective ensemble shall have at least the following additional statement immediately following the compliance statement, specified in 5.1.2.1, on the product label:

“This Class 3 ensemble is designed for use at incidents where it is necessary to provide sufficient vapor protection for the intended operation, where direct contact of liquid droplets is possible, and where victims are symptomatic and ambulatory.”

5.1.2.5 Each protective ensemble shall have at least the following additional statement immediately following the class statement, specified in 5.1.2.2, 5.1.2.3, or 5.1.2.4 on the product label:

“The technical data package contains information on chemical/biological agents for which this garment is certified. Consult the technical data package and manufacturer’s instructions before use.

DO NOT REMOVE THIS LABEL.”

5.1.3 Glove and Footwear Elements Compliance Statements.

5.1.3.1 Each glove element and footwear element shall have at least the following compliance statement on the product label. The appropriate numeral for the class of the ensemble, 1, 2, or 3; and the appropriate term for the type of element, *glove* or *footwear*, shall be inserted where indicated in the label text.

“THIS CLASS (insert 1, 2, or 3 here)
CHEMICAL/BIOLOGICAL PROTECTIVE (insert
GLOVE or FOOTWEAR here) MEETS THE
REQUIREMENTS OF NFPA 1994, STANDARD ON
PROTECTIVE ENSEMBLES FOR
CHEMICAL/BIOLOGICAL TERRORISM
INCIDENTS, 2001 EDITION, FOR THE
ABOVE-NOTED CLASS.”

5.1.3.2 Each Class 1 glove and footwear element shall have at least the following additional statement immediately following the compliance statement, specified in 5.1.3.1, on the product label:

“This Class 1 (insert *glove* or *footwear* here) element is designed for use as part of a total ensemble at incidents where the identity or concentration of the vapor or liquid agent is unknown, or where it is necessary to provide vapor protection, or where liquid contact is expected and no direct skin contact can be permitted.”

5.1.3.3 Each Class 2 glove and footwear element shall have at least the following additional statement immediately following the compliance statement, specified in 5.1.3.1, on the product label:

“This Class 2 (insert *glove* or *footwear* here) element is designed for use as part of a total ensemble at incidents where it is necessary to provide sufficient vapor protection for the intended operation, where direct contact of liquid droplets is probable, and where victims are symptomatic and are nonambulatory.”

5.1.3.4 Each Class 3 glove and footwear element shall have at least the following additional statement immediately following the compliance statement, specified in 5.1.3.1, on the product label:

“This Class 3 (insert *glove* or *footwear* here) element is designed for use as part of a total ensemble at incidents where it is necessary to provide sufficient vapor protection for the intended operation, where direct contact of liquid droplets is possible, and where victims are symptomatic and are ambulatory.”

5.1.3.5 Each glove and footwear element shall have at least the following additional statement immediately following the class statement, specified in 5.1.3.2, 5.1.3.3, or 5.1.3.4, on the product label. The appropriate term for the type of element, *glove* or *footwear*, shall be inserted where indicated in the label text:

“The technical data package contains information on chemical/biological agents for which this (insert *glove* or *footwear* here) is certified. Consult the technical data package and manufacturer’s instructions before use.

DO NOT REMOVE THIS LABEL.”

5.2 User Information.

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

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

5.2.3 The manufacturer shall provide at least the following instructions and information with each liquid splash-protective clothing item or ensemble:

- (1) Pre-use information, as follows:
 - (a) Safety considerations
 - (b) Limitations of use
 - (c) Ensemble element marking recommendations and restrictions
 - (d) Statement that most performance properties of the chemical and biological ensemble or ensemble element cannot be tested by the user in the field
 - (e) Closure lubricants, if applicable
 - (f) Visor antifog agents or procedures
 - (g) Recommended undergarments
 - (h) Respirator considerations for ensembles
 - (i) Warranty information
- (2) Recommended storage practices
- (3) Inspection frequency and details
- (4) Don/doff, as follows:
 - (a) Donning and doffing procedures
 - (b) Sizing and adjustment procedures
 - (c) Ensemble interface issues
 - (d) Respirator interface with ensemble
- (5) Proper use in accordance with the following:
 - (a) NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program*
 - (b) For users in the United States, 29 CFR 1910.132, *Personal Protective Equipment*

- (c) For users in other countries, a statement to advise users to consult national or other applicable personal protective equipment regulations
- (6) Maintenance and cleaning, as follows:
 - (a) Cleaning instructions and precautions with a statement advising users not to use clothing or ensembles that are not thoroughly cleaned and dried
 - (b) Inspection details
 - (c) Maintenance criteria and repair methods, where applicable
 - (d) Decontamination procedures for both chemical/biological contamination
- (7) Retirement and disposal criteria and consideration

5.2.4 The manufacturer shall state the storage life for each chemical/biological terrorism incident ensemble or ensemble element.

5.3 Technical Data Package.

5.3.1* The manufacturer shall furnish a technical data package for the ensemble or ensemble element upon the request of the purchaser.

5.3.2* The technical data package shall contain all documentation required by this standard and the data showing compliance with this standard.

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

5.3.4* In the technical data package, the manufacturer shall describe the available sizes of the ensemble or ensemble element.

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

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

5.3.5 Garment Material and Component Descriptions.

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

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

- (1) Garment material
- (2) Visor material
- (3) Glove material and type of attachment
- (4) Footwear material and type of attachment
- (5) Zipper/closure type and materials
- (6) Material seam types and composition
- (7) Exhaust valve types and material(s)
- (8) External fitting types and material(s)
- (9) External gasket types and material(s)
- (10) Outer garment, glove, or footwear material(s)

- (11) Manufacturer and specific model of respirator(s) tested with the ensemble
- (12) Type or style of head protection accommodated within the suit

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

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

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

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

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

Chapter 6 Design Requirements

6.1 Protective Ensemble Requirements.

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

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

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

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

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

6.1.6 All respirators specified by the ensemble manufacturer for inclusion in Class 1, Class 2, or Class 3 ensembles shall be

NIOSH certified respirators in accordance with 42 CFR 84 and cover, at a minimum, the eyes, nose, and mouth.

6.1.6.1 Where the respirator specified in 6.1.6 provides a chemical/biological barrier, the components of the respirator that are exposed to the environment shall meet the requirements of 7.1.2, 7.2.2, or 7.3.2 as applicable for the specific ensemble class.

6.1.6.2 Where the respirator specified in 6.1.6 is an open-circuit SCBA, the SCBA shall also be certified as compliant with NFPA 1981, *Standard on Open-Circuit Self-Contained Breathing Apparatus for the Fire Service*.

6.1.7 Class 1 and Class 2 protective ensembles shall be designed such that all components, including the garment and including the hood if not attached to the garment, gloves, and footwear, can be removed without causing respiratory protection to be removed.

6.2 Garment Element Requirements.

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

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

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

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

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

6.3 Glove Element Requirements.

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

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

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

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

6.4 Footwear Element Requirements.

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

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

6.4.3 Footwear shall be available in at least sizes 6 through 15 when measured in accordance with the Footwear Industries of America document, *Shoe Size Conversion, Research Results and Recommendations*.

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

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

6.4.6 Where booties are used as part of the ensemble, the manufacturer shall specify types of outer footwear that provide the physical performance requirements for footwear as specified in 7.1.4, 7.2.4, and 7.3.4 as applicable for the specific ensemble class.

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

6.5 Accessory Requirements.

6.5.1 Any accessories attached to any ensemble element shall not interfere with the function of the ensemble element or with the function of any of the ensemble element's component parts.

6.5.2 Any accessories attached to any ensemble element shall not degrade the designed protection or performance of the ensemble element below the requirements of this standard.

Chapter 7 Performance Requirements

7.1 Class 1 Ensembles.

7.1.1 Class 1 Ensemble General Requirements.

7.1.1.1 Class 1 ensembles shall be tested as specified in Section 8.3, Overall Ensemble Inward Leakage Test, and shall show no inward leakage greater than 0.02 percent.

7.1.1.2 Class 1 ensembles shall be tested for overall function as specified in Section 8.4, Overall Ensemble Function and Integrity Test, and shall have the following performance:

- (1) Class 1 ensembles shall have an ending pressure of at least 80 mm ($3\frac{5}{32}$ in.) water gauge pressure.
- (2) Class 1 ensembles shall allow the test subject to complete all tasks.
- (3) Class 1 ensembles shall accommodate head protection devices meeting the requirements for Type I, Class G helmets of ANSI Z89.1, *Standard for Industrial Head Protection*.
- (4) Where Class 1 ensembles have hoods with visors, such ensembles shall permit the test subject to see through the visor with a visual acuity of 20/35 or better.
- (5) Where Class 1 ensembles use the respirator facepiece of the respirator designated by the ensemble manufacturer for the ensemble as a face/visor chemical/biological barrier material, such ensembles shall permit the test subject to see through the facepiece with a visual acuity of 20/35 or better.

7.1.1.3 Class 1 ensembles shall be tested for airflow capacity as specified in Section 8.5, Maximum Ensemble Ventilation Rate Test, and shall not exhibit internal pressure greater than 100 mm (4 in.) water gauge pressure, and shall show an ending pressure of at least 80 mm ($3\frac{5}{32}$) water gauge pressure after subsequent testing for gas-tight integrity as specified in Section 8.2, Gas-Tight Integrity Test.

7.1.1.4 Exhaust valves installed in Class 1 ensembles shall be tested for inward leakage as specified in Section 8.7, Exhaust Valve Inward Leakage Test, and shall not exhibit a leakage rate exceeding 30 ml/min (1.83 in.³/min).

7.1.1.5 Exhaust valves installed in Class 1 ensembles shall be tested for mounting strength as specified in Section 8.8, Exhaust Valve Mounting Strength Test, and shall not have a failure force of less than 135 N (30 lbf).

7.1.1.6 Class 1 ensembles, on which external fittings are installed that penetrate any primary materials, shall be tested for gas-tight integrity as specified in Section 8.2, Gas-Tight Integrity Test, and shall show an ending pressure of at least 80 mm ($3\frac{3}{32}$) water gauge.

7.1.1.7 External fittings installed in Class 1 ensembles shall be tested for pull-out strength as specified in Section 8.9, Fitting Pull-Out Strength Test, and shall not have a failure force of less than 1000 N (225 lbf).

7.1.2 Class 1 Garment Element Requirements.

7.1.2.1 Class 1 garment materials and seams shall be tested for permeation resistance as specified in Section 8.10, Chemical Permeation Resistance Test, and shall meet the following performance criteria:

- (1) For permeation testing of chemical warfare agents Lewisite (L) and Distilled Mustard (HD), the average cumulative permeation in 1 hour shall not exceed $4.0 \mu\text{g}/\text{cm}^2$.
- (2) For permeation testing of chemical warfare agents Sarin (GB) and VX, the average cumulative permeation in 1 hour shall not exceed $1.25 \mu\text{g}/\text{cm}^2$.
- (3) For permeation testing of liquid and gaseous industrial chemicals, the average breakthrough time shall be not be less than 60 minutes.

7.1.2.2 Class 1 garment materials shall be tested for bursting strength as specified in Section 8.11, Burst Strength Test, and shall have a bursting strength of not less than 200 N (45 lbf).

7.1.2.3 Class 1 garment materials shall be tested for puncture propagation tear resistance as specified in Section 8.12, Puncture Propagation Tear Resistance Test, and shall have a puncture propagation tear resistance of not less than 49 N (11 lbf).

7.1.2.4 Class 1 garment materials shall be tested for cold weather performance as specified in Section 8.13, Cold Temperature Performance Test One, and shall have a bending moment of not greater than $0.057 \text{ N}\cdot\text{m}$ ($\frac{1}{2}$ in.-lbf) at an angular deflection of 60 degrees at -25°C (-13°F).

7.1.2.5 Class 1 garment seams shall be tested for seam strength as specified in Section 8.14, Seam/Closure Breaking Strength Test, and shall have a breaking strength of not less than $2.63 \text{ kN}/\text{m}$ (30 lbf/2 in.).

7.1.2.6 Class 1 garment closure assemblies shall be tested for closure strength as specified in Section 8.14, Seam/Closure Breaking Strength Test, and shall have a breaking strength of not less than $2.63 \text{ kN}/\text{m}$ (30 lbf/2 in.).

7.1.2.7 Class 1 Garment Visor Requirements.

7.1.2.7.1 Class 1 garment visor materials and seams and those respirator facepiece materials and seams of the respirator designated by the ensemble manufacturer for the ensemble that are face/visor chemical/biological barriers shall be tested for permeation resistance as specified in Section 8.10, Chemical Permeation Resistance Test, and shall meet the following performance criteria:

- (1) For permeation testing of chemical warfare agents Lewisite (L) and Distilled Mustard (HD), the average cumulative permeation in 1 hour shall not exceed $4.0 \mu\text{g}/\text{cm}^2$.

- (2) For permeation testing of chemical warfare agents Sarin (GB) and VX, the average cumulative permeation in 1 hour shall not exceed $1.25 \mu\text{g}/\text{cm}^2$.
- (3) For permeation testing of liquid and gaseous industrial chemicals, the average breakthrough time shall be not be less than 60 minutes.

7.1.2.7.2 Class 1 respirator facepiece materials of the respirator designated by the ensemble manufacturer for the ensemble that are face/visor chemical/biological barriers and Class 1 garment visor materials shall be tested for bursting strength as specified in Section 8.11, Burst Strength Test, and shall have a bursting strength of not less than 200 N (45 lbf).

7.1.2.7.3 Class 1 respirator facepiece materials of the respirator facepiece designated by the ensemble manufacturer for the ensemble that are face/visor chemical/biological barriers and Class 1 garment visor materials shall be tested for puncture propagation tear resistance as specified in Section 8.12, Puncture Propagation Tear Resistance Test, and shall have a puncture propagation tear resistance of not less than 49 N (11 lbf).

7.1.2.7.4 Class 1 respirator facepiece materials of the respirator facepiece designated by the ensemble manufacturer for the ensemble that are face/visor chemical/biological barriers and Class 1 garment visor materials shall be tested for cold temperature bending at -25°C (-13°F) as specified in Section 8.15, Cold Temperature Performance Test Two, and shall not crack or show evidence of visible damage.

7.1.2.7.5 Class 1 respirator facepiece material seams of the respirator facepiece designated by the ensemble manufacturer for the ensemble that are face/visor chemical/biological barrier seams and Class 1 garment visor material seams shall be tested for seam strength as specified in Section 8.14, Seam/Closure Breaking Strength Test, and shall have a breaking strength of not less than $2.63 \text{ kN}/\text{m}$ (30 lbf/2 in.).

7.1.3 Class 1 Glove Element Requirements.

7.1.3.1 Class 1 glove materials and seams shall be tested for permeation resistance as specified in Section 8.10, Chemical Permeation Resistance Test, and shall meet the following performance criteria:

- (1) For permeation testing of chemical warfare agents Lewisite (L) and Distilled Mustard (HD), the average cumulative permeation in 1 hour shall not exceed $4.0 \mu\text{g}/\text{cm}^2$.
- (2) For permeation testing of chemical warfare agents Sarin (GB) and VX, the average cumulative permeation in 1 hour shall not exceed $1.25 \mu\text{g}/\text{cm}^2$.
- (3) For permeation testing of liquid and gaseous industrial chemicals, the average breakthrough time shall be not be less than 60 minutes.

7.1.3.2 Class 1 glove material shall be tested for cut resistance as specified in Section 8.16, Cut Resistance Test, and shall have the distance of blade travel not be less than 25 mm (1 in.).

7.1.3.3 Class 1 glove materials shall be tested for puncture resistance as specified in Section 8.17, Puncture Resistance Test One, and shall have a puncture resistance of not less than 22 N (5 lbf).

7.1.3.4 Class 1 glove materials shall be tested for cold weather performance as specified in Section 8.13, Cold Temperature Performance Test One, and shall have a bending moment of $0.057 \text{ N}\cdot\text{m}$ ($\frac{1}{2}$ in.-lbf) at an angular deflection of 60 degrees at -25°C (-13°F).

7.1.3.5 Class 1 gloves shall be tested for hand function as specified in Section 8.18, Glove Hand Function Test, and shall have an average percent increase over barehanded control less than 600 percent.

7.1.4 Class 1 Footwear Element Requirements.

7.1.4.1 Class 1 footwear upper material shall be tested for permeation resistance as specified in Section 8.10, Chemical Permeation Resistance Test, and shall meet the following performance criteria:

- (1) For permeation testing of chemical warfare agents Lewisite (L) and Distilled Mustard (HD), the average cumulative permeation in 1 hour shall not exceed $4.0 \mu\text{g}/\text{cm}^2$.
- (2) For permeation testing of chemical warfare agents Sarin (GB) and VX, the average cumulative permeation in 1 hour shall not exceed $1.25 \mu\text{g}/\text{cm}^2$.
- (3) For permeation testing of liquid and gaseous industrial chemicals, the average breakthrough time shall be not be less than 60 minutes.

7.1.4.2 Class 1 footwear upper materials shall be tested for cut resistance as specified in Section 8.16, Cut Resistance Test, and shall have the distance of blade travel not be less than 25 mm (1 in.).

7.1.4.3 Upper materials for Class 1 footwear shall be tested for puncture resistance as specified in Section 8.17, Puncture Resistance Test One, and shall have a puncture resistance of not less than 36 N (8 lbf).

7.1.4.4 Class 1 Footwear soles and heels shall be tested for abrasion resistance as specified in Section 8.19, Abrasion Resistance Test, and have an abrasion-resistance rating of not less than 65.

7.1.4.5 Class 1 footwear soles and heels shall be tested for puncture resistance as specified in Section 8.20, Puncture Resistance Test Two, and have a puncture resistance of not less than 1.21kN (272 lbf).

7.1.4.6 Class 1 footwear soles shall be tested for slip resistance as specified in Section 8.21, Slip Resistance Test, and shall have a static coefficient of 0.75 or greater.

7.1.4.7 Class 1 footwear toes shall be tested for impact and compression resistance as specified in Section 8.22, Impact and Compression Resistance Test, and shall have an impact resistance of not less than 101.7J (75 ft-lbs) and a compression resistance of not less than 11,121 N (2500 lbf).

7.1.4.8 Where booties are used in the construction of the Class 1 ensemble, the bootie shall meet the chemical resistance requirement for footwear specified in 7.1.4.1 and the specified outer footwear shall meet the physical performance requirements for footwear specified in 7.1.4.2 through 7.1.4.7.

7.2 Class 2 Ensembles.

7.2.1 Class 2 Ensemble General Requirements.

7.2.1.1 Class 2 ensembles shall be tested as specified in Section 8.3, Overall Ensemble Inward Leakage Test, and shall show no inward leakage greater than 2.0 percent.

7.2.1.2 Class 2 Ensembles shall be tested for overall function as specified in Section 8.4, Overall Ensemble Function and Integrity Test, and shall have the following performance:

- (1) Class 2 ensembles shall allow no liquid penetration in subsequent liquid-integrity testing as specified in Section 8.6,

Liquid-Tight Integrity Test One. Where outer gloves are designed to be worn in conjunction with gloves attached to the ensemble, or where outer boots are designed to be worn in conjunction with garment booties to meet foot protection requirements, such items shall not collect liquid.

- (2) Class 2 ensembles shall allow the test subject to complete all tasks.
- (3) Class 2 ensembles shall accommodate head protection devices meeting the requirements for Type I, Class G helmets of ANSI Z89.1, *Standard for Industrial Head Protection*.
- (4) Where Class 2 ensembles have hoods with visors, such ensembles shall permit the test subject to see through the visor with a visual acuity of 20/35 or better.
- (5) Where Class 2 ensembles use the respirator facepiece of the respirator designated by the ensemble manufacturer for the ensemble as a face/visor chemical/biological barrier material, such ensembles shall permit the test subject to see through the facepiece with a visual acuity of 20/35 or better.

7.2.2 Class 2 Garment Element Requirements.

7.2.2.1 Class 2 garment materials and seams shall be tested for permeation resistance as specified in Section 8.10, Chemical Permeation Resistance Test, and shall meet the following performance criteria:

- (1) For permeation testing of chemical warfare agents Lewisite (L) and Distilled Mustard (HD), the average cumulative permeation in 1 hour shall not exceed $4.0 \mu\text{g}/\text{cm}^2$.
- (2) For permeation testing of chemical warfare agents Sarin (GB) and VX, the average cumulative permeation in 1 hour shall not exceed $1.25 \mu\text{g}/\text{cm}^2$.
- (3) For permeation testing of liquid and gaseous industrial chemicals, the average breakthrough time shall be not be less than 60 minutes.

7.2.2.2 Class 2 garment materials shall be tested for bursting strength as specified in Section 8.11, Burst Strength Test, and shall have a bursting strength of not less than 156 N (35 lbf).

7.2.2.3 Class 2 garment materials shall be tested for puncture propagation tear resistance as specified in Section 8.12, Puncture Propagation Tear Resistance Test, and shall have a puncture propagation tear resistance of not less than 31 N (7 lbf).

7.2.2.4 Class 2 garment materials shall be tested for cold weather performance as specified in Section 8.13, Cold Temperature Performance Test One, and shall have a bending moment of not greater than $0.057 \text{ N}\cdot\text{m}$ ($\frac{1}{2}$ in.-lbf) at an angular deflection of 60 degrees at -25°C (-13°F).

7.2.2.5 Class 2 garment seams shall be tested for seam strength as specified in Section 8.14, Seam/Closure Breaking Strength Test, and shall have a breaking strength of not less than $1.31 \text{ kN}/\text{m}$ (15 lbf/2 in.).

7.2.2.6 Class 2 garment closure assemblies shall be tested for closure strength as specified in Section 8.14, Seam/Closure Breaking Strength Test, and shall have a breaking strength of not less than $1.31 \text{ kN}/\text{m}$ (15 lbf/2 in.).

7.2.2.7 Class 2 garment materials and seams shall be tested for resistance to liquid or bloodborne pathogens as specified in Section 8.23, Viral Penetration Resistance Test, and shall allow no penetration of the Phi-X-174 bacteriophage for at least 1 hour.

7.2.2.8 Class 2 Garment Visor Requirements.

7.2.2.8.1 Class 2 seams and those respirator facepiece materials and seams of the respirator facepiece designated by the

ensemble manufacturer for the ensemble that are face/visor chemical/biological barrier materials and seams and Class 2 garment visor materials shall be tested for permeation resistance as specified in Section 8.10, Chemical Permeation Resistance Test, and shall meet the following performance criteria:

- (1) For permeation testing of chemical warfare agents Lewisite (L) and Distilled Mustard (HD), the average cumulative permeation in 1 hour shall not exceed $4.0 \mu\text{g}/\text{cm}^2$.
- (2) For permeation testing of chemical warfare agents Sarin (GB) and VX, the average cumulative permeation in 1 hour shall not exceed $1.25 \mu\text{g}/\text{cm}^2$.
- (3) For permeation testing of liquid and gaseous industrial chemicals, the average breakthrough time shall be not be less than 60 minutes.

7.2.2.8.2 Class 2 respirator facepiece materials of the respirator facepiece designated by the ensemble manufacturer for the ensemble that are face/visor chemical/biological barrier materials and Class 2 garment visor materials shall be tested for bursting strength as specified in Section 8.11, Burst Strength Test, and shall have a bursting strength of not less than 156 N (35 lbf).

7.2.2.8.3 Class 2 respirator facepiece materials of the respirator facepiece designated by the ensemble manufacturer for the ensemble that are face/visor chemical/biological barrier materials and Class 2 garment visor materials shall be tested for puncture propagation tear resistance as specified in Section 8.12, Puncture Propagation Tear Resistance Test, and shall have a puncture propagation tear resistance of not less than 36 N (8 lbf).

7.2.2.8.4 Class 2 respirator facepiece materials of the respirator facepiece designated by the ensemble manufacturer for the ensemble that are face/visor chemical/biological barrier materials and Class 2 garment visor materials shall be tested for cold temperature bending at -25°C (-13°F) as specified in Section 8.15, Cold Temperature Performance Test Two, and shall not crack or show evidence of visible damage.

7.2.2.8.5 Class 2 respirator facepiece material seams of the respirator facepiece designated by the ensemble manufacturer for the ensemble that are face/visor chemical/biological barrier material seams and Class 2 garment visor material seams shall be tested for seam strength as specified in Section 8.14, Seam/Closure Breaking Strength Test, and shall have a breaking strength of not less than $1.31 \text{ kN}/\text{m}$ (15 lbf/2 in.).

7.2.2.8.6 Class 2 visor seams and those respirator facepiece materials and seams of the respirator facepiece designated by the ensemble manufacturer for the ensemble that are face/visor chemical/biological barrier materials and Class 2 garment visor materials shall be tested for resistance to liquid or bloodborne pathogens as specified in Section 8.23, Viral Penetration Resistance Test, and shall allow no penetration of the Phi-X-174 bacteriophage for at least 1 hour.

7.2.3 Class 2 Glove Element Requirements.

7.2.3.1 Class 2 gloves shall be tested for liquid-tight integrity as specified in Section 8.24, Liquid-Tight Integrity Test Two, and shall show no leakage.

7.2.3.2 Class 2 glove material and seams shall be tested for permeation resistance as specified in Section 8.10, Chemical Permeation Resistance Test, and shall meet the following performance criteria:

- (1) For permeation testing of chemical warfare agents Lewisite (L) and Distilled Mustard (HD), the average cumulative permeation in 1 hour shall not exceed $4.0 \mu\text{g}/\text{cm}^2$.
- (2) For permeation testing of chemical warfare agents Sarin (GB) and VX, the average cumulative permeation in 1 hour shall not exceed $1.25 \mu\text{g}/\text{cm}^2$.
- (3) For permeation testing of liquid and gaseous industrial chemicals, the average breakthrough time shall be not be less than 60 minutes.

7.2.3.3 Class 2 glove materials shall be tested for cut resistance as specified in Section 8.16, Cut Resistance Test, and shall have the distance of blade travel not be less than 25 mm (1 in.).

7.2.3.4 Class 2 glove materials shall be tested for puncture resistance as specified in Section 8.17, Puncture Resistance Test One, and shall have a puncture resistance of not less than 22 N (5 lbf).

7.2.3.5 Class 2 glove materials shall be tested for cold weather performance as specified in Section 8.13, Cold Temperature Performance Test One, and shall have a bending moment of not greater than $0.057 \text{ N}\cdot\text{m}$ ($\frac{1}{2} \text{ in}\cdot\text{lbf}$) at an angular deflection of 60 degrees at -25°C (-13°F).

7.2.3.6 Class 2 gloves shall be tested for hand function as specified in Section 8.18, Glove Hand Function Test, and shall have an average percent increase over barehanded control less than 450 percent.

7.2.3.7 Class 2 glove materials and seams shall be tested for resistance to liquid or bloodborne pathogens as specified in Section 8.23, Viral Penetration Resistance Test, and shall allow no penetration of the Phi-X-174 bacteriophage for at least 1 hour.

7.2.4 Class 2 Footwear Element Requirements.

7.2.4.1 Class 2 footwear shall be tested for liquid-tight integrity as specified in Section 8.24, Liquid-Tight Integrity Test Two, and shall show no leakage.

7.2.4.2 Class 2 footwear upper material shall be tested for permeation resistance as specified in Section 8.10, Chemical Permeation Resistance Test, and shall meet the following performance criteria:

- (1) For permeation testing of chemical warfare agents Lewisite (L) and Distilled Mustard (HD), the average cumulative permeation in 1 hour shall not exceed $4.0 \mu\text{g}/\text{cm}^2$.
- (2) For permeation testing of chemical warfare agents Sarin (GB) and VX, the average cumulative permeation in 1 hour shall not exceed $1.25 \mu\text{g}/\text{cm}^2$.
- (3) For permeation testing of liquid and gaseous industrial chemicals, the average breakthrough time shall be not be less than 60 minutes.

7.2.4.3 Class 2 footwear upper materials shall be tested for cut resistance as specified in Section 8.16, Cut Resistance Test, and shall have the distance of blade travel not be less than 25 mm (1 in.).

7.2.4.4 Class 2 footwear upper materials shall be tested for puncture resistance as specified in Section 8.17, Puncture Resistance Test One, and shall have a puncture resistance of not less than 36 N (8 lbf).

7.2.4.5 Class 2 footwear soles and heels shall be tested for abrasion resistance as specified in Section 8.19, Abrasion Re-

sistance Test, and have an abrasion-resistance rating of not less than 65.

7.2.4.6 Class 2 footwear soles shall be tested for slip resistance as specified in Section 8.21, Slip Resistance Test, and shall have a static coefficient of 0.75 or greater.

7.2.4.7 Class 2 footwear upper material shall be tested for resistance to liquid or bloodborne pathogens as specified in Section 8.23, Viral Penetration Resistance Test, and shall allow no penetration of the Phi-X-174 bacteriophage for at least 1 hour.

7.2.4.8 Where booties are used in the construction of the ensemble, then the bootie shall meet the chemical resistance requirement for footwear specified in 7.2.4.2 and the specified outer footwear shall meet the physical performance requirements for footwear specified in 7.2.4.3 through 7.2.4.7.

7.3 Class 3 Ensembles.

7.3.1 Class 3 Ensemble General Requirements.

7.3.1.1 Class 3 ensembles shall be tested for overall function as specified in Section 8.4, Overall Ensemble Function and Integrity Test, and shall have the following performance:

- (1) Class 3 ensembles shall allow no liquid penetration in subsequent liquid-tight integrity testing as specified in Section 8.6, Liquid-Tight Integrity Test One. Where outer gloves are designed to be worn in conjunction with gloves attached to the ensemble, or where outer boots are designed to be worn in conjunction with garment booties to meet foot protection requirements, such items shall not collect liquid.
- (2) Class 3 ensembles shall allow the test subject to complete all tasks.
- (3) Class 3 ensembles shall accommodate head protection devices meeting the requirements for Type I, Class G helmets of ANSI Z89.1, *Standard for Industrial Head Protection*.
- (4) Where Class 3 ensembles have hoods with visors, ensembles shall permit the test subject to see through the visor with a visual acuity of 20/35 or better.
- (5) Where Class 3 ensembles use the respirator facepiece of the respirator designated by the ensemble manufacturer for the ensemble as a face/visor chemical/biological barrier material, ensembles shall permit the test subject to see through the facepiece with a visual acuity of 20/35 or better.

7.3.2 Class 3 Garment Element Requirements.

7.3.2.1 Class 3 garment materials and seams shall be tested for permeation resistance as specified in Section 8.10, Chemical Permeation Resistance Test, and shall meet the following performance criteria:

- (1) For permeation testing of chemical warfare agents Lewisite (L) and Distilled Mustard (HD), the average cumulative permeation in 1 hour shall not exceed $4.0 \mu\text{g}/\text{cm}^2$.
- (2) For permeation testing of chemical warfare agents Sarin (GB) and VX, the average cumulative permeation in 1 hour shall not exceed $1.25 \mu\text{g}/\text{cm}^2$.
- (3) For permeation testing of liquid industrial chemicals, the average breakthrough time shall be not be less than 60 minutes.

7.3.2.2 Class 3 garment materials and seams shall be tested for resistance to liquid or bloodborne pathogens as specified in Section 8.23, Viral Penetration Resistance Test, and shall

allow no penetration of the Phi-X-174 bacteriophage for at least 1 hour.

7.3.2.3 Class 3 garment materials shall be tested for bursting strength as specified in Section 8.11, Burst Strength Test, and shall have a bursting strength of not less than 134 N (30 lbf).

7.3.2.4 Class 3 garment materials shall be tested for puncture propagation tear resistance as specified in Section 8.12, Puncture Propagation Tear Resistance Test, and shall have a puncture propagation tear resistance of not less than 25 N (5½ lbf).

7.3.2.5 Class 3 garment materials shall be tested for cold weather performance as specified in Section 8.13, Cold Temperature Performance Test One, and shall have a bending moment of not greater than 0.057 N·m (½ in.-lbf) at an angular deflection of 60 degrees at -25°C (-13°F).

7.3.2.6 Class 3 garment seams shall be tested for seam strength as specified in Section 8.14, Seam/Closure Breaking Strength Test, and shall have a breaking strength of not less than 1.31 kN/m (15 lbf/2 in.).

7.3.2.7 Class 3 garment closure assemblies shall be tested for closure strength as specified in Section 8.14, Seam/Closure Breaking Strength Test, and shall have a breaking strength of not less than 1.31 kN/m (15 lbf/2 in.).

7.3.2.8 Class 3 Garment Visor Requirements.

7.3.2.8.1 Class 3 respirator facepiece materials and seams of the respirator facepiece designated by the ensemble manufacturer for the ensemble that are face/visor chemical/biological barrier materials and seams and Class 3 garment visor materials and seams shall be tested for permeation resistance as specified in Section 8.10, Chemical Permeation Resistance Test, and shall meet the following performance criteria:

- (1) For permeation testing of chemical warfare agents Lewisite (L) and Distilled Mustard (HD), the average cumulative permeation in 1 hour shall not exceed $4.0 \mu\text{g}/\text{cm}^2$.
- (2) For permeation testing of chemical warfare agents Sarin (GB) and VX, the average cumulative permeation in 1 hour shall not exceed $1.25 \mu\text{g}/\text{cm}^2$.
- (3) For permeation testing of liquid industrial chemicals, the average breakthrough time shall be not be less than 60 minutes.

7.3.2.8.2 Class 3 seams and those respirator facepiece materials and seams of the respirator facepiece designated by the ensemble manufacturer for the ensemble that are face/visor chemical/biological barrier materials and seams and Class 3 garment visor materials shall be tested for resistance to liquid or bloodborne pathogens as specified in Section 8.23, Viral Penetration Resistance Test, and shall allow no penetration of the Phi-X-174 bacteriophage for at least 1 hour.

7.3.2.8.3 Class 3 respirator facepiece materials of the respirator facepiece designated by the ensemble manufacturer for the ensemble that are face/visor chemical/biological barrier materials and Class 3 garment visor materials shall be tested for bursting strength as specified in Section 8.11, Burst Strength Test, and shall have a bursting strength of not less than 134 N (30 lbf).

7.3.2.8.4 Class 3 respirator facepiece materials of the respirator facepiece designated by the ensemble manufacturer for the ensemble that are face/visor chemical/biological barrier materials and Class 3 garment visor materials shall be tested for puncture propagation tear resistance as specified in Sec-

tion 8.12, Puncture Propagation Tear Resistance Test, and shall have a puncture propagation tear resistance of not less than 25 N (5½ lbf).

7.3.2.8.5 Class 3 respirator facepiece materials of the respirator facepiece designated by the ensemble manufacturer for the ensemble that are face/visor chemical/biological barrier materials and Class 3 garment visor materials shall be tested for cold temperature bending at -25°C (-13°F) as specified in Section 8.15, Cold Temperature Performance Test Two, and shall not crack or show evidence of visible damage.

7.3.2.8.6 Class 3 respirator facepiece material seams of the respirator facepiece designated by the ensemble manufacturer for the ensemble that are face/visor chemical/biological barrier material seams and Class 3 garment visor material seams shall be tested for seam strength as specified in Section 8.14, Seam/Closure Breaking Strength Test, and shall have a breaking strength of not less than 1.31 kN/m (15 lbf/2 in.).

7.3.3 Class 3 Glove Element Requirements.

7.3.3.1 Class 3 gloves shall be tested for liquid-tight integrity as specified in Section 8.24, Liquid-Tight Integrity Test Two, and shall show no leakage.

7.3.3.2 Class 3 glove material and seams shall be tested for permeation resistance as specified in Section 8.10, Chemical Permeation Resistance Test, and shall meet the following performance criteria:

- (1) For permeation testing of chemical warfare agents Lewisite (L) and Distilled Mustard (HD), the average cumulative permeation in 1 hour shall not exceed $4.0\ \mu\text{g}/\text{cm}^2$.
- (2) For permeation testing of chemical warfare agents Sarin (GB) and VX, the average cumulative permeation in 1 hour shall not exceed $1.25\ \mu\text{g}/\text{cm}^2$.
- (3) For permeation testing of liquid industrial chemicals, the average breakthrough time shall be not be less than 60 minutes.

7.3.3.3 Class 3 glove materials and seams shall be tested for resistance to liquid or bloodborne pathogens as specified in Section 8.23, Viral Penetration Resistance Test, and shall allow no penetration of the Phi-X-174 bacteriophage for at least 1 hour.

7.3.3.4 Class 3 glove materials shall be tested for cut resistance as specified in Section 8.16, Cut Resistance Test, and shall have the distance of blade travel be not less than 25 mm (1 in.).

7.3.3.5 Class 3 glove materials shall be tested for puncture resistance as specified in Section 8.17, Puncture Resistance Test One, and shall have a puncture resistance of not less than 22 N (5 lbf).

7.3.3.6 Class 3 garment materials shall be tested for cold weather performance as specified in Section 8.13, Cold Temperature Performance Test One, and shall have a bending moment of not greater than $0.057\ \text{N}\cdot\text{m}$ ($\frac{1}{2}\ \text{in}\cdot\text{lbf}$) at an angular deflection of 60 degrees at -25°C (-13°F).

7.3.3.7 Class 3 gloves shall be tested for hand function as specified in Section 8.18, Glove Hand Function Test, and shall have an average percent increase over barehanded control less than 200 percent.

7.3.4 Class 3 Footwear Element Requirements.

7.3.4.1 Class 3 footwear shall be tested for liquid-tight integrity as specified in Section 8.24, Liquid-Tight Integrity Test Two, and shall show no leakage.

7.3.4.2 Class 3 footwear upper material shall be tested for permeation resistance as specified in Section 8.10, Chemical Permeation Resistance Test, and shall meet the following performance criteria:

- (1) For permeation testing of chemical warfare agents Lewisite (L) and Distilled Mustard (HD), the average cumulative permeation in 1 hour shall not exceed $4.0\ \mu\text{g}/\text{cm}^2$.
- (2) For permeation testing of chemical warfare agents Sarin (GB) and VX, the average cumulative permeation in 1 hour shall not exceed $1.25\ \mu\text{g}/\text{cm}^2$.
- (3) For permeation testing of liquid industrial chemicals, the average breakthrough time shall be not be less than 60 minutes.

7.3.4.3 Class 3 footwear upper material shall be tested for resistance to liquid or bloodborne pathogens as specified in Section 8.23, Viral Penetration Resistance Test, and shall allow no penetration of the Phi-X-174 bacteriophage for at least 1 hour.

7.3.4.4 Class 3 footwear upper materials shall be tested for cut resistance as specified in Section 8.16, Cut Resistance Test, and shall have the distance of blade travel not be less than 25 mm (1 in.).

7.3.4.5 Class 3 footwear upper materials shall be tested for puncture resistance as specified in Section 8.17, Puncture Resistance Test One, and shall have a puncture resistance of not less than 36 N (8 lbf).

7.3.4.6 Class 3 footwear soles and heels shall be tested for abrasion resistance as specified in Section 8.19, Abrasion Resistance Test, and have an abrasion-resistance rating of not less than 65.

7.3.4.7 Class 3 footwear soles shall be tested for slip resistance as specified in Section 8.21, Slip Resistance Test, and shall have a static coefficient of 0.75 or greater.

7.3.4.8 Where booties are used in the construction of the ensemble, then the bootie shall meet the chemical/biological resistance requirements for footwear specified in 7.3.4.2 and 7.3.4.3, and the specified outer footwear shall meet the physical performance requirements for footwear specified in 7.3.4.4 through 7.3.4.8.

Chapter 8 Test Methods

8.1 Sample Preparation Procedures.

8.1.1 Application.

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

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

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

8.1.2.1 Specimens shall be conditioned at a temperature of $21^{\circ}\text{C} \pm 3^{\circ}\text{C}$ ($70^{\circ}\text{F} \pm 5^{\circ}\text{F}$) and a relative humidity of 65 percent ± 5 percent until equilibrium is reached, as determined in

accordance with Section 4 of Federal Test Method Standard 191A, *Textile Test Methods*, or for at least 24 hours, whichever is shortest.

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

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

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

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

- (1) A 2.3 kg (5 lb) tension weight shall be used.
- (2) A 1.6 kg (3.5 lb) head weight shall be used.
- (3) The wire screen of the test apparatus shall be used as the abradant.
- (4) The specimen shall be abraded for 100 continuous cycles.

8.1.5 Flexural Fatigue Procedure for Gloves. Specimen gloves shall be subjected to one full cycle of testing for hand function as specified in Section 8.18, Glove Hand Function Test.

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

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

8.2 Gas-Tight Integrity Test.

8.2.1 Application.

8.2.1.1 This test method shall apply to Class 1 ensembles, gloves, and footwear.

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

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

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

8.2.2 Specimens.

8.2.2.1 A minimum of one specimen shall be tested.

8.2.2.2 Where the ensemble consists of multiple separate layers, and outer layers are not considered gas-tight, then only the portion of the ensemble that is considered gas-tight shall be tested.

8.2.2.3 For the purpose of certification testing, multiple external layers shall be permitted to be installed and tested simultaneously.

8.2.3 Sample Preparation.

8.2.3.1 Samples for conditioning shall be complete ensembles, individual glove elements, or individual footwear elements.

8.2.3.2 Specimens shall be conditioned as specified in 8.1.2.

8.2.4 Procedure.

8.2.4.1 Specimens shall be tested in accordance with ASTM F 1052, *Standard Test Method for Pressure Testing 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 reported for each specimen.

8.2.6 Interpretation.

8.2.6.1 If the ending pressure is less than 80 mm (3¹/₂ in.), the specimen shall be recorded as failing.

8.2.6.2 Any one specimen failing the test constitutes failure of the item.

8.2.7 Specific Requirements for Testing Ensembles.

8.2.7.1 A minimum of one ensemble shall be tested.

8.2.7.2 Where the ensemble consists of multiple separate layers, and outer layers are not considered gas-tight, then only the portion of the ensemble that is considered gas-tight 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 Gloves.

8.2.8.1 A minimum of one glove pair shall be tested.

8.2.8.2 A test fixture that provides a gas-tight seal with the cuff of the glove shall be utilized. The fixture shall have a valved port to allow air introduction and pressure measurement. The test fixture shall be permitted to be an ensemble.

8.2.8.3 Gloves failing the test shall not be permitted to be repaired.

8.2.9 Specific Requirements for Testing Footwear.

8.2.9.1 A minimum of one footwear item shall be tested.

8.2.9.2 A test fixture that provides a gas-tight seal with the footwear shall be utilized. The fixture shall have a valved port to allow air introduction and pressure measurement. The test fixture shall be permitted to be an ensemble.

8.2.9.3 Footwear failing the test shall not be permitted to be repaired.

8.3 Overall Ensemble Inward Leakage Test.

8.3.1 Application. This test shall apply to Class 1 and Class 2 ensembles.

8.3.2 Specimens.

8.3.2.1 The specimen shall be a complete ensemble with gloves and footwear and shall include the respirator where applicable. Where the ensemble utilizes the respirator facepiece as the ensemble visor, as specified in 6.1.6, each style and size of the ensemble shall be tested with each style and size of the respirator specified by the manufacturer.

8.3.2.2 A minimum of one specimen shall be tested.

8.3.2.3 Where the ensemble has multiple types of external fittings, each type of external fitting shall be present at the time of testing.

8.3.3 Preparation.

8.3.3.1 Samples for conditioning shall be complete ensembles.

8.3.3.2 Specimens shall be conditioned as specified in 8.1.2 and shall include the respirator where the ensemble utilizes the respirator facepiece as the ensemble visor.

8.3.4 Apparatus.

8.3.4.1 Sulfur hexafluoride, CAS No. 2551-62-4, with a minimum purity of 99.8 percent, shall be used as the test agent.

8.3.4.2 The test shall be conducted in a sealed test chamber with minimum volume of sufficient dimension to permit free movement of the test subject when fully dressed in the ensemble.

8.3.4.2.1 The chamber shall have a circulation fan or other means to ensure uniform concentration of the test agent throughout the chamber during the test.

8.3.4.2.2 The exact dimension of the chamber shall be measured and used to calculate the total volume of the chamber in order to determine the amount of sulfur hexafluoride gas to be added to achieve the required concentration specified in 8.3.5.8.

8.3.4.3 Two calibrated portable pumps that are capable of maintaining a flow rate of 0.4 L/min shall be provided.

8.3.4.3.1 Both pumps shall be placed outside the test chamber.

8.3.4.3.2 Pump A shall have a gas stream selection valve with a minimum of four isolated stream settings. A stream setting shall be provided for each ensemble interior sampling location.

8.3.4.4 A minimum of five gas-tight suit wall connectors shall be installed in the ensemble in such a manner that the fixtures do not interfere with the movement of the test subject.

8.3.4.4.1 One gas-tight suit wall connector shall be designated as an air sample return port.

8.3.4.4.2 Each remaining suit wall connector shall have 10-mm ($\frac{3}{8}$ -in.) nominal outer diameter flexible tubing attached to the interior of the suit wall connector in such a manner as to allow the other end of the tubing to be attached to required sampling locations on the test subject's body. Pinning tubing to the test subject's body shall be permitted.

8.3.4.5 Equal lengths of 3-mm ($\frac{1}{8}$ -in.) nominal outer diameter gas-tight flexible tubing shall be used to transfer air samples from sampling ports to sample pumps and back to the return port from the exhaust port of sample pump A.

8.3.4.5.1 One length of tubing shall be attached to the test chamber ceiling in such a manner that one end of the tubing hangs as close as possible to the center of the test chamber and the other end is attached to the intake port of sample pump B.

8.3.4.5.2 One length of tubing shall be attached to each gas-tight suit wall connector exterior sampling port with the other end attached to an inlet port on the gas stream selection valve on pump A.

8.3.4.5.3 One length of tubing shall be connected to the gas-tight suit wall connector exterior designated as the return port with the other end of the tubing attached to the exhaust port of pump A.

8.3.4.5.4 Sample tubing shall be permitted to be joined together by means of hose clamps or taping in a manner that does not restrict airflow.

8.3.4.5.5 Sample tubing shall be permitted to be taped to the exterior of the ensemble to permit the reduction of hanging weight stress and strain on the suit wall connectors by the employment of one piece of duct tape no greater in length than 30 cm. All tubing shall be taped together in no more than one location on the ensemble. The tape shall not cover any seams.

8.3.4.5.6 The total interior volume of each gas tubing sampling stream shall be determined for each sampling location.

8.3.4.6 At least 23 gas-tight sample bags shall be used to collect air samples. A gas-tight adapter shall be used to connect the inlet valve of the sample bags to the exhaust ports of the pumps to facilitate changing of sample bags.

8.3.4.7 A thermometer sensor shall be placed in the test chamber in a manner allowing the test administrator to record the initial and final test chamber temperature.

8.3.4.8 A gas-tight syringe capable of delivering the required amount of sulfur hexafluoride into the chamber shall be placed in the test chamber with a gas-tight bag containing 10 percent v/v sulfur hexafluoride in nitrogen.

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

8.3.4.10 Test subjects shall be familiar with the use of chemical protection clothing ensembles and with the selected respirator. The test subject shall select the appropriate size of the ensemble from available sizes using the manufacturer's sizing chart.

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

8.3.5 Procedure.

8.3.5.1 Interior sampling tubes shall be pinned to the test subject as follows:

- (1) One tube attached to the middle of the subject's back directly under the shoulder
- (2) One tube attached to the sternum
- (3) One tube attached to an extremity location on the forearm or calf
- (4) One tube attached to the crotch

Additional sampling locations shall be permitted if the testing apparatus allows such sampling.

8.3.5.2 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. Donning shall be accomplished without causing the restriction of flow through interior sampling tubes. Adjustment of tube pathways shall be permitted to connect the sample tubes to the interior sampling ports.

8.3.5.3 Exterior sampling tubing and return tubing shall be attached to the exterior sampling ports and return port.

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

8.3.5.5 Sample pumps A and B shall be turned on and function at a flow rate of 0.4 L/min. Each pump shall be placed on hold while not actively performing purging or sampling.

8.3.5.6 At least one baseline sample set shall be taken prior to the addition of sulfur hexafluoride to the chamber.

8.3.5.6.1 A baseline sample shall consist of one test chamber air sample and one sample taken from each sampling location within the ensemble after sampling lines have been purged.

8.3.5.6.2 Sampling lines shall be purged for a duration of time that flushes the air volume completely out of the sampling lines twice. The gas sample return line to the ensemble shall be disconnected during this purge cycle. Ensemble air sampling shall be taken between purge cycles of each air sampling line. Purge cycles shall be employed for all inward leakage sampling.

8.3.5.6.3 Each air test sample shall be collected from the exhaust port of the sample pumps at a rate of 0.4 L/min \pm 0.005 L/min for 1 minute \pm 1 second.

8.3.5.6.4 Test chamber and ensemble baseline air samples shall be permitted to be taken simultaneously.

8.3.5.7 At the end of the baseline test chamber and ensemble air sampling periods, the sampling bags shall be removed from the pump, sealed, and stored. The gas sample return line shall be reconnected to the exhaust port of pump A. The removal of the gas sample return line from the exhaust port of pump A shall be permitted during sample acquisition.

8.3.5.8 The test subject shall add sufficient sulfur hexafluoride to achieve a concentration of 0.1 ppm \pm 0.01 ppm on a volume basis. The air inside the chamber shall be allowed to reach equilibrium for a period of 1 minute \pm 1 second prior to performing inward leakage testing.

8.3.5.9 At least three full sets of air samples from each sampling location shall be taken, and at least three sets of two test chamber samples shall be taken for inward leakage detection testing.

8.3.5.10 At the conclusion of the challenge agent equilibrium period, the test subject shall perform one series of stationary exercises for each of the three air test sample sets. The stationary exercise shall be as specified in Procedure A of ASTM F 1154, *Standard Practice for Qualitatively Evaluating the Comfort, Fit, Function, and Integrity of Chemical Protective Suit Ensembles*, as modified by 8.3.5.11.

8.3.5.11 The stationary exercises specified in Procedure A of ASTM F 1154, *Standard Practice for Qualitatively Evaluating the Comfort, Fit, Function, and Integrity of Chemical Protective Suit Ensembles*, shall be performed with the following modifications:

- (1) At the conclusion of the "duck squat" exercise specified in 8.8.2 of ASTM F 1154, test subjects shall remain in a squatting position and exhaust as much of the internal volume of the suit as possible by placing their hands on top of their heads, tucking their arms in toward their bodies, and gathering as much of the excess ensemble material to the body as possible.
- (2) The test subject shall then resume the exercise protocol as specified in Procedure A of ASTM F 1154.

8.3.5.12 For each exercise protocol, at least two test chamber air samples shall be collected while the test subject is performing the exercise protocol.

8.3.5.13 At least one sample from each ensemble sampling location shall be taken after the completion of each exercise protocol. The test subject shall be allowed to rest while the ensemble samples are acquired.

8.3.5.14 At the conclusion of the three exercise series and collection of chamber and ensemble air samples, the test subject shall exit the chamber and doff the ensemble in an area located away from the chamber.

8.3.5.15* All samples collected shall be analyzed using an appropriate analytical technique within 8 hours of collection. The sensitivity of the analytical technique chosen shall provide for a detection limit of at least 0.00002 ppm in order to determine compliance with 7.1.1.1, or a least 0.002 ppm in order to determine compliance with 7.2.1.1.

8.3.5.16 Alternate plumbing of gas-tight sample tubing streams directly into analytical equipment shall be permitted if the device meets the criteria required in 8.3.5.15 and each required measurement is able to be individually acquired.

8.3.6 Report. The percent inward leakage of sulfur hexafluoride into the ensemble shall be calculated and reported based on the averaged measured concentration inside the ensemble versus the average measured concentration in the test chamber for each sampling location using the following equation:

$$\text{Percent inward leakage} = \frac{\left(\frac{\text{concentration inside the ensemble} - \text{baseline inside ensemble}}{\text{concentration in the test chamber} - \text{baseline in test chamber}} \right) \times 100}$$

8.3.7 Interpretation. Failure at any sampling location shall constitute failure of the test.

8.4 Overall Ensemble Function and Integrity Test.

8.4.1 Application.

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

8.4.1.2 Where the ensemble utilizes the respirator facepiece as the ensemble visor, as specified in 6.1.6, each style and size of the ensemble shall be tested with each style and size of the respirator specified by the manufacturer.

8.4.2 Specimens.

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

8.4.2.2 The specimen shall include all outer wear and other items required for the ensemble to be compliant with this standard.

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

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

8.4.3 Sample Preparation.

8.4.3.1 Samples for conditioning shall be complete ensembles.

8.4.3.2 Specimens shall be conditioned as specified in 8.1.2.

8.4.4 Procedure.

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

- (1) Exercise Procedure A shall be used. Testing of ensembles immediately following testing as specified in Section 8.3, Overall Ensemble Inward Leakage Test, shall be permitted.
- (2) Ensembles tested shall meet the sizing range of the test subject as determined in 5.3.4. The ensemble shall be donned in accordance with the manufacturer's instructions.
- (3) Testing shall be conducted at 25°C ±7°C (77°F ±10°F) and relative humidity of 50 percent ±20 percent.
- (4) For Class 1 ensembles, gas-tight integrity shall be measured as specified in Section 8.2, Gas-Tight Integrity Test. Gas-tight integrity shall be measured after the exercise procedures are completed.
- (5) For Class 2 and Class 3 ensembles, liquid-tight integrity shall be measured as specified in Section 8.6, Liquid-Tight Integrity Test One. Liquid-tight integrity shall be determined after the exercise procedures are completed.
- (6) Where hoods are provided, a determination shall be made that the ensemble is designed to at least accommodate head protection meeting the dimensional requirements for Type 1, Class G helmets of ANSI Z89.1, *Standard for Industrial Head Protection*. For Class 1 ensembles, the hood shall accommodate the wearing of head protection inside the ensemble. For Class 2 and Class 3 ensembles, the hood shall be permitted to accommodate head protection worn either inside or outside the ensemble.
- (7) Where hoods with visors or facepieces are provided, the test subject shall have a minimum visual acuity of 20/20 in each eye uncorrected or corrected with contact lenses as determined in a visual acuity test or doctor's examination.
- (8) Appropriate under clothing and a respirator shall be worn.

8.4.4.2 Where hoods with visors or facepieces are provided, visual acuity testing within the ensemble shall be conducted using a standard 6.1-m (20-ft) eye chart with a normal lighting range of 100 to 150 ft-candles at the chart and with the test subject positions at a distance of 6.1 m (20 ft) from the chart.

8.4.4.3 Where hoods with visors or facepieces are provided, the test subject shall then read the standard eye chart through the lens of the respirator facepiece, if present, and ensemble visor or facepiece to determine the test subject's visual acuity.

8.4.5 Report.

8.4.5.1 For Class 1 ensembles, the ending suit pressure shall be reported.

8.4.5.2 For Class 2 and Class 3 ensembles, a diagram shall be prepared for each test that identifies the locations of any liquid leakage as detected on the liquid-absorptive garment.

8.4.5.3 The ability of the test subject to satisfactorily complete all exercises shall be reported.

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

8.4.5.5 Where hoods with visors or facepieces are provided, the visual acuity of the test subject in and out of the ensemble shall be reported.

8.4.6 Interpretation.

8.4.6.1 For Class 1 ensembles an ending ensemble pressure of less than 80 mm (3½ in.) shall constitute failing performance.

8.4.6.2 For Class 2 and Class 3 ensembles, any evidence of liquid on the liquid-absorptive garment shall constitute failing performance.

8.4.6.3 The inability of the test subject to satisfactorily complete all exercises within 15 minutes shall constitute failing performance.

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

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

8.5 Maximum Ensemble Ventilation Rate Test.

8.5.1 Application. This test method shall apply to Class 1 ensembles.

8.5.2 Specimens.

8.5.2.1 A minimum of one complete ensemble shall be evaluated. The test specimen shall include all outerwear and other items required for the ensemble to be compliant with this standard.

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

8.5.2.3 Where the ensemble consists of multiple separate layers and outer layers are not considered gas-tight, only the portion of the ensemble that is considered gas-tight shall be tested.

8.5.3 Sample Preparation.

8.5.3.1 Samples for conditioning shall be complete ensembles.

8.5.3.2 Specimens shall be conditioned as specified in 8.1.2.

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 ensemble to be tested. The connector and airline hose shall allow an air flow 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 flow meter capable of measuring air flow 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.

8.5.4.3 A pressure gauge capable of measuring pressures from 0 to 510 mm Hg ±2.5 mm Hg (0 to 20 in. ±0.1 in.) water gauge pressure shall be attached via a second suit wall connector at the very top of the ensemble.

8.5.5 Procedure.

8.5.5.1 Following the attachment of the two connectors, the gas-tight integrity of the ensemble shall be tested as specified in Section 8.2, Gas-Tight Integrity Test.

8.5.5.2 During the test, the pressure gauge specified in 8.5.4.3 shall be attached to one bulkhead connector; the other bulkhead connector shall be plugged. During the test, a soapy water solution shall be applied around the edges of the connectors to ensure that no leakage occurs through the installed ensemble wall connectors. The remaining steps of this procedure shall be completed only if the sample ensemble shows an ending pressure of 80 mm (3 $\frac{1}{2}$ in.) water gauge or higher.

8.5.5.3 The ensemble 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 ensemble at a rate of 500 L/min.

8.5.5.5 After a period of 5 minutes, the pressure head connector shall be measured. A pressure greater than 100 mm (4 in.) water gauge pressure shall constitute failing performance.

8.5.5.6 The specialized fittings installed in the ensemble for this test shall be plugged to prevent air leakage, and the ensemble shall be subjected to a second overall gas-tight integrity test as specified in Section 8.2, Gas-Tight Integrity Test.

8.5.6 Report.

8.5.6.1 The maximum internal ensemble pressure during the air flow period shall be reported.

8.5.6.2 The ending ensemble pressure for the gas-tight integrity tests before and after the air flow period shall be reported.

8.5.7 Interpretation.

8.5.7.1 A maximum internal ensemble pressure greater than 100 mm (4 in.) water gauge pressure during the air-flow period shall constitute failing performance.

8.5.7.2 Following the maximum air flow test, an ending ensemble pressure of less than 80 mm (3 $\frac{1}{2}$ in.) water gauge pressure shall constitute failing performance.

8.6 Liquid-Tight Integrity Test One.

8.6.1 Application.

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

8.6.1.2 Specific requirements for testing Class 2 ensembles shall be specified as in 8.6.8.

8.6.1.3 Specific requirements for testing Class 3 ensembles shall be specified as in 8.6.9.

8.6.2 Specimens.

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

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

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

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

8.6.3 Preparation.

8.6.3.1 Samples for conditioning shall be complete garments or ensembles.

8.6.3.2 Specimens shall be conditioned as specified in 8.1.2.

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

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

8.6.5 Procedure.

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

- (1) No provisions for garments or ensembles with a partial barrier layer shall be allowed.
- (2) The method used for mounting of the mannequin in the spray chamber shall not interfere with the water spray.
- (3) The suited mannequin shall be exposed to the liquid spray for a total of 20 minutes, 5 minutes in each of the four specified mannequin orientations.
- (4) At the end of the liquid spray exposure period, excess liquid shall be removed from the surface of the specimen.

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

8.6.5.3 Where outer gloves and outer boots are used as part of the ensemble, the interior of the outer gloves or outer boots shall be inspected to determine if the collection of liquid has occurred.

8.6.6 Report. A diagram shall be prepared for each test that identifies the locations of any liquid leakage as detected on the liquid-absorptive garment.

8.6.7 Interpretation.

8.6.7.1 Any evidence of liquid on the liquid-absorptive garment, as determined by visual, tactile, or absorbent toweling, shall constitute failure of the specimen.

8.6.7.2 Where outer gloves are to be worn in conjunction with gloves attached to the ensemble or where outer boots are worn in conjunction with garment booties to meet foot protection requirements, these items shall not be permitted to fill with liquid.

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

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

8.7 Exhaust Valve Inward Leakage Test.

8.7.1 Application. This test method shall apply to Class 1 ensemble exhaust valves.

8.7.2 Specimens.

8.7.2.1 A minimum of 10 specimens shall be tested.

8.7.2.2 Specimens shall be individual ensemble exhaust valves including mounting means.

8.7.3 Sample Preparation.

8.7.3.1 Specimens shall be conditioned as specified in 8.1.2.

8.7.3.2 Samples for conditioning shall be individual ensemble exhaust valves.

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

8.7.4 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 air-tight 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 water column height (–1-in. water gauge vacuum).
- (3) The fixture shall include a pressure gauge or manometer capable of measuring pressures ranging from –25 mm to 75 mm ± 6.5 mm water column height (–1 to 3 in. $\pm 1/4$ in. water 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 ± 0.61 in.³/min).

8.7.5 Procedure. The exhaust valve shall be mounted in the test fixture and a suction of –25-mm water column height (–1-in. water 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.

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

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

8.8 Exhaust Valve Mounting Strength Test.

8.8.1 Application. This test method shall apply to exhaust valves mounted in Class 1 ensembles.

8.8.2 Specimens. A minimum of three specimens shall be tested. A specimen shall consist of 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 to fabricate the ensemble.

8.8.3 Sample Preparation.

8.8.3.1 Samples for conditioning shall be exhaust valves and garment material specimens described in 8.8.2.

8.8.3.2 Specimens shall be conditioned as specified in 8.1.2.

8.8.4 Apparatus.

8.8.4.1 A specimen mounting ring shall be used for clamping the specimen.

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

8.8.4.1.2 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.

8.8.4.1.3 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.

8.8.4.2 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.

8.8.4.3 The tensile testing machine shall meet the following criteria:

- (1) It shall be capable of holding the specimen mounting ring securely in the fixed lower arm.
- (2) It shall be capable of holding the flat plate pushing device securely in the movable upper arm.
- (3) It shall have a calibrated dial, scale, or chart to indicate the applied load and elongation.
- (4) The error of the machine shall not exceed 2 percent of any reading within its load range.
- (5) It shall be outfitted with a compression cell. The testing machine shall be configured with the compression cell on either the lower or upper arm.

8.8.5 Procedure.

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

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

8.8.5.3 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.

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

8.8.6 Report. The mounting strength of each specimen shall be reported to the nearest 1 N ($1/4$ lbf). The average mounting strength shall be calculated and reported to the nearest 1 N ($1/4$ lbf).

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

8.9 Fitting Pull-Out Strength Test.

8.9.1 Application. This test method shall apply to each type of external fitting mounted in Class 1 ensembles.

8.9.2 Specimens.

8.9.2.1 A minimum of three specimens shall be tested.

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

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

8.9.3 Sample Preparation.

8.9.3.1 Samples for conditioning shall be exhaust valves and garment material specimens described in 8.9.2.

8.9.3.2 Specimens shall be conditioned as specified in 8.1.2.

8.9.4 Apparatus.

8.9.4.1 A specimen mounting ring shall be used for clamping the specimen. The mounting ring shall have an inner diameter of 150 mm (6 in.). The mounting ring shall have a means for tightly clamping the specimen along the circumference of the ring and shall hold the specimen perpendicular to the motion of the pushing force. The mounting ring shall be designed such that a means is provided for affixing it to the fixed (bottom) arm of a tensile testing machine.

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

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

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

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 tensile testing machine jaws shall have a velocity of 508 mm/min (20 in./min) under load conditions and shall be uniform at all times.

8.9.5.4 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 pull out strength of each specimen shall be reported to the nearest 1 N ($\frac{1}{4}$ lbf).

8.9.6.2 The average pull out strength shall be calculated and reported to the nearest 1 N ($\frac{1}{4}$ lbf).

8.9.7 Interpretation. The average pull out strength shall be used to determine pass/fail performance.

8.10 Chemical Permeation Resistance Test.

8.10.1 Application.

8.10.1.1 This method shall apply to garment, visor, glove, and footwear materials.

8.10.1.2 Specific requirements for testing garment materials after flexing and abrasion shall be as specified in 8.10.7.

8.10.1.3 Specific requirements for testing visor materials shall be as specified in 8.10.8. Where the ensemble utilizes the respirator facepiece as the ensemble visor, as specified in 6.1.6, this test method shall also apply to the applicable portions of the respirator.

8.10.1.4 Specific requirements for testing glove materials after flexing shall be as specified in 8.10.9.

8.10.1.5 Specific requirements for testing footwear materials after flexing and abrasion shall be as specified in 8.10.10.

8.10.1.6 Specific requirements for testing garment, visor, and glove seams shall be as specified in 8.10.11.

8.10.1.7 Garment, visor, glove, and footwear materials shall be tested for permeation resistance against the chemical warfare agents, industrial liquid chemicals, and industrial gaseous chemicals as specified in 8.10.4.

8.10.2 Specimens.

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

8.10.2.2 For composite materials, only the chemical protection layer shall be tested for chemical permeation resistance.

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

8.10.3 Preparation. Specimens shall be conditioned at least as specified in 8.1.2.

8.10.4 Procedures.

8.10.4.1 Specimens shall be tested for permeation resistance for not less than 60 minutes against the chemicals specified in 8.10.4.2 and 8.10.4.3 in accordance with ASTM F 739, *Standard Test Method for Resistance of Protective Clothing Materials to Permeation by Liquids or Gases Under Conditions of Continuous Contact*, with the following modifications:

- (1) The test cells shall be designed to accommodate the introduction of liquid chemicals in a safe manner.
- (2) The collection media shall be filtered air flowed through the bottom of the test cell at a rate of 1 lpm \pm 0.1 lpm.

- (3) Analytical methods used shall be sensitive to concentrations of at least two orders of magnitude lower than the required end points.
- (4) Where cumulative permeation end points are not specified in this standard, a permeation rate of $0.1 \mu\text{g}/\text{cm}^2/\text{minute}$, as defined by ASTM F 739, *Standard Test Method for Resistance of Protective Clothing Materials to Permeation by Liquids or Gases Under Conditions of Continuous Contact*, shall be used.

8.10.4.2 The following liquid chemicals shall be tested:

- (1) Liquid chemical warfare agents
 - (a) Distilled sulfur mustard: [HD; bis (2-chloroethyl) sulfide] 505-60-2; at $32^\circ\text{C} \pm 1^\circ\text{C}$ ($90^\circ\text{F} \pm 2^\circ\text{F}$)
 - (b) Lewisite: [L; dichloro(2-chlorovinyl)arsine] 541-25-3; at $32^\circ\text{C} \pm 1^\circ\text{C}$ ($90^\circ\text{F} \pm 2^\circ\text{F}$)
 - (c) Sarin: (GB; isopropyl methanefluorophosphonate) 107-44-8; at $32^\circ\text{C} \pm 1^\circ\text{C}$ ($90^\circ\text{F} \pm 2^\circ\text{F}$)
 - (d) V-Agent: [VX, O-ethyl S-(2-diisopropylaminoethyl) methylphosphonothiolate] 50782-69-9; at $32^\circ\text{C} \pm 1^\circ\text{C}$ ($90^\circ\text{F} \pm 2^\circ\text{F}$)
- (2) Liquid industrial chemical
 - (a) Dimethyl sulfate (DMA, sulfuric acid dimethyl ester), 77-78-1; at $32^\circ\text{C} \pm 1^\circ\text{C}$ ($90^\circ\text{F} \pm 2^\circ\text{F}$)

8.10.4.3 The following gases shall be tested:

- (1) Ammonia (7664-41-7); at $32^\circ\text{C} \pm 1^\circ\text{C}$ ($90^\circ\text{F} \pm 2^\circ\text{F}$)
- (2) Chlorine (Cl_2 ; 7782-50-5); at $32^\circ\text{C} \pm 1^\circ\text{C}$ ($90^\circ\text{F} \pm 2^\circ\text{F}$)
- (3) Cyanogen chloride (CK; 506-77-4); at $32^\circ\text{C} \pm 1^\circ\text{C}$ ($90^\circ\text{F} \pm 2^\circ\text{F}$)
- (4) Carbonyl chloride (CG; 75-44-5); at $32^\circ\text{C} \pm 1^\circ\text{C}$ ($90^\circ\text{F} \pm 2^\circ\text{F}$)
- (5) Hydrogen cyanide (AC, HCN, CAS; 74-90-8); at $32^\circ\text{C} \pm 1^\circ\text{C}$ ($90^\circ\text{F} \pm 2^\circ\text{F}$)

8.10.4.4 Class 1 Elements.

8.10.4.4.1 For Class 1 elements, the gas concentration shall be 100 percent undiluted technical grade, and the cell shall be assembled in closed-top configuration.

8.10.4.4.2 For Class 1 elements, the liquid concentration density shall be $100 \text{ g}/\text{m}^2 +10/-0 \text{ g}/\text{m}^2$, and the cell shall be assembled in closed-top configuration.

8.10.4.5 Class 2 Elements.

8.10.4.5.1 For Class 2 elements, the gas concentration shall be 1000 ppm $+100/-0$ ppm, and the cell shall be assembled in closed-top configuration.

8.10.4.5.2 For Class 2 elements, the liquid concentration density shall be $10 \text{ g}/\text{m}^2 +1/-0 \text{ g}/\text{m}^2$, applied as nominal 1 μl drops. Drops shall be applied uniformly over the sample surface. Where a seam, closure, or fixture is included, at least one drop shall be applied to each critical juncture, such as the seam edge.

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

8.10.4.6 Class 3 Elements.

8.10.4.6.1 For Class 3 elements, the liquid concentration density shall be $10 \text{ g}/\text{m}^2 +1/-0 \text{ g}/\text{m}^2$, applied as nominal 1 μl drops.

8.10.4.6.2 Drops shall be applied uniformly over the sample surface. Where a seam, closure, or fixture is included, at least

one drop shall be applied to each critical juncture, such as the seam edge.

8.10.4.6.3 For the liquid chemicals specified in 8.10.4.2, the test cell shall be assembled in the open-top configuration with 1 lpm ± 0.1 lpm of filtered air flowing through the top of the cell. With the open-top configuration, the test cell washer shall be allowed to be sealed by an impermeable nonreactive sealant.

8.10.4.6.4 The gaseous chemicals specified in 8.10.4.3 shall not apply to Class 3.

8.10.5 Report.

8.10.5.1 For permeation testing of chemical warfare agents, the cumulative permeation in 1 hour shall be reported in $\mu\text{g}/\text{cm}^2$ for each specimen. The average cumulative permeation in 1 hour for all specimens shall be calculated and also reported. The report shall include the pass/fail results for each chemical tested.

8.10.5.2 For permeation testing of liquid and gaseous industrial chemicals, the normalized breakthrough time shall be reported in minutes for each specimen. The average normalized breakthrough time shall also be calculated and reported.

8.10.6 Interpretation.

8.10.6.1 For permeation testing of chemical warfare agents specified in 8.10.4.2(1), the average cumulative permeation shall be used to determine pass/fail performance.

8.10.6.2* For permeation testing of liquid and gaseous industrial chemicals specified in 8.10.4.2(2), the average normalized breakthrough time shall be used to determine pass/fail performance.

8.10.7 Specific Requirements for Testing Garment Materials.

8.10.7.1 Samples shall be conditioned by flexing as specified in 8.1.3. Samples shall be $200 \text{ mm} \times 280 \text{ mm}$ (8 in. \times 11 in.). Following flexing, one specimen shall be taken from the center of each sample subjected to flexing for permeation resistance testing.

8.10.7.2 Samples shall be conditioned by abrading as specified in 8.1.4. Samples shall be $45 \text{ mm} \times 230 \text{ mm}$ (1 $\frac{7}{8}$ in. \times 9 in.). Following abrading, one specimen shall be taken from the center of each sample subjected to abrading for permeation resistance testing.

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

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

8.10.9 Specific Requirements for Testing Glove Materials After Flexing.

8.10.9.1 Samples for conditioning shall be whole gloves.

8.10.9.2 Samples shall be conditioned as specified in 8.1.5.

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

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

8.10.10.2 Where the footwear incorporates a bootie constructed of garment material, the garment material flex fa-

tigue resistance test shall be permitted to be substituted for this test.

8.10.10.3 Samples for conditioning shall be whole footwear items.

8.10.10.4 Samples shall first be conditioned by flexing as specified in 8.1.6.

8.10.10.5 Following flexing, new samples shall be taken in areas from the footwear upper where the greatest flexing occurred, usually at the footwear quarter or vamp, measuring 45 mm × 225 mm (1 7/8 in. × 9 in.).

8.10.10.6 The new samples shall then be conditioned by abrading as specified in 8.1.4.

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

8.10.10.8 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.

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

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

8.10.11.2 Seam specimens shall be prepared from seam samples that have a minimum of 75 mm (3 in.) of material on each side of the seam center.

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

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

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

8.10.12 Specific Requirements for Testing Respirator Facepiece Materials.

8.10.12.1 Samples for conditioning shall be respirator facepiece materials.

8.10.12.2 Samples shall be taken from each type of material that is the same material used in the actual construction of the facepiece material that is also the chemical/biological barrier portion of the respirator facepiece.

8.10.12.3 Samples shall be a minimum of four 100 mm × 100 mm × average material thickness (4 in. × 4 in. × average material thickness) of the exposed materials specified in 8.10.12.2.

8.10.12.4 Samples of material specified in 8.10.12.2 shall be flat.

8.10.12.5 The average thickness of the material shall be determined by measuring 20 places evenly spaced around the circumference of the seal area of the respirator, with each measurement taken 38 mm (½ in.) from the outer edge of the seal.

8.11 Burst Strength Test.

8.11.1 Application.

8.11.1.1 This test shall apply to garment and visor materials.

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

8.11.1.3 Where the ensemble utilizes the respirator facepiece as the ensemble visor, as specified in 6.1.6, this test method shall also apply to the applicable portions of the respirator.

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

8.11.3 Preparation.

8.11.3.1 Specimens shall be conditioned as specified in 8.1.2.

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

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

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

8.11.6 Interpretation. The average burst strength shall be used to determine pass/fail performance.

8.12 Puncture Propagation Tear Resistance Test.

8.12.1 Application.

8.12.1.1 This test shall apply to garment and visor materials. If the protective garment is constructed of several layers, then all layers, assembled in the order in which they appear in the garment, shall be tested as a composite.

8.12.1.2 Where the ensemble utilizes the respirator facepiece as the ensemble visor, as specified in 6.1.6, this test method shall also apply to each type of material used in the construction of the respirator facepiece that is exposed to the environment.

8.12.2 Specimens.

8.12.2.1 A minimum of five specimens in both the warp direction, machine or coarse, and the filling direction, cross-machine or wales, shall be tested.

8.12.2.2 If the material is non-anisotropic, then 10 specimens shall be tested.

8.12.3 Sample Preparation.

8.12.3.1 Specimens shall be conditioned as specified in 8.1.2.

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

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

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

8.12.6 Interpretation. Pass/fail performance shall be based on the average puncture propagation tear resistance in the

warp and filling directions. Failure in any one direction constitutes failure for the material.

8.13 Cold Temperature Performance Test One.

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

8.13.2 Specimens.

8.13.2.1 A minimum of five specimens in each of the warp, machine or coarse direction, and the filling, cross-machine or wales direction, shall be tested.

8.13.2.2 If the material is non-anisotropic, then 10 specimens shall be tested.

8.13.3 Preparation.

8.13.3.1 Specimens shall be conditioned as specified in 8.1.2.

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

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

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

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

$$\text{Bending moment (Nm)} = \text{bending moment, in.-lb} \times 0.113$$

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

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

8.14 Seam/Closure Breaking Strength Test.

8.14.1 Application.

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

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

8.14.1.3 Modifications to this test method for testing closure assemblies shall be as specified in 8.14.8.

8.14.2 Specimens.

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

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

8.14.2.3 The specimen shall also include the respirator where applicable.

8.14.3 Preparation.

8.14.3.1 Specimens shall be conditioned as specified in 8.1.2.

8.14.3.2 Samples for conditioning shall be 600 mm (23½ in.) lengths of seam.

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

8.14.5 Report.

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

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

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

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

8.14.8 Specific Procedures for Testing Closure Assemblies.

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

8.14.8.2 Specimens shall be conditioned as specified in 8.1.7.

8.15 Cold Temperature Performance Test Two.

8.15.1 Application.

8.15.1.1 This test method shall apply to visor materials.

8.15.1.2 Where the ensemble utilizes the respirator facepiece as the ensemble visor, as specified in 6.1.6, this test method shall also apply to the applicable portions of the respirator.

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

8.15.3 Preparation.

8.15.3.1 Specimens shall be conditioned as specified in 8.1.2.

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

8.15.3.3 The specimen shall also include the respirator where applicable.

8.15.4 Procedure.

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

8.15.4.2 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.

8.15.5 Report. Observations of visible damage shall be reported for each specimen.

8.15.6 Interpretation.

8.15.6.1 Damage of any one specimen shall constitute failing performance.

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

8.16 Cut Resistance Test.

8.16.1 Application.

8.16.1.1 This test method shall apply to glove and footwear 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 Specimens. A minimum of three specimens, consisting of all layers, shall be tested.

8.16.3 Preparation.

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

8.16.3.2 Specimens shall be conditioned as specified in 8.1.2.

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

8.16.5 Report. The cut distance of blade travel shall be reported to the nearest 1 mm ($\frac{1}{32}$ in.) for each sample specimen. The average cut distance of blade travel shall be reported for all specimens tested.

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

8.16.7 Specific Requirements for Testing Glove Materials.

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

8.16.7.2 Class 1 glove specimens shall be tested at a load of 90 g (3.2 oz).

8.16.7.3 Class 2 glove specimens shall be tested at a load of 75 g (2.6 oz).

8.16.7.4 Class 3 glove specimens shall be tested at a load of 60 g (2.1 oz).

8.16.8 Specific Requirements for Testing Footwear Upper Materials.

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

8.16.8.2 Class 1 footwear upper specimens shall be tested at a load of 800 g (28 oz).

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

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

8.17 Puncture Resistance Test One.

8.17.1 Application.

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

8.17.1.2 Modifications to this test method for testing glove materials shall be as specified in 8.17.7.

8.17.1.3 Modifications to this test method for testing footwear upper materials shall be as specified in 8.17.8.

8.17.2 Specimens.

8.17.2.1 Specimens shall consist of each composite of the palm, palm side of the fingers, and back of the glove used in actual suit glove configuration, with layers arranged in the proper order. Where the specimen composites of the palm, palm side of the fingers, and back of the glove are identical, only one representative composite shall be required to be tested.

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

8.17.3 Preparation.

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

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

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

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

8.17.6 Interpretation. The average puncture force shall be used to determine pass/fail performance.

8.17.7 Specific Requirements for Testing Glove Materials. Specimens shall be taken from the back and palm of the glove and shall not include seams.

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

8.18 Glove Hand Function Test.

8.18.1 Application. This test shall apply to gloves.

8.18.2 Specimens.

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

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

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

8.18.3 Sample Preparation.

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

8.18.3.2 Samples for conditioning shall be whole glove pairs.

8.18.4 Apparatus.

8.18.4.1 A pegboard apparatus shall be used that consists of 25 stainless steel pins and a peg board.

8.18.4.2 Each stainless steel pin shall have a diameter of 9.5 mm ($\frac{3}{8}$ in.) and length of 38 mm (1½ in.).

8.18.4.3 The pegboard shall have 25 holes with each hole having a diameter of 10 mm ($1\frac{3}{32}$ in.) and a depth of 13 mm ($\frac{1}{2}$ in.).

8.18.4.4 The holes shall be in a 5 × 5 pattern and each hole shall have a separation of 25 mm (1 in.) from other holes.

8.18.5 Procedures.

8.18.5.1 Each glove size shall be evaluated by a separate test subject.

8.18.5.2 A minimum of three different glove pairs shall be evaluated.

8.18.5.3 Test subjects shall be selected such that their hand dimensions are as close as possible to those specified in accordance with manufacturing glove sizing guidelines.

8.18.5.4 Each test subject used to perform this testing shall practice the hand functions a minimum of three times before conducting actual testing.

8.18.5.5* Before each test, the pegs shall be placed on a hard, smooth surface adjacent to the pegboard. The pegs shall be randomly scattered in the working area most comfortable to the test subject.

8.18.5.6 In starting the test, each peg shall be picked up using a pincer grasp near the center of the barrel of the peg and shall be placed in pegboard beginning at the upper left corner, left-to-right and top-to-bottom.

8.18.5.7 The time to place all pegs in the pegboard shall be measured for each test subject and shall be known as the dexterity test time.

8.18.5.8 Each test subject shall perform the test following the requirements of 8.18.5.5 through 8.18.5.7 until the variance of the dexterity times of the test subject's last three repetitions does not exceed 8 percent.

8.18.5.8.1 Variance shall be calculated by dividing the standard deviation by the average of the three repetitions, shall be used as the baseline dexterity test time (DTT_b), and shall be between 25 seconds and 45 seconds.

8.18.5.8.2 The test shall be conducted without the test subject's knowledge of the dexterity test time for each repetition.

8.18.5.9 Each test subject shall then perform the test with one pair of gloves following the steps in 8.18.5.5 through 8.18.5.7 until the variance of the dexterity times of that test subject's fastest three repetitions does not exceed 8 percent. Variance shall be calculated as in 8.18.5.8.1.

8.18.5.9.1 The average of the fastest three repetitions shall be used as the dexterity test time with gloves (DTT_g).

8.18.5.9.2 Each test shall be conducted without the test subject's knowledge of the dexterity test time for each repetition.

8.18.5.10 The dexterity test times with gloves shall be compared with the baseline dexterity test time for each test subject.

8.18.5.11 The percentage increase in barehanded control shall be calculated as follows:

$$\text{Percent increase in barehanded control} = \frac{DTT_g}{DTT_b} \times 100$$

8.18.6 Report.

8.18.6.1 The average percent increase in barehanded control shall be reported for each test subject.

8.18.6.2 The average percent increase in barehanded control for all test subjects shall be calculated.

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

8.19 Abrasion Resistance Test.

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

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

8.19.3 Preparation.

8.19.3.1 Samples for conditioning shall be footwear soles.

8.19.3.2 Specimens shall be conditioned as specified in 8.1.2.

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

8.19.5 Report. The abrasion-resistance rating of each specimen shall be reported.

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

8.20 Puncture Resistance Test Two.

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

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

8.20.3 Sample Preparation.

8.20.3.1 Samples for conditioning shall be footwear sole sections.

8.20.3.2 Specimens shall be conditioned as specified in 8.1.2.

8.20.4 Procedure. Puncture resistance shall be performed in accordance with Section 3 of CSA Z195-M, *Standard for Protective Footwear, Occupational Health and Safety*.

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

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

8.21 Slip Resistance Test.

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

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

8.21.3 Preparation.

8.21.3.1 Samples for conditioning shall be footwear.

8.21.3.2 Specimens shall be conditioned as specified in 8.1.2.

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

8.21.5 Report. The static coefficient of friction of each specimen shall be reported.

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

8.22 Impact and Compression Resistance Test.

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

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

8.22.3 Sample Preparation.

8.22.3.1 Samples for conditioning shall be complete footwear toes.

8.22.3.2 Specimens shall be conditioned as specified in 8.1.2.

8.22.4 Procedure. Footwear specimens shall be tested in accordance with Section 1.4 of ANSI Z41, *Standard for Safety-Toe Footwear*.

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

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

8.23 Viral Penetration Resistance Test.

8.23.1 Application.

8.23.1.1 This test shall apply to Class 2 and Class 3 garments, gloves, and footwear materials, and garment and glove seams.

8.23.1.2 Modifications to this test method for testing garment materials after flexing and abrasion shall be as specified in 8.23.7.

8.23.1.3 Modifications to this test method for testing visor or facepiece materials shall be as specified in 8.23.8.

8.23.1.4 Modifications to this test method for testing gloves materials after flexing shall be as specified in 8.23.9.

8.23.1.5 Modifications to this test method for testing footwear materials after flexing and abrasion shall be as specified in 8.23.10.

8.23.1.6 Modifications to this test method for testing garment and glove seams shall be as specified in 8.23.11.

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

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

8.23.4 Procedure.

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

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

8.23.5 Report. The pass/fail result for each specimen shall be reported.

8.23.6 Interpretation. One or more failures of any specimen against any liquid constitutes failure of the material.

8.23.7 Specific Requirements for Testing Garment Materials.

8.23.7.1 Samples shall be conditioned by flexing as specified in 8.1.3. Samples shall be 200 mm × 280 mm (8 in. × 11 in.). Following flexing, one specimen shall be taken from the center of each sample subjected to flexing for viral penetration testing.

8.23.7.2 Samples shall be conditioned by abrading as specified in 8.1.4. Samples shall be 45 mm × 230 mm (1⅞ in. × 9 in.). Following abrading, one specimen shall be taken from the center of each sample subjected to abrading for viral penetration testing.

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

8.23.8 Specific Requirements for Testing Visor or Facepiece Materials.

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

8.23.8.2 Where the ensemble utilizes the respirator facepiece as the ensemble visor, as specified in 6.1.6, this test method shall also apply to each type of material used in the construction of the respirator facepiece that is exposed to the environment.

8.23.8.3 The specimen shall also include the respirator where applicable.

8.23.9 Specific Requirements for Testing Glove Materials After Flexing.

8.23.9.1 Samples for conditioning shall be whole gloves.

8.23.9.2 Samples shall be conditioned as specified in 8.1.5.

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

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

8.23.10.2 Samples for conditioning shall be whole footwear items.

8.23.10.3 Samples shall first be conditioned by flexing as specified in 8.1.6. Following flexing, new samples shall be taken in areas from the footwear upper where the greatest flexing occurred, usually at the footwear quarter or vamp, measuring 45 mm × 230 mm (1⅞ in. × 9 in.).

8.23.10.4 The new samples shall then be conditioned by abrading as specified in 8.1.4.

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

8.23.10.4.2 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.

8.23.11 Specific Requirements for Testing Garment or Glove Seams.

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

8.23.11.2 Seam specimens shall be prepared from seam samples that have a minimum of 75 mm (3 in.) of material on each side of the seam center. Permeation test specimens shall be cut such that the exact seam center divides the specimen in half.

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

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

8.24 Liquid-Tight Integrity Test Two.

8.24.1 Application.

8.24.1.1 This test method shall apply to Class 2 and Class 3 gloves and footwear.

8.24.1.2 Modifications to this test method for testing gloves shall be as specified in 8.24.7.

8.24.1.3 Modifications to this test method for testing footwear shall be as specified in 8.24.8.

8.24.2 Specimens. A minimum of 10 specimens shall be tested. Specimens shall consist of the entire glove or footwear item with all layers assembled that are required for the item to be compliant.

8.24.3 Preparation.

8.24.3.1 Samples for conditioning shall be whole gloves or footwear.

8.24.3.2 Specimens shall be conditioned as specified in 8.1.2.

8.24.4 Procedure. Liquid-tight integrity testing of gloves and footwear shall be conducted in accordance with ASTM D 5151, *Standard Test Method for Detection of Holes in Medical Gloves*, with the following modifications:

- (1) The surface tension of the water used in testing shall be 32 dynes/cm \pm 2 dynes/cm.
- (2) The surfactant-treated water shall remain in the specimen for a period of 1 hour +5/-0 minutes.
- (3) Observations for leakage shall be performed at the end of the test period.
- (4) Blotting paper shall be permitted to be used for assisting in the determination that liquid leakage has occurred.

8.24.5 Report. Observations of water leakage shall be noted by specific area on the test specimen.

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

8.24.7 Specific Requirements for Testing Gloves.

8.24.7.1 Specimens shall be conditioned as specified in 8.1.5.

8.24.7.2 A sufficient amount of surfactant-treated water shall be added to the specimen so that the water is within 25 mm (1 in.) of the edge of the glove opening.

8.24.8 Specific Requirements for Testing Footwear.

8.24.8.1 Specimens shall be conditioned as specified in 8.1.6.

8.24.8.2 A sufficient amount of surfactant-treated water shall be added to the specimen so that the water is within 25 mm (1 in.) of the edge of the footwear opening.

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.1.1.1 The ensemble classes described in this document were developed for use in environments that can generally be described by considering the following:

- (1) Exposure and delivery method
- (2) Potential for skin contact
- (3) Contaminant identification and concentration level
- (4) Persistency (longevity) of the contaminant
- (5) Threat of contamination and cross-contamination

Table A.1.1.1 provides a general description of the environment from which Class 1, Class 2, and Class 3 compliant ensembles are designed to provide protection. Selection of the appropriate class ensemble should be based on a thorough risk assessment of the incident.

A.1.1.3 Users are cautioned that exposure of ensembles to chemical/biological agents should require disposal, particularly if the effectiveness of decontamination cannot be assessed.

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

A.1.1.8 One example of a product being certified to two standards is a hazardous materials protective ensemble, an ensemble element, or protective clothing that is certified as compliant with NFPA 1992, *Standard on Liquid Splash-Protective Ensembles and Clothing for Hazardous Materials Emergencies*, that is also being certified as a Class 3 chemical/biological protective ensemble in accordance with this standard.

Another example is a vapor/protective ensemble that is certified as compliant with NFPA 1991, *Standard on Vapor-Protective Ensembles for Hazardous Materials Emergencies*, that is also being certified as a Class 1 chemical/biological protective ensemble in accordance with this standard.

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

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

A.3.2.1 Approved. The National Fire Protection Association does not approve, inspect, or certify any installations, procedures, equipment, or materials; nor does it approve or evaluate testing laboratories. In determining the acceptability of installations, procedures, equipment, or materials, the authority having jurisdiction may base acceptance on compliance with NFPA or other appropriate standards. In the absence of