NFPA 1991
Standard on Vapor-Protective Suits for Hazardous Chemical Emergencies

1994 Edition

National Fire Protection Association, 1 Batterymarch Park, PO Box 9101, Quincy, MA 02269-9101
An International Codes and Standards Organization

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.

NFPA 1991

Standard on

Vapor-Protective Suits for Hazardous Chemical Emergencies

1994 Edition

This edition of NFPA 1991, *Standard on Vapor-Protective Suits for Hazardous Chemical Emergencies*, was prepared by the Technical Committee on Fire Service Protective Clothing and Equipment and acted on by the National Fire Protection Association, Inc., at its Annual Meeting held May 16–18, 1994, in San Francisco, CA. It was issued by the Standards Council on July 14, 1994, with an effective date of August 5, 1994, and supersedes all previous editions.

The 1994 edition of this document has been approved by the American National Standards Institute.

Origin and Development of NFPA 1991

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

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

At the same time, ASTM was developing a document on a selection of chemicals for evaluating protective clothing materials that would serve as one of several ASTM testing criteria that would be referenced in the NFPA standards.

The subcommittee met several times over a $2^1/_2$-year period at different locations across the country and developed two standards, one for vapor-protective suits and one for liquid splash-protective suits.

NFPA 1991 addresses vapor-protective suits designed to protect emergency response personnel against exposure to specified chemicals in vapor and liquid splash environments during hazardous chemical emergencies. Chemical permeation resistance documentation is required for primary suit materials (garment, visor, gloves, and boots) against each chemical in the NFPA battery of chemicals and any additional chemicals or specific chemical mixtures for which the manufacturer is certifying the suit. The NFPA battery of chemicals consists of 21 chemicals: those specified in ASTM F1001, *Standard Guide for Chemicals to Evaluate Protective*

Clothing Materials. These chemicals were selected because they are representative of the classes of chemicals that are encountered during hazardous chemical emergencies.

The standard includes performance requirements that were established to reflect simulated use conditions. A suit pressurization test is used to check the airtight integrity of each protective suit. Also, an overall suit water penetration test is designed to ensure the suit provides full body protection against liquid splashes. Primary suit materials must resist permeation for one hour or more by each chemical in the NFPA battery. Manufacturers may certify protective suits for additional chemicals when the same permeation performance is met. Also included are penetration resistance testing of closures, and leak and cracking pressure tests for exhaust valves. These tests allow determination of adequate suit component performance in hazardous chemical environments.

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

NFPA 1992 addresses liquid splash-protective suits designed to protect emergency response personnel against exposure to specified chemicals in liquid splash environments during hazardous chemical emergencies. Chemical penetration resistance documentation of garment material against an NFPA battery of test chemicals and any additional chemicals or specific chemical mixtures for which the manufacturer is certifying the suit is required. The NFPA battery of chemicals were selected from ASTM Fl00l, *Standard Guide for Chemicals to Evaluate Protective Clothing Materials*. These do not include liquid chemicals with known or suspected carcinogenicity or skin toxicity because these garments deal with skin exposure and not inhalation. This criterion produces a different subset of ASTM Fl00l chemicals to be certified.

The standard includes performance requirements that were established to reflect simulated use conditions. An overall suit water penetration test is included to ensure the suit provides full body splash protection. Materials testing includes burst strength, tear resistance, flammability resistance testing, abrasion resistance, cold temperature performance, and flexural fatigue testing. These tests are required so that garment materials will provide adequate protection in the environment in which they will be used.

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

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

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

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

Technical Committee on Fire Service Protective Clothing and Equipment

Kirk H. Owen, *Chair*
Plano Fire Dept., TX
Rep. NFPA Fire Service Section

Wayde B. Miller, *Secretary*
Mine Safety Appliances Co., PA
(Nonvoting)

Peter V. Ackerman, S. Plainfield, NJ
Rep. Nat'l Volunteer Fire Council
Donald Aldridge, Lion Apparel Inc., OH
Curtis Berger, Menlo Park Fire Protection District, CA
Rep. Northern Area Fire Equipment Research Organization
Joseph A. Bigler, Mine Safety Appliances Co., PA
Rep. Compressed Gas Assn.
Donna P. Brehm, Virginia Beach Fire Dept., VA
Dennis W. Browner, Scott Aviation, NY
Rep. Industrial Safety Equipment Assn.
Rand-Scott Coggan, City of Redmond Fire Dept., WA
Rep. Int'l Assn. of Fire Chiefs
Christopher E. Coombs, Cairns & Brother Inc., NJ
Paul H. Crawford, Riverside Fire Dept., CA
Rep. Southern Area Fire Equipment Research
Patricia A. Freeman, Globe Fire Fighters Suits, NH
Glen E. Gardner, U.S. Occupational Safety & Health Admin., DC
Daniel Gohlke, W. L. Gore & Assoc., MD
Jonathan J. Greenawalt, Kitsap Cnty Fire District #2, WA
William L. Grilliot, Morning Pride Manufacturing Co. Inc., OH
Bryan C. Heirston, Oklahoma State Dept. of Labor, OK
James R. Lawson, Nat'l Inst. of Standards & Technology, MD
Cy Long, Commission on Fire Protection, TX
Robert T. McCarthy, U.S. Fire Administration, MD
Christopher B. Preu, Louisville Division of Fire, KY
Alexander W. Santora, New York City Fire Dept., NY
Kenneth L. Simmons, Arizona State Fire Marshal, AZ
Brian A. Stoneback, U.S. Air Force Fire Protection, FL
Jeffrey O. Stull, TRI/Environmental Inc., TX
Bruce H. Varner, City of Carrollton Fire Dept., TX
James H. Veghte, Biotherm Inc., OH
Thomas L. Wollan, Underwriters Laboratories Inc., NC

Alternates

Roger L. Barker, N. Carolina State University, NC
(Alt. to P. A. Freeman)
Mary I. Grilliot, Morning Pride Manufacturing Co. Inc., OH
(Alt. to W. L. Grilliot)
Tom Hillenbrand, Underwriters Laboratories Inc., IL
(Alt. to T. L. Wollan)
Dominick A. Martucci, United States Testing Co., NJ
(Alt. to U.S. Testing Rep.)
Robert J. Richter, Cairns & Brother Inc., NJ
(Alt. to C. E. Coombs)
Joanne E. Slattery, U.S. Occupational Safety & Health Admin., DC
(Alt. to G. E. Gardner)
Richard L. Stein, Survivair, CA
(Alt. to D. W. Browner)
Frank P. Taylor, Lion Apparel Inc., OH
(Alt. to D. Aldridge)
Robert Vettori, Nat'l Inst. of Standards & Technology, MD
(Alt. to J. R. Lawson)

Bruce W. Teele, NFPA Staff Liaison

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

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

Committee Scope: This Committee shall have primary responsibility for documents on the design, construction, and performance criteria for protective clothing and equipment for the fire service, including chemical protective clothing and aircraft rescue and firefighting protective clothing.

Contents

NFPA 1991

Standard on

Vapor-Protective Suits for Hazardous Chemical Emergencies

1994 Edition

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

Information on referenced publications can be found in Chapter 10 and Appendix D.

Chapter 1 Administration

1-1 Scope.

1-1.1* This standard specifies minimum requirements for vapor-protective suits and replacement components designed to protect emergency response personnel from specified chemicals and chemical mixtures in vapor, liquid splash, and particulate environments during hazardous chemical emergencies.

1-1.2* The requirements of this standard specify minimum certification, documentation, design, and performance criteria; test methods for chemical protection; and additional optional criteria for chemical flash fire protection and liquefied gas protection.

1-1.3* This standard does not apply to protective clothing for any fire fighting applications and does not provide criteria for protection from radiological, biological, or cryogenic gas hazards, or against explosive atmospheres.

1-1.4* This standard is not intended to be utilized as a detailed manufacturing or purchase specification but can be referenced in purchase specifications as minimum requirements.

1-2 Purpose.

1-2.1 The purpose of this standard is to provide minimum requirements for:

(a) Vapor-protective suits and replacement components used in hazardous chemical emergencies.

(b) Vapor-protective suits described in 1-2.1(a) combined with chemical flash fire protection.

(c) Vapor-protective suits described in 1-2.1(a) combined with liquefied gas protection.

(d) Vapor-protective suits described in 1-2.1(a) combined with chemical flash fire protection and liquefied gas protection.

1-2.2 The purpose of the options in 1-2.1 is to provide users with the flexibility to choose the combination of features that matches their anticipated exposure.

1-2.3 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 might be exposed.

1-2.4 Nothing herein is intended to restrict any jurisdiction or manufacturer from exceeding these minimum requirements.

1-3 Definitions.

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

Approved.* Acceptable to the authority having jurisdiction.

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

Biological Agents. Biological materials that are capable of causing acute or long-term damage to the human body.

Boot. See "Footwear."

Bootie. A sock-like extension of the suit leg designed to protect the wearer's feet where worn in conjunction with an outer boot.

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 compliances with the requirements of this standard.

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

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

Chemical Protection Layer. The layer or layers included in the composite that are intended to provide permeation resistance to chemicals and provide gastight integrity for the overall chemical-protective suit.

Chemical-Protective Clothing Material. Any material or composite used in an item of clothing for the purpose of protecting parts of the wearer's body from chemical or physical hazards.

Chemical-Protective Suit.* A single or multipiece garment constructed of chemical-protective clothing materials designed and configured to protect the wearer's torso, head, arms, legs, hands, and feet. It shall be permitted to completely enclose the wearer by itself or in combination with the wearer's respiratory equipment, hood, gloves, and boots.

Cold Zone. Those geographical areas designated as contamination-free from a chemical spill or release. These areas contain the command post and other support functions necessary to control the incident. The cold zone is also referred to as the "clean" or "support zone." (*See also Hot Zone and Warm Zone.*)

Compliant. Meeting or exceeding all applicable requirements of this standard.

Component. Gloves or footwear used in the construction of the vapor-protective suit.

Composite. Any layering of protective clothing materials or components as they appear in the final garment construction.

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

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

Emergency Response Personnel. Personnel assigned to organizations that have responsibility for responding to hazardous chemical emergencies.

Exhaust Valve. One-way vent valves designed to release exhaust air from the inside of the chemical-protective suit to the outside environment and prevent entry of contaminated air into the chemical protective suit from the outside environment.

External Fittings. Any fitting externally located on, and part of, the vapor-protective suit that is not part of the garment material, visor material, gloves, footwear, seams, or closure assembly. Airline, cooling device, and communications system connections or pass-throughs and glove and boot interface materials on the chemical protective suit are examples of external fittings.

External Gaskets. Any gasket externally located on, and part of, the vapor-protective suit that is not part of the garment material, visor material, boot assembly, glove assembly, or closure assembly. External gaskets can be used in conjunction with external fittings.

Flammable or Explosive Atmospheres. Atmospheres containing chemical vapors or gases at concentrations that will burn or explode if ignited.

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 listed products that are being produced by the manufacturer to the requirements of this standard.

Footwear. The segment of the chemical-protective suit designed to protect the wearer's feet and ankles. Footwear includes boots or outer boots in conjunction with booties.

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

Garment Material. The principal chemical-protective clothing material used in the construction of the chemical-protective suit.

Glove. The segment of the chemical-protective suit designed to protect the wearer's hands and wrists.

Hazardous Chemical. Any solid, liquid, gas, or mixture thereof that can potentially cause harm to the human body through respiration, ingestion, skin absorption, or contact.

Hazardous Chemical Emergencies.* Incidents involving the release or potential release of hazardous chemicals into the environment, which can cause loss of life, personnel injury, or damage to property and the environment.

Hot Zone. The area immediately surrounding a hazardous material incident that extends far enough to prevent adverse effects from hazardous materials releases to personnel outside the zone. This zone is also referred to as the "exclusion zone" or "restricted zone." (*See also Cold Zone and Warm Zone.*)

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.

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

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

Liquid Splash-Protective Suit. A chemical-protective suit that meets at least the base requirements of NFPA 1992, *Standard on Liquid Splash-Protective Suits for Hazardous Chemical Emergencies*, and protects against chemical liquid splashes but not against chemical vapors or gases.

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

Normalized Breakthrough Detection Time. The time at which the permeation rate of a chemical through a material reaches 0.1 $\mu g/cm^2/min$.

Outer Boot. A boot worn over footwear or bootie for the purposes of providing additional protection to the wearer and for meeting the requirements of this standard.

Outer Garment. A secondary garment worn over a chemical-protective suit for the purposes of providing additional protection to the wearer and for meeting the requirements of this standard.

Particulates. Solid matter that is dispersed in air as a mixture. Particulates, for the purpose of this standard, do not include aerosol, or suspended liquid droplets in air. Aerosols are considered liquids.

Primary Suit Materials. Chemical-protective suit materials limited to the garment material, visor or faceshield material, glove material, and footwear material. This includes, in addition to the above mentioned materials, the wearer's respiratory equipment when designed to be worn outside the vapor-protective suit, the umbilical air hose, and all other exposed respiratory equipment materials designed to protect the wearer's breathing air and air path. Primary materials can be either single layers or composites.

Product Label. A label affixed to the garment by the manufacturer containing general information, warnings, care, maintenance, or similar data.

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.

Replacement Component. A component that meets the respective requirements of Chapter 8. For this standard, replacement components only include gloves and footwear.

Respiratory Equipment. A positive pressure, self-contained breathing apparatus (SCBA) or combination SCBA/supplied-air breathing apparatus certified by the National Institute for Occupational Safety and Health (NIOSH) and the Mine Safety and Health Administration (MSHA).

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

Shall. Indicates a mandatory requirement.

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

Suit Closure. The suit component designed and configured to allow the wearer to enter (don) and exit (doff) the chemical-protective suit.

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

Support Function. Activities of the hazardous materials incident that take place outside the hot zone involving controlled chemical uses or exposures in nonflammable atmospheres with minimum threats to loss of life, personnel injury, or damage to property or to the environment. Functions include decontamination, remedial cleanup of identified chemicals, and training.

Support Function Protective Clothing. An item of chemical-protective clothing or a chemical-protective suit that meets all requirements of NFPA 1993, *Standard on Support Function Protective Clothing for Hazardous Chemical Operations.*

Vapor-Protective Suit. A chemical-protective suit that protects against chemical vapors, gases, and liquids and meets at least all base requirements of this standard, except those requirements in Chapters 5 and 6.

Vapor-Protective Suit with Additional Chemical Flash Fire Escape and Liquefied Gas Protection. A vapor-protective suit also meeting the requirements in Chapter 7 of this standard.

Vapor-Protective Suit with Additional Chemical Flash Fire Escape Protection.* A vapor-protective suit also meeting the requirements in Chapter 5 of this standard.

Vapor-Protective Suit with Additional Liquefied Gas Protection.* A vapor-protective suit also meeting the requirements in Chapter 6 of this standard.

Visor or Faceshield Material. The transparent chemical-protective clothing material that allows the wearer to see outside the chemical protective suit.

Warm Zone. The area where personnel and equipment decontamination and hot zone support takes place. It includes control points for the access corridor and thus assists in reducing the spread of contamination. This is also referred to as the decontamination, contamination reduction, or limited access zone. (*See also Cold Zone and Hot Zone.*)

1-4 Units.

1-4.1 In this standard, values for measurement are followed by an equivalent in parentheses, but only the first stated value shall be regarded as the requirement. Equivalent values in parentheses shall not be considered as the requirement, as these values might be approximate.

Chapter 2 Certification

2-1 General.

2-1.1* Vapor-protective suits that are labeled as being compliant with this standard shall meet or exceed all applicable requirements specified in this standard and shall be certified.

2-1.2 Compliant vapor-protective suits shall be labeled and listed. Such vapor-protective suits also shall have a product label that meets the requirements specified in Section 2-5.

2-1.3 Replacement components that are labeled as compliant with this standard shall meet or exceed all applicable requirements in Chapter 8 and shall be certified.

2-1.4 Compliant replacement components shall be labeled and listed. Such replacement components also shall have a product label that meets the applicable requirements specified in Chapter 8.

2-1.5 Where vapor-protective suits and replacement components are certified for additional chemicals and mixtures, as provided for in 4-2.2, then they shall also meet or exceed the requirements specified in 4-3.1, 4-3.2, 4-5.4, 4-5.5, 4-6.4, 4-6.5, and, if applicable, 6-2.2.

2-1.6 All certification shall be performed by an approved certification organization.

2-2 Certification Program.

2-2.1* 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.

2-2.2 The certification organization shall refuse to certify products to this standard that do not comply with all requirements of this standard.

2-2.3* 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.

2-2.4* For certification, laboratory facilities and equipment for conducting proper tests shall be available, 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, from data sheets, documented calibration and calibration routines, performance verification, proficiency testing, and staff qualification and training programs.

2-2.5 Manufacturers shall be required to establish and maintain a program of production inspection and testing that meets the requirements of Section 2-4.

2-2.6 The manufacturer and the certification organization shall evaluate any changes affecting the form, fit, or function of the certified product to determine its continual certification to this standard.

2-2.7* Product certifications shall include a follow-up inspection program, with at least two random and unannounced visits per 12-month period.

2-2.8 The certification organization shall have a program for investigating field reports alleging malperformance or failure of listed products.

2-2.9 The operating procedures of the certification organization shall provide a mechanism for the manufacturer to appeal decisions. The procedures shall include the presentation of information from both sides of a controversy to a designated appeals panel.

2-2.10 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.

2-3 Inspection and Testing.

2-3.1 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 as being compliant with the standard are compliant. This information shall be included in the manufacturer's technical data package.

2-3.2 Each vapor-protective suit shall be tested to the requirements of 4-1.2.

2-3.3 Testing for determining material and component compliance with the requirements specified in Chapters 4, 5, and 6 shall be performed on samples representative of materials and components used in the actual construction of the vapor-protective suit. The certification organization shall also be permitted to use sample materials cut from a representative vapor-protective suit.

2-3.4 Except where otherwise noted, determinations of pass or fail performance shall be based on the average measurement. In cases where materials are tested in more than one direction, determinations of pass or fail performance shall be based on the average result in each direction. Failure in any one direction shall constitute failure of the material for the test.

2-3.5* Except where otherwise noted, any combination of materials or multipiece garment that is needed to meet any of the performance requirements specified in Chapters 4, 5, and 6 shall also be required to meet all the requirements for that particular segment of the vapor-protective suit or replacement component.

2-3.6 The certification organization shall review the technical data package to determine compliance with the requirements of Chapter 3.

2-4 Manufacturer's Quality Assurance.

2-4.1 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.

2-4.2 The manufacturer shall maintain written inspection and testing instructions. The instructions shall prescribe inspection and test of materials, work in process, and completed articles. Criteria for acceptance and rejection of materials, processes, and final product shall be part of the instructions.

2-4.3 The manufacturer shall maintain records of all pass/fail tests. Pass/fail records shall indicate the disposition of the failed material or product.

2-4.4 The manufacturer's inspection system shall provide for procedures that ensure the latest applicable drawings, specifications, and instructions are used for fabrication, inspection, and testing.

2-4.5 The manufacturer shall, as part of the quality assurance process, 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.

2-4.6 The manufacturer shall establish and maintain a system for identifying the appropriate inspection status of component materials, work in process, and finished goods.

2-4.7 The manufacturer shall 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.

2-4.8 The manufacturer's quality assurance systems and procedures shall be audited by the third-party certification agency to determine that the system is sufficient to ensure continued compliance to this standard.

2-5 Product Labeling.

2-5.1* The vapor-protective suit shall have a product label permanently and conspicuously attached to the inside of the garment upon which at least the following warning and information are printed in at least $^{1}/_{16}$-in. (1.5-mm) high letters.

"THIS VAPOR-PROTECTIVE SUIT MEETS:

YES THE BASE REQUIREMENTS IN CHAPTERS 2, 3, AND 4;

NO ADDITIONAL REQUIREMENTS IN CHAPTER 5 FOR LIMITED CHEMICAL FLASH FIRE PROTECTION; THIS ENSEMBLE PROVIDES LIMITED PROTECTION IN THE EVENT OF CHEMICAL FLASH FIRES TO ALLOW ESCAPE ONLY.

NO ADDITIONAL REQUIREMENTS IN CHAPTER 6 FOR LIQUEFIED GAS PROTECTION;

OF NFPA 1991, STANDARD ON VAPOR-PROTECTIVE SUITS FOR HAZARDOUS CHEMICAL EMERGENCIES, 1994 EDITION, FOR THE CHEMICALS LISTED BELOW. THE TECHNICAL DATA PACKAGE CONTAINS ADDITIONAL INFORMATION ON THESE AND ANY ADDITIONAL CHEMICALS AND SPECIFIC CHEMICAL MIXTURES FOR WHICH THIS SUIT IS CERTIFIED.

Acetone	**Hexane**
Acetonitrile	**Hydrogen chloride (gas)**
Anhydrous ammonia (gas)	**Methanol**

1,3-Butadiene (gas)
Carbon disulfide
Chlorine (gas)
Dichloromethane
Diethyl amine
Dimethyl formamide
Ethyl acetate
Ethylene oxide (gas)
Methyl chloride (gas)
Nitrobenzene
Sodium hydroxide
Sulfuric acid
Tetrachloroethylene
Tetrahydrofuran
Toluene

CONSULT THE TECHNICAL DATA PACKAGE, MANUFACTURER'S INSTRUCTIONS, AND MANUFACTURER'S RECOMMENDATIONS BEFORE USE.

WARNING

WHERE MULTIPLE LAYERS ARE PROVIDED AS A SINGLE AND INTEGRATED UNIT, ALL SEPARABLE LAYERS MUST BE WORN TOGETHER. UNLESS THIS GARMENT IS SPECIFICALLY CERTIFIED AS APPROPRIATE TO THE FOLLOWING APPLICATIONS, DO NOT USE FOR ANY FIRE FIGHTING APPLICATIONS OR FOR PROTECTION FROM RADIOLOGICAL, BIOLOGICAL, OR CRYOGENIC AGENTS, OR IN FLAMMABLE OR EXPLOSIVE ATMOSPHERES. CHEMICAL CONTAMINATION OF THIS SUIT MAY WARRANT ITS DISPOSAL. MAINTAIN ONLY IN ACCORDANCE WITH MANUFACTURER'S INSTRUCTIONS. NO PROTECTIVE CLOTHING CAN PROVIDE PROTECTION FROM ALL CONDITIONS. USE EXTREME CARE FOR ALL EMERGENCY OPERATIONS, PARTICULARLY IN HAZARDOUS ATMOSPHERES. FAILURE TO COMPLY WITH THESE INSTRUCTIONS MAY RESULT IN SERIOUS INJURY OR DEATH."

Manufacturer's name
Manufacturer's address
Country of manufacture
Suit model, style, and serial number
Date of compliance testing to ASTM F1052
Size
Garment material(s)
Visor material(s)
Glove(s)
Footwear item(s)

"DO NOT REMOVE THIS LABEL."

2-5.2* The manufacturer shall identify on the product label any other clothing items such as outer garments, outer gloves, or outer boots that must be worn in order to meet the performance requirements of this standard using the following language:

FOR COMPLIANCE WITH NFPA 1991, THE FOLLOWING PROTECTIVE CLOTHING ITEMS MUST BE WORN IN CONJUNCTION WITH THIS GARMENT:
(List items by type and identification.)

2-5.3 Other clothing items used to meet the performance requirements of this standard shall meet the label requirements specified in ASTM F1301, *Standard Practice for Labeling Chemical Protective Clothing*. The label shall be printed in at least $^{1}/_{16}$-in. (1.5-mm) high letters.

2-5.4 All portions of the required product label shall be printed in at least English.

2-6* User Information.

2-6.1* Vapor-protective suit manufacturers shall provide the following instructions and information with each suit:

(a) Cleaning instructions;
(b) Marking and storage instructions;
(c) Frequency and details of inspections;
(d) Maintenance criteria;
(e) How to use test equipment, where applicable;
(f) Methods of repair, if recommended by manufacturer; and
(g) Warranty information.

2-6.2 Vapor-protective suit manufacturers shall furnish training materials that address, but are not limited to:

(a) Donning procedures;
(b) Doffing procedures;
(c) Safety considerations;
(d) Optimum storage conditions;
(e) Recommended storage life;
(f) Decontamination recommendations and considerations;
(g) Retirement considerations;
(h) Closure lubricants, if applicable;
(i) Visor/faceshield antifog agents or procedures; and
(j) Recommended undergarments.

2-6.3* Vapor-protective suit manufacturers shall furnish a logbook with each vapor-protective suit along with instructions on its proper completion and maintenance.

Chapter 3 Documentation Requirements

3-1 Technical Data Package.

3-1.1* The manufacturer shall furnish a technical data package with each vapor-protective suit.

3-1.2* The technical data package shall contain all documentation required by this standard and the data showing compliance with this standard.

3-1.3 In the technical data package, the manufacturer shall describe the vapor-protective suit in terms of manufacturer trade name and model number, manufacturer replaceable components and available options, accessories such as testing devices, and sizes.

3-1.4* In the technical data package, the manufacturer shall describe the available sizes of the vapor-protective suit. Descriptions of size shall include the range in height and weight for persons fitting each particular size and shall provide information to the wearer as to whether these sizes apply to persons wearing SCBA, hard hats, communications devices, turnout clothing, and other similar gear.

3-1.5* In the technical data package, the manufacturer shall document the average donning and doffing times for the vapor-protective suit where measured as specified in Section 9-1.

3-2 Suit Material and Component Descriptions.

3-2.1* Where specific clothing items and equipment are required for certifying the vapor-protective suit to this standard, the manufacturer shall list these clothing items and equipment in the technical data package.

3-2.2 The manufacturer shall provide, in the technical data package, a list and descriptions of the following suit materials and components, if applicable:

(a) Garment material;

(b) Visor/faceshield material;

(c) Glove material and type of attachment;

(d) Footwear material and type of attachment;

(e) Zipper/closure type and materials;

(f) Material seam types and composition;

(g) Exhaust valve types and material(s);

(h) External fitting types and material(s);

(i) External gasket types and material(s);

(j) Outer garment, glove, or boot material(s); and

(k) Type or style of head protection accommodated within the suit.

3-2.2.1 All descriptions of material composition shall specify either the generic material names or trade names if the composition of the material is proprietary.

3-2.2.2 Descriptions of respective suit materials and components shall include the following information, if applicable:

(a) Visor/faceshield material.

(1) The availability of any permanent detachable covers and films.

(b) Gloves.

(1) Type of linings or surface treatments

(2) Available glove sizes.

(c) Footwear.

(1) Type of linings or surface treatments

(2) Type of soles or special toe reinforcements

(3) Available footwear sizes.

(d) Suit zipper or closure.

(1) The material(s) of construction for the closure (including chain, slide, pull, and tape for zippers)

(2) The location and the length of the completed closure assembly

(3) A description of any protective covers or flaps.

(e) Suit exhaust valves or ports.

(1) Type (such as flapper, pressure demand)

(2) Number and method of attachment to the suit

(3) A description of any protective covers or pockets.

(f) Other clothing items (e.g., outer garments).

(1) Type and how used with protective suit.

3-2.3 The manufacturer shall describe, in the technical data package, the type of seams or methods of attachment for the following suit material and component combinations:

(a) Garment material—garment material,

(b) Garment material—visor,

(c) Garment material—glove,

(d) Garment material—footwear,

(e) Garment material—suit closure, and

(f) Garment material—outer cover.

3-2.4* Sample gloves shall be tested for dexterity and results where tested as specified in Section 9-17.

Chapter 4 Design and Performance Requirements

4-1 Overall Suit Requirements.

4-1.1 Protective covers or pockets constructed using the garment material shall be provided to protect the exhaust valves from direct chemical splashes to the seat of the exhaust valves. The pockets or covers shall allow access to the valves for removal and inspection.

4-1.2 Each vapor-protective suit shall be tested for gastight integrity and shall show an ending pressure of at least 1.6 in. (40 mm Hg) water gauge pressure where tested as specified in Section 9-2. The date of the test shall be placed on the label.

4-1.3 Sample suits shall be tested for liquidtight integrity and shall allow no water penetration where tested as specified by Section 9-3.

4-1.4 Sample suits shall be tested for overall function and integrity, as specified in Section 9-4, and shall show an ending pressure of at least 1.6 in. (40 mm Hg) water gauge pressure after testing for gastight integrity as specified in Section 9-2.

4-1.5 Sample vapor-protective suits shall be tested for airflow capacity and shall exhibit no internal pressures greater than 1.5 in. (38 mm Hg) water gauge pressure, and show an ending pressure of at least 1.6 in. (40 mm Hg) water gauge pressure after subsequent testing for gastight integrity where tested in accordance with Section 9-5.

4-1.6 Vapor-protective suits shall be designed to at least accommodate head protection meeting the dimensional requirements for Class B Caps of ANSI Z89.1, *Protective Headwear for Industrial Workers.*

4-1.7* Other than outer gloves and outer boots, vapor-protective suits shall be designed so that all separate parts and components are securely attached and provided as a single and integrated unit.

4-2 Primary Suit Material Requirements.

4-2.1 Samples of the primary suit materials shall be tested for permeation resistance and shall not exhibit normalized breakthrough detection times of one hour or less for each chemical in ASTM F1001, *Standard Guide for Chemicals to Evaluate Protective Clothing Materials*, where tested as specified in Section 9-6.

4-2.2 For any additional chemicals or specific chemical mixtures for which the manufacturer is certifying the suit, samples of the primary suit materials shall be tested for permeation resistance and shall not exhibit normalized breakthrough detection times of one hour or less for each additional chemical or specific chemical mixture where tested as specified in Section 9-6.

4-2.3 Primary suit materials shall not ignite during the initial 3.0-second exposure period, shall not burn a distance of greater than 4.0 in. (10.2 cm), shall not sustain burning for more than 10 seconds, and shall not melt as evidenced by flowing or dripping during the subsequent 12-second exposure period where tested for flame resistance as specified in Section 9-7.

4-3 Additional Garment Material Requirements.

4-3.1 Garment material samples shall not exhibit a normalized breakthrough detection time of one hour or less after abrasion for each chemical in ASTM F1001, *Standard Guide for Chemicals to Evaluate Protective Clothing Materials*, where tested as specified in Section 9-8 of this standard.

4-3.2 Garment material samples shall not exhibit a normalized breakthrough detection time of one hour or less after flexing for each chemical in ASTM F1001, *Standard Guide for Chemicals to Evaluate Protective Clothing Materials*, where tested as specified in Section 9-9 of this standard.

4-3.3 Garment material samples shall be tested for bursting strength and shall have a bursting strength of not less than 100 psi (7.0 kg/cm^2) as specified in Section 9-10.

4-3.4 Garment material samples shall be tested for puncture propagation tear resistance and shall have a puncture propagation tear resistance of not less than 11 lb (5 kg) where tested as specified in Section 9-11.

4-3.5 Garment material samples shall have a bending moment of not greater than 0.50 in.-lb (0.057 Nm) at an angular deflection of 60 degrees and –13°F (–25°C) where tested for cold weather performance as specified in Section 9-12.

4-4 Additional Visor or Faceshield Requirements.

4-4.1 The visor or faceshield of sample suits shall be tested for clarity and test subjects shall have a visual acuity of 20/35 or better where tested as specified in Section 9-13.

4-4.2 Visor or faceshield material samples shall be tested for bursting strength and shall have a bursting strength of not less than 100 psi (7.0 kg/cm^2) where tested as specified in Section 9-10.

4-4.3 Visor or faceshield samples shall be tested for puncture propagation tear resistance and shall have a puncture propagation tear resistance of not less than 11 lb (5 kg) where tested as specified in Section 9-11.

4-4.4 Visor or faceshield samples shall be tested for cold temperature bending at –13°F (–25°C) and shall not crack or show evidence of visible damage where tested as specified in Section 9-14.

4-5 Additional Glove Requirements.

4-5.1 Gloves shall provide protection from the finger tips to at least 1 in. (25.4 mm) beyond the wrist crease.

4-5.2 Glove material samples shall be tested for cut resistance and shall have a cut resistance of not less than 6.5 lb (3.0 kg) where tested as specified in Section 9-15.

4-5.3 Glove material samples shall be tested for puncture resistance and shall have a puncture resistance of not less than 5 lb (2.3 kg) where tested as specified in Section 9-16.

4-5.4 Glove material samples shall be tested for abrasion resistance and shall not exhibit a normalized breakthrough detection time of one hour or less for each chemical in ASTM F1001, *Standard Guide for Chemicals to Evaluate Protective Clothing Materials*, where tested as specified in Section 9-8 of this standard.

4-5.5 Glove material samples shall be tested for flex fatigue resistance and shall not exhibit a normalized breakthrough detection time of one hour or less for each chemical in ASTM F1001, *Standard Guide for Chemicals to Evaluate Protective Clothing Materials*, where tested as specified in Section 9-9 of this standard.

4-5.6 Glove material samples shall have a bending moment of 0.50 in.-lb (0.057 Nm) at an angular deflection of 60 degrees and –13°F (–25°C) where tested for cold weather performance as specified in Section 9-12.

4-6 Additional Footwear Requirements.

4-6.1 Footwear shall provide protection not less than 8.0 in. (20.3 cm) in height where measured from the plane of the sole bottom.

4-6.2 Footwear upper material samples shall be tested for cut resistance and shall have a cut resistance of not less than 10 lb (4.5 kg) where tested as specified in Section 9-15.

4-6.3 Footwear upper material samples shall be tested for puncture resistance and shall have a puncture resistance of not less than 8 lb (3.6 kg) where tested as specified in Section 9-16.

4-6.4 Footwear upper material samples shall be tested for abrasion resistance and shall not exhibit a normalized breakthrough detection time of one hour or less for each chemical in ASTM F1001, *Standard Guide for Chemicals to Evaluate Protective Clothing Materials*, where tested as specified in Section 9-8 of this standard.

4-6.5 Footwear upper material samples shall be tested for flex fatigue resistance and shall not exhibit a normalized breakthrough detection time of one hour or less for each chemical in ASTM F1001, *Standard Guide for Chemicals to Evaluate Protective Clothing Materials*, where tested as specified in Section 9-18 of this standard.

4-6.6 Footwear sole and heel samples shall be tested for puncture resistance and shall have a puncture resistance of not less than 272 lb (123.4 kg) as specified in Section 9-19.

4-6.7 Footwear sole and heel samples shall be tested for abrasion resistance and shall have an abrasion-resistance rating of not less than 65 where tested as specified in Section 9-20.

4-6.8 Sample footwear toes shall be tested for impact and compression resistance and shall have an impact resistance of not less than 75 ft-lb (101.7 J) and a compression resistance of not less than 2500 lb (11121 N) where tested as specified in Section 9-21.

4-6.9 Sample footwear soles (or ladder shanks) shall be tested for bending resistance and shall not deflect more than 0.25 in. (0.6 cm) where tested as specified in Section 9-22.

4-6.10 Sample footwear soles shall be tested for slip resistance and shall have a static coefficient of 0.75 or greater in a dry condition, and 0.50 or greater in a wet condition, where tested as specified in Section 9-23.

4-7 Seam Requirements.

4-7.1 Seams shall not exhibit normalized breakthrough detection times of one hour or less for each chemical in ASTM F1001, *Standard Guide for Chemicals to Evaluate Protective Clothing Materials*, and for any additional chemicals or specific chemical mixtures for which the manufacturer is certifying the suit, where tested as specified in Section 9-6 of this standard.

4-7.2 All seams shall possess a breaking strength of not less than 30 lbf/2 in. (2.88 kN/m) where tested as specified in Section 9-24.

4-8 Suit Closure Assembly Requirements.

4-8.1 Sample suit closure assemblies shall show no penetration for each liquid chemical in ASTM F1001, *Standard Guide for Chemicals to Evaluate Protective Clothing Materials*, and for any additional chemicals or specific chemical mixtures for which the manufacturer is certifying the suit, where tested as specified in Section 9-25 of this standard.

4-8.2 The suit closure assembly shall possess a breaking strength of not less than 30 lbf/2 in. (2.88 kN/m) where tested as specified in Section 9-24.

4-9* Suit Exhaust Valve Requirements.

4-9.1 The mounting mechanism of exhaust valves shall be designed to allow for their removal from and reinstallation or replacement in the vapor-protective suit for inspection.

4-9.2 Each exhaust valve installed in a vapor-protective suit shall be tested for inward leakage and shall not exhibit a flow rate exceeding 1.83 $in.^3$/min (30 ml/min) where tested as specified in Section 9-26.

4-10 External Fitting Requirements.

4-10.1 All external fittings shall be free of rough spots, burrs, or sharp edges that could tear primary materials.

4-10.2 Vapor-protective suits, on which external fittings are installed that penetrate any primary materials, shall be tested for gastight integrity and shall show an ending pressure of at least 1.6 in. (40 mm Hg) water gauge where tested as specified in Section 9-2.

Chapter 5 Optional Requirements for Chemical Flash Fire Protection

5-1 Product Labeling Requirements.

5-1.1 The vapor-protective suit shall have a product label permanently and conspicuously attached to the inside of the garment upon which at least the following warning and information are printed in at least $^1/_{16}$-in. (1.5-mm) high letters.

"THIS VAPOR-PROTECTIVE SUIT MEETS:

YES THE BASE REQUIREMENTS IN CHAPTERS 2, 3, AND 4;

YES ADDITIONAL REQUIREMENTS IN CHAPTER 5 FOR LIMITED CHEMICAL FLASH FIRE PROTECTION; THIS ENSEMBLE PROVIDES LIMITED PROTECTION IN THE EVENT OF CHEMICAL FLASH FIRES TO ALLOW ESCAPE ONLY.

NO ADDITIONAL REQUIREMENTS IN CHAPTER 6 FOR LIQUEFIED GAS PROTECTION;

OF NFPA 1991, STANDARD ON VAPOR-PROTECTIVE SUITS FOR HAZARDOUS CHEMICAL EMERGENCIES, 1994 EDITION, FOR THE CHEMICALS LISTED BELOW. THE TECHNICAL DATA PACKAGE CONTAINS ADDITIONAL INFORMATION ON THESE AND ANY ADDITIONAL CHEMICALS AND SPECIFIC CHEMICAL MIXTURES FOR WHICH THIS SUIT IS CERTIFIED.

Acetone	**Hexane**
Acetonitrile	**Hydrogen chloride (gas)**
Anhydrous ammonia (gas)	**Methanol**
1,3-Butadiene (gas)	**Methyl chloride (gas)**
Carbon disulfide	**Nitrobenzene**
Chlorine (gas)	**Sodium hydroxide**
Dichloromethane	**Sulfuric acid**
Diethyl amine	**Tetrachloroethylene**
Dimethyl formamide	**Tetrahydrofuran**
Ethyl acetate	**Toluene**
Ethylene oxide (gas)	

CONSULT THE TECHNICAL DATA PACKAGE, MANUFACTURER'S INSTRUCTIONS, AND MANUFACTURER'S RECOMMENDATIONS BEFORE USE.

WARNING

WHERE MULTIPLE LAYERS ARE PROVIDED AS A SINGLE AND INTEGRATED UNIT, ALL SEPARABLE LAYERS MUST BE WORN TOGETHER. UNLESS THIS GARMENT IS SPECIFICALLY CERTIFIED AS APPROPRIATE TO THE FOLLOWING APPLICATIONS, DO NOT USE FOR ANY FIRE FIGHTING APPLICATIONS OR FOR PROTECTION FROM RADIOLOGICAL, BIOLOGICAL, OR CRYOGENIC AGENTS, OR IN FLAMMABLE OR EXPLOSIVE ATMOSPHERES. CHEMICAL CONTAMINATION OF THIS SUIT MAY WARRANT ITS DISPOSAL. MAINTAIN ONLY IN ACCORDANCE WITH MANUFAC-

TURER'S INSTRUCTIONS. NO PROTECTIVE CLOTHING CAN PROVIDE PROTECTION FROM ALL CONDITIONS. USE EXTREME CARE FOR ALL EMERGENCY OPERATIONS, PARTICULARLY IN HAZARDOUS ATMOSPHERES. FAILURE TO COMPLY WITH THESE INSTRUCTIONS MAY RESULT IN SERIOUS INJURY OR DEATH."

Manufacturer's name

Manufacturer's address

Country of manufacture

Suit model, style, and serial number

Date of compliance testing to ASTM F1052

Size

Garment material(s)

Visor material(s)

Glove(s)

Footwear items(s)

"DO NOT REMOVE THIS LABEL."

5-1.2 The manufacturer shall identify on the product label any other clothing items, such as outer garments, outer gloves, or outer boots that must be worn in order to meet the performance requirements of this standard using the following language:

FOR COMPLIANCE WITH NFPA 1991, THE FOLLOWING PROTECTIVE CLOTHING ITEMS MUST BE WORN IN CONJUNCTION WITH THIS GARMENT:

(List items by type and identification.)

5-1.3 Other clothing items used to meet the performance requirements of this standard shall meet the label requirements specified in ASTM F1301, *Standard Practice for Labeling Chemical Protective Clothing*. The label shall be printed in at least $^{1}/_{16}$-in. (1.5-mm) high letters.

5-1.4 All portions of the required product label shall be printed in at least English.

5-2 Design and Performance Requirements.

5-2.1 Sample vapor-protective suits shall be tested for overall ensemble flash protection and shall show afterflame times no longer than 2 seconds, show an ending pressure of at least 1.6 in. (40 mm Hg) water gauge pressure in a subsequent gastight integrity test, and in subsequent human wearing of the sample ensemble, shall allow test subjects to have a visual acuity of $^{20}/_{100}$ where tested as specified in Section 9-27.

5-2.2 Samples of primary materials shall have an average thermal protective performance (TPP) of not less than 12 where tested as specified in Section 9-28.

5-2.3 Samples of primary materials shall be tested for flame impingement and shall display no afterflame, and shall not melt, as evidenced by flowing or dripping, after either the 3- or 12-second exposure period where tested as specified in Section 9-7.

5-2.4 Samples of primary materials shall be tested for the rate of static electric discharge and shall show no voltage greater than 350 volts, 5 seconds after termination of charge generation, where tested as specified in Section 9-29.

Chapter 6 Optional Requirements for Liquefied Gas Protection

6-1 Product Labeling Requirements.

6-1.1 The vapor-protective suit shall have a product label permanently and conspicuously attached to the inside of the garment upon which at least the following warning and information are printed in at least $^{1}/_{16}$-in. (1.5-mm) high letters.

"THIS VAPOR-PROTECTIVE SUIT MEETS:

YES THE BASE REQUIREMENTS IN CHAPTERS 2, 3, AND 4;

NO ADDITIONAL REQUIREMENTS IN CHAPTER 5 FOR LIMITED CHEMICAL FLASH FIRE PROTECTION; THIS ENSEMBLE PROVIDES LIMITED PROTECTION IN THE EVENT OF CHEMICAL FLASH FIRES TO ALLOW ESCAPE ONLY.

YES ADDITIONAL REQUIREMENTS IN CHAPTER 6 FOR LIQUEFIED GAS PROTECTION;

OF NFPA 1991, STANDARD ON VAPOR-PROTECTIVE SUITS FOR HAZARDOUS CHEMICAL EMERGENCIES, 1994 EDITION, FOR THE CHEMICALS LISTED BELOW. THE TECHNICAL DATA PACKAGE CONTAINS ADDITIONAL INFORMATION ON THESE AND ANY ADDITIONAL CHEMICALS AND SPECIFIC CHEMICAL MIXTURES FOR WHICH THIS SUIT IS CERTIFIED.

Acetone
Acetonitrile
Anhydrous ammonia (gas and liquefied gas)
1,3-Butadiene (gas and liquefied gas)
Carbon disulfide
Chlorine (gas and liquefied gas)
Dichloromethane
Diethyl amine
Dimethyl formamide
Ethyl acetate
Ethylene oxide (gas and liquefiedgas)
Hexane
Hydrogen chloride (gas and liquefied gas)
Methanol
Methyl chloride (gas and liquefied gas)
Nitrobenzene
Sodium hydroxide
Sulfuric acid
Tetrachloroethylene
Tetrahydrofuran
Toluene

CONSULT THE TECHNICAL DATA PACKAGE, MANUFACTURER'S INSTRUCTIONS, AND MANUFACTURER'S RECOMMENDATIONS BEFORE USE.

WARNING

WHERE MULTIPLE LAYERS ARE PROVIDED AS A SINGLE AND INTEGRATED UNIT, ALL SEPARABLE LAYERS MUST BE WORN TOGETHER. UNLESS THIS GARMENT IS SPECIFICALLY CERTIFIED AS APPROPRIATE TO THE FOLLOWING APPLICATIONS, DO NOT USE FOR ANY FIRE FIGHTING APPLICATIONS OR FOR PROTECTION FROM RADIOLOGICAL, BIOLOGICAL, OR CRYOGENIC

AGENTS, OR IN FLAMMABLE OR EXPLOSIVE ATMOSPHERES. CHEMICAL CONTAMINATION OF THIS SUIT MAY WARRANT ITS DISPOSAL. MAINTAIN ONLY IN ACCORDANCE WITH MANUFACTURER'S INSTRUCTIONS. NO PROTECTIVE CLOTHING CAN PROVIDE PROTECTION FROM ALL CONDITIONS. USE EXTREME CARE FOR ALL EMERGENCY OPERATIONS, PARTICULARLY IN HAZARDOUS ATMOSPHERES. FAILURE TO COMPLY WITH THESE INSTRUCTIONS MAY RESULT IN SERIOUS INJURY OR DEATH."

Manufacturer's name
Manufacturer's address
Country of manufacture
Suit model, style, and serial number
Date of compliance testing to ASTM F1052
Size
Garment material(s)
Visor material(s)
Glove material(s)
Footwear material(s)

"DO NOT REMOVE THIS LABEL."

6-1.2 The manufacturer shall identify on the product label any other clothing items, such as outer garments, outer gloves, or outer boots, that must be worn in order to meet the performance requirements of this standard using the following language:

FOR COMPLIANCE WITH NFPA 1991, THE FOLLOWING PROTECTIVE CLOTHING ITEMS MUST BE WORN IN CONJUNCTION WITH THIS GARMENT:

(List items by type and identification.)

6-1.3 Other clothing items used to meet the performance requirements of this standard shall meet the label requirements specified in ASTM F1301, *Standard Practice for Labeling Chemical Protective Clothing*. The label shall be printed in at least $^1/_{16}$-in. (1.5-mm) high letters.

6-1.4 All portions of the required product label shall be printed in at least English.

6-2 Design and Performance Requirements.

6-2.1 Samples of the primary suit materials shall be tested for permeation resistance and shall not exhibit normalized breakthrough detection times of 15 minutes or less for each gaseous chemical in ASTM F1001, *Standard Guide for Chemicals to Evaluate Protective Clothing Materials*, where tested as specified in Section 9-30 of this standard.

6-2.2 For any additional liquefied gas chemicals or specific liquefied gas chemical mixtures for which the manufacturer is certifying the suit, samples of the primary suit materials shall be tested for permeation resistance and shall not exhibit normalized breakthrough detection times of 15 minutes or less for each additional chemical or specific chemical mixture where tested as specified in Section 9-30.

6-2.3 Samples of primary materials shall be tested for cold temperature embrittlement and shall not exhibit normalized breakthrough detection times of 60 minutes or less and shall show no signs of damage where tested as specified in Section 9-31.

Chapter 7 Requirements for Combined Chemical Flash Fire and Liquefied Gas Protection

7-1 Product Labeling Requirements.

7-1.1 The vapor-protective suit shall have a product label permanently and conspicuously attached to the inside of the garment upon which at least the following warning and information are printed in at least $^1/_{16}$- in. (1.5-mm) high letters.

"THIS VAPOR-PROTECTIVE SUIT MEETS:

YES THE BASE REQUIREMENTS IN CHAPTERS 2, 3, AND 4;

YES REQUIREMENTS IN CHAPTER 5 FOR ADDITIONAL CHEMICAL FLASH FIRE PROTECTION;

YES REQUIREMENTS IN CHAPTER 6 FOR ADDITIONAL LIQUEFIED GAS PROTECTION;

OF NFPA 1991, STANDARD ON VAPOR-PROTECTIVE SUITS FOR HAZARDOUS CHEMICAL EMERGENCIES, 1994 EDITION, FOR THE CHEMICALS LISTED BELOW. THE TECHNICAL DATA PACKAGE CONTAINS ADDITIONAL INFORMATION ON THESE AND ANY ADDITIONAL CHEMICALS AND SPECIFIC CHEMICAL MIXTURES FOR WHICH THIS SUIT IS CERTIFIED.

Acetone
Acetonitrile
Anhydrous ammonia (gas and liquefied gas)
1,3-Butadiene (gas and liquefied gas)
Carbon disulfide
Chlorine (gas and liquefied gas)
Dichloromethane
Diethyl amine
Dimethyl formamide
Ethyl acetate
Ethylene oxide (gas and liquefied gas)
Hexane
Hydrogen chloride (gas and liquefied gas)
Methanol
Methyl chloride (gas and liquefied gas)
Nitrobenzene
Sodium hydroxide
Sulfuric acid
Tetrachloroethylene
Tetrahydrofuran
Toluene

CONSULT THE TECHNICAL DATA PACKAGE, MANUFACTURER'S INSTRUCTIONS, AND MANUFACTURER'S RECOMMENDATIONS BEFORE USE.

WARNING

WHERE MULTIPLE LAYERS ARE PROVIDED AS A SINGLE AND INTEGRATED UNIT, ALL SEPARABLE LAYERS MUST BE WORN TOGETHER. UNLESS THIS GARMENT IS SPECIFICALLY CERTIFIED AS APPROPRIATE TO THE FOLLOWING APPLICATIONS, DO NOT USE FOR ANY FIRE FIGHTING APPLICATIONS OR FOR PROTECTION FROM RADIOLOGICAL, BIOLOGICAL, OR CRYOGENIC AGENTS, OR IN FLAMMABLE OR EXPLOSIVE ATMOSPHERES. CHEMICAL CONTAMINATION OF

THIS SUIT MAY WARRANT ITS DISPOSAL. MAINTAIN ONLY IN ACCORDANCE WITH MANUFACTURER'S INSTRUCTIONS. NO PROTECTIVE CLOTHING CAN PROVIDE PROTECTION FROM ALL CONDITIONS. USE EXTREME CARE FOR ALL EMERGENCY OPERATIONS, PARTICULARLY IN HAZARDOUS ATMOSPHERES. FAILURE TO COMPLY WITH THESE INSTRUCTIONS MAY RESULT IN SERIOUS INJURY OR DEATH."

Manufacturer's name
Manufacturer's address
Country of manufacture
Suit model, style, and serial number
Date of compliance testing to ASTM F1052
Size
Garment material(s)
Visor material(s)
Glove material(s)
Footwear material(s)

"DO NOT REMOVE THIS LABEL."

7-1.2 The manufacturer shall identify on the product label any other clothing items, such as outer garments, outer gloves, or outer boots, that must be worn in order to meet the performance requirements of this standard using the following language:

FOR COMPLIANCE WITH NFPA 1991, THE FOLLOWING PROTECTIVE CLOTHING ITEMS MUST BE WORN IN CONJUNCTION WITH THIS GARMENT:

(List items by type and identification.)

7-1.3 Other clothing items used to meet the performance requirements of this standard shall meet the label requirements specified in ASTM F1301, *Standard Practice for Labeling Chemical Protective Clothing*. The label shall be printed in at least $^{1}/_{16}$-in. (1.5-mm) high letters.

7-1.4 All portions of the required product label shall be printed in at least English.

7-2 Design and Performance Requirements.

7-2.1 The vapor-protective suit and all primary materials shall meet the requirements in Chapters 4, 5, and 6.

Chapter 8 Replacement Components

8-1 Gloves.

8-1.1 Sample gloves shall be tested for gastight integrity and shall show an ending pressure of at least 1.6 in. (40 mm Hg) water gauge where tested as specified in Section 9-32.

8-1.2 Gloves for use with vapor-protective suits meeting the base requirements in this standard shall also meet or exceed all requirements in Sections 4-2 and 4-5.

8-1.2.1 Gloves for use with vapor-protective suits meeting the base requirements and additional optional requirements for limited chemical flash fire protection in this standard shall also meet the requirements in Sections 4-2, 4-5, and 5-2.

8-1.2.2 Gloves for use with vapor-protective suits meeting the base requirements and additional optional requirements for liquefied gas protection in this standard shall also meet the requirements in Sections 4-2, 4-5, and 6-2.

8-1.2.3 Gloves for use with vapor-protective suits meeting the base requirements and additional optional requirements for limited chemical flash fire protection and liquefied gas protection in this standard shall also meet the requirements in Sections 4-2, 4-5, 5-2, and 6-2.

8-1.3 Gloves shall have a label that meets the requirements in ASTM F1301, *Standard Practice for Labeling Chemical Protective Clothing*. The label shall be printed in at least $^{1}/_{16}$-in. (1.5-mm) high letters.

8-1.3.1 Gloves for use with vapor-protective suits meeting the base requirements shall also include the following statement on the product label:

THIS REPLACEMENT COMPONENT MEETS THE BASE REQUIREMENTS OF NFPA 1991 (1994 EDITION).

8-1.3.2 Gloves for use with vapor-protective suits meeting the base requirements and additional optional requirements for limited chemical flash fire protection in this standard shall also include the following statement on the product label:

THIS REPLACEMENT COMPONENT MEETS THE BASE REQUIREMENTS OF NFPA 1991 (1994 EDITION) PLUS REQUIREMENTS FOR OPTIONAL LIMITED CHEMICAL FLASH FIRE PROTECTION.

8-1.3.3 Gloves for use with vapor-protective suits meeting the base requirements and additional optional requirements for liquefied gas protection shall also include the following statement on the product label:

THIS REPLACEMENT COMPONENT MEETS THE BASE REQUIREMENTS OF NFPA 1991 (1994 EDITION) PLUS REQUIREMENTS FOR OPTIONAL LIQUEFIED GAS PROTECTION.

8-1.3.4 Gloves for use with vapor-protective suits meeting the base requirements and additional optional requirements for limited chemical flash fire protection and liquefied gas protection shall also include the following statement on the product label:

THIS REPLACEMENT COMPONENT MEETS THE BASE REQUIREMENTS OF NFPA 1991 (1994 EDITION) PLUS REQUIREMENTS FOR BOTH OPTIONAL LIMITED CHEMICAL FLASH FIRE PROTECTION AND LIQUEFIED GAS PROTECTION.

8-1.4 Replacement glove components that consist of more than one part shall have each item labeled with a statement describing how each part must be worn together to form the replacement components.

8-2 Footwear.

8-2.1 Sample footwear shall be tested for gastight integrity and shall show an ending pressure of at least 1.6 in. (40 mm Hg) water gauge where tested as specified in Section 9-32.

8-2.2 Footwear for use with vapor-protective suits meeting the base requirements in this standard shall also meet or exceed all requirements in Sections 4-2 and 4-6.

8-2.2.1 Footwear for use with vapor-protective suits meeting the base requirements and additional optional requirements for limited chemical flash fire protection in this standard shall also meet the requirements in Sections 4-2, 4-6, and 5-2.

8-2.2.2 Footwear for use with vapor-protective suits meeting the base requirements and additional optional requirements for liquefied gas protection in this standard shall also meet the requirements in Sections 4-2, 4-6, and 6-2.

8-2.2.3 Footwear for use with vapor-protective suits meeting the base requirements and additional optional requirements for limited chemical flash fire protection and liquefied gas protection in this standard shall also meet the requirements in Sections 4-2, 4-6, 5-2, and 6-2.

8-2.3 Footwear shall have a label that meets the requirements in ASTM F1301, *Standard Practice for Labeling Chemical Protective Clothing*. The label shall be printed in at least $^{1}/_{16}$-in. (1.5-mm) high letters.

8-2.3.1 Footwear for use with vapor-protective suits meeting the base requirements shall also include the following statement on the product label:

THIS REPLACEMENT COMPONENT MEETS THE BASE REQUIREMENTS OF NFPA 1991 (1994 EDITION)

8-2.3.2 Footwear for use with vapor-protective suits meeting the base requirements and additional optional requirements for limited chemical flash fire protection in this standard shall also include the following statement on the product label:

THIS REPLACEMENT COMPONENT MEETS THE BASE REQUIREMENTS OF NFPA 1991 (1994 EDITION) PLUS REQUIREMENTS FOR OPTIONAL LIMITED CHEMICAL FLASH FIRE PROTECTION.

8-2.3.3 Footwear for use with vapor-protective suits meeting the base requirements and additional optional requirements for liquefied gas protection shall also include the following statement on the product label:

THIS REPLACEMENT COMPONENT MEETS THE BASE REQUIREMENTS OF NFPA 1991 (1994 EDITION) PLUS REQUIREMENTS FOR OPTIONAL LIQUEFIED GAS PROTECTION.

8-2.3.4 Footwear for use with vapor-protective suits meeting the base requirements and additional optional requirements for limited chemical flash fire protection and liquefied gas protection shall also include the following statement on the product label:

THIS REPLACEMENT COMPONENT MEETS THE BASE REQUIREMENTS OF NFPA 1991 (1994 EDITION) PLUS REQUIREMENTS FOR BOTH OPTIONAL LIMITED CHEMICAL FLASH FIRE PROTECTION AND LIQUEFIED GAS PROTECTION.

8-2.4 Replacement footwear components that consist of more than one part shall have each item labeled with a statement describing how each part must be worn together to form the replacement component.

Chapter 9 Test Methods

9-1 Donning and Doffing Time Test.

9-1.1 Donning and doffing time testing shall be conducted with a test subject. Suits tested shall meet the sizing range of the test subject as determined in 3-1.4.

9-1.2 The suit to be worn shall be unpacked and laid out in front of the test subject.

9-1.3 The test subject shall be permitted to be assisted in donning or doffing the suit by an attendant.

9-1.4 The starting time shall begin when the seated test subject is dressed in the designated level of protection, including appropriate underclothing and the self-contained breathing apparatus, for the vapor-protective suit ensemble. The suit shall be donned in accordance with the manufacturer's instructions.

9-1.5 The donning time shall be measured when the complete vapor-protective suit and all components have been donned.

9-1.6 The doffing time shall be measured when the complete protective suit and all components have been removed.

9-1.7 The same test subject shall be used in three repetitive donning/doffing trials.

9-1.8 The test subject shall practice the test until the baseline time of the last repetition varies no more than 10 percent.

9-1.9 The average of three time trials shall be used for documenting the donning and doffing time.

9-1.10 The type of underclothing, self-contained breathing apparatus, and any other equipment shall be documented with the test results.

9-2 Overall Gastight Integrity Test.

9-2.1 Overall suit gastight integrity shall be measured in accordance with ASTM F1052, *Standard Practice for Pressure Testing of Gas-Tight Totally Encapsulating Chemical-Protective Suits*.

9-2.2 The following pressures shall be used during testing:

(a) Pretest expansion pressure of 3 in. (76 mm Hg) water gauge,

(b) Suit test pressure of 2 in. (51 mm Hg) water gauge.

9-2.3 If the ending suit pressure is less than 1.6 in. (40 mm Hg), the suit has failed the test.

9-2.4 Suits failing the test shall be permitted to be repaired. A report indicating the repairs made shall be provided by the manufacturer.

9-3 Overall Liquidtight Integrity Test.

9-3.1 Suit overall liquidtight integrity shall be measured in accordance with ASTM F1359, *Standard Practice for Determining the Liquid-Tight Integrity of Chemical Protective Suits or Ensembles Under Static Conditions*.

9-3.2 Evidence of liquid, either inside the vapor-protective suit or on the inner water-absorptive garment, shall constitute failure of the suit to this test.

9-3.3 If outer gloves are to be worn in conjunction with chemical-protective suit gloves or if outer boots are worn in conjunction with suit booties to meet foot protection requirements, the vapor-protective suit shall not fill with liquid.

9-4 Overall Suit Function and Integrity Test.

9-4.1 Overall suit function and integrity shall be measured in accordance with ASTM F1154, *Standard Practices for Qualitatively Evaluating the Comfort, Fit, Function, and Integrity of Chemical-Protective Suit Ensembles*, with the following parameters:

(a) Both exercise procedures A and B shall be used.

(b) Suits tested shall meet the sizing range of the test subject as determined in 3-1.4. The suit shall be donned in accordance with the manufacturer's instructions.

(c) Testing shall be conducted at 77°F, ± 10°F (25°C, ± 7°C) and relative humidity of 50 percent, ± 20 percent.

(d) Gastight integrity shall be measured as specified in Section 9-2.

9-4.2 Following the test subject exercises, an ending suit pressure of less than 1.6 in. (40 mm Hg) water column gauge constitutes failing performance.

9-5 Maximum Suit Ventilation Rate Test.

9-5.1 A suit wall connector capable of accommodating the attachment of an airline hose from a pressurized air source shall be installed in the mid-torso region of the vapor-protective suit to be tested as indicated in Figure 9-5.1. The connector and airline hose shall allow an airflow rate of 500 L/min. The connector used in this test shall be permitted to be a standard airline connection that is used with airline respiratory equipment.

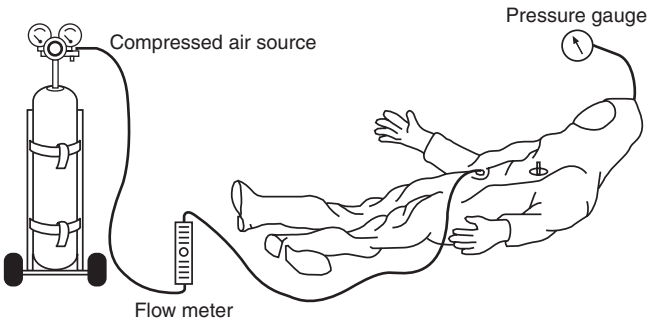

Figure 9-5.1 Configuration of whole suit maximum airflow test.

9-5.2 A flow meter capable of measuring airflow rates of 0 to 1000 L/min, ± 25 L/min, shall be used on the airline hose.

9-5.3 A pressure gauge capable of measuring pressures from 0 to 20 in., ± 1 in. (0 to 510 mm Hg, ± 25 mm Hg) water gauge pressure shall be attached via a second suit wall connector at the very top of the vapor-protective suit.

9-5.4 Following the attachment of the two connectors, the gastight integrity of the suit shall be tested as specified in Section 9-2. During the test, the pressure gauge specified in 9-5.3 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 suit wall connectors. The remaining steps of this procedure shall be completed only if the sample suit shows an ending pressure of 1.6 in. (40 mm Hg) water gauge or higher.

9-5.5 The suit shall be connected to a pressurized air source capable of providing 500 L/min by attaching an airline to the installed mid-torso suit wall connector.

9-5.6 Beginning at time zero, air shall be flowed into the suit at a rate of 500 L/min.

9-5.7 After a period of five minutes, the pressure at the head connector shall be measured. A pressure of 1.5 in. (38 mm Hg) water gauge or higher shall constitute failing performance.

9-5.8 The specialized fittings installed in the suit for this test shall be plugged to prevent air leakage and the suit shall be subjected to a second overall gastight integrity test as specified in Section 9-2. Following the maximum airflow test, an ending suit pressure of less than 1.6 in. (40 mm Hg) shall constitute failing performance.

9-6 Chemical Permeation Resistance Test.

9-6.1 For composite materials, only the chemical protection layer shall be tested for chemical permeation resistance.

9-6.2 Permeation resistance shall be measured in accordance with ASTM F739, *Standard Test Method for Resistance of Protective Clothing Materials to Permeation by Liquids or Gases Under Conditions of Continuous Contact*, at 77°F, ± 3°F (25°C, ± 2°C) for a test duration of at least three hours.

9-6.3* The minimum detectable permeation rate for the permeation test apparatus shall be measured for each chemical tested. The minimum detectable permeation rate shall be less than or equal to 0.10 $\mu g/cm^2/min$ for all permeation resistance tests. Where using closed loop systems, the testing laboratory shall assume one hour accumulated permeation.

9-6.4 The following information and results shall be reported:

(a) Material type or name,

(b) Chemical or chemical mixture (volume composition of mixture),

(c) Permeation normalized breakthrough detection time (minutes) calculated at a system detectable permeation rate of 0.10 $\mu g/cm^2/min$,

(d) Maximum permeation rate ($\mu g/cm^2/min$) observed,

(e) Minimum detectable rate for test apparatus ($\mu g/cm^2/min$),

(f) Detection method,

(g) Date of test, and

(h) Testing laboratory.

9-6.5* In the technical data package, the manufacturer shall report all three measured times for that time at which the permeation rate reaches 0.10 $\mu g/cm^2/min$ (i.e., normalized breakthrough detection time). The shortest normalized breakthrough detection time for each material/chemical combination shall be used to determine compliance. Any normalized breakthrough detection time less than 60 minutes shall constitute failing performance.

9-6.6 The manufacturer shall report all three observed permeation rates in the technical data package.

9-7 Flammability Resistance Test.

9-7.1 All samples to be tested shall be conditioned for not less than 4 hours in standard atmospheric conditions at a relative humidity of 65 percent, ± 2 percent and a temperature of 70°F, ± 2°F (21°C, ± 1°C). Samples shall be tested not more than 5 minutes after removal from conditioning.

9-7.2 Vertical flammability testing shall be performed in accordance with Method 5903.1, Flame Resistance of Cloth; Vertical, of Federal Test Method Standard 191A, *Textile Test Methods*, with the following modifications:

(a) Specimens shall consist of at least ten protective clothing material samples measuring 3×16 in., $\pm 1/16$ in. (76×203 mm, ± 1.6 mm). If the material is anisotropic, specimens shall be cut in both the machine and transverse directions.

(b) Specimens shall be folded in half such that the folded edge is exposed in the apparatus holder. The fold shall be produced by placing a $1/4$-in. (6.4-mm) rod at the bend of the material. The rod shall then be removed after the material is clamped in the holder prior to flame contact. The folded edge of the specimen shall protrude $1/4$ in. (6.4 mm) below the lower horizontal end of the metal specimen clamp.

(c) A stopwatch or other device reading in seconds shall be started. The tip of the flame shall be applied to the end of the specimen until it is ignited, but no longer than 3 seconds. The operator shall observe and note whether or not the specimen ignites and supports self-sustaining burning after removal of the flame from the specimen.

(d) If the specimen fails to ignite in 3 seconds, the time shall be restarted and the flame shall be reapplied to the end of the specimen for an additional 12 seconds. If the specimen ignites, the timer shall be stopped when the flame is extinguished.

(e) The vertical distance, measured from the horizontal edge of the specimen to which the ignition flame is applied, to the farthest point on the specimen visibly charred or melted by the burning process, shall be recorded. This measurement shall be made on the specimen after exposure. The apparent cause of extinguishment, such as melting or dripping, shall be noted.

9-7.3 The ignition propensity shall be noted as those specimens igniting within the 3-second exposure period, specimens igniting within the 12-second exposure period, and specimens not igniting at all.

9-7.4 Burning time shall be the time, reported in seconds, from the moment that the operator removes the flame from the sample until burning is extinguished.

9-7.5 The distance of burn shall be the distance, reported in inches (cm), from the ignited edge of the sample to the farthest vertical point on the sample that is burned in the test.

9-7.6 The burning behavior of the specimen shall be noted and characterized for the samples that ignite, are self-extinguishing, or as otherwise observed. The specimen shall be considered self-extinguishing if the distance of burning is less than 4.0 in. (10.24 cm) and the burning time is less than 10 seconds. The appearance of decomposition by melting or dripping shall be noted.

9-7.7 Report items for determining pass/fail shall be summarized as:

(a) Test specimens igniting in 3 seconds or less;

(b) Test specimens igniting in 12 seconds or less;

(c) Test specimens not igniting in the test;

(d) Test specimens with an ignition time exceeding 3 seconds but that support burning for 10 seconds or more;

(e) Test specimens with an ignition time exceeding 3 seconds but that have a burn distance exceeding 4 in. (10.24 cm):

(f) Notation of specimen melting or dripping.

9-8 Abrasion Resistance Test.

9-8.1 Abrasion resistance testing shall be conducted in accordance with ASTM D4157, Standard *Test Method for Abrasion Resistance of Textile Fabrics (Oscillatory Cylinder Method)*, with the following conditions:

(a) A 5-lb (2.27-kg) tension weight shall be used;

(b) A $3\,1/2$-lb (1.60-kg) head weight shall be used;

(c) An 80 grit abradant trimite D-weight open coat #1A4180, or equivalent, shall be used;

(d) The specimen shall be abraded for 25 continuous cycles; and

(e) Permeation resistance testing as specified in Section 9-6 shall be substituted for abrasion to rupture and percentage loss in breaking load for interpreting abrasion resistance test results.

9-8.2 Only one specimen for permeation resistance testing shall be taken from each sample subjected to abrasion. 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. For composite materials, only the chemical protection layer shall be tested for chemical permeation resistance.

9-8.3 The average normalized breakthrough detection time in minutes for the abraded samples shall be reported. An average normalized breakthrough detection time of less than 60 minutes shall constitute failing performance.

9-8.4 The average minimum permeation rate observed for abraded samples in $\mu g/cm^2/min$ shall be reported.

9-8.5 Any visual observations, such as sample rupture, loss of luster, or deformation of the outside coating for tested specimens, shall be reported.

9-9 Garment and Glove Material Flexural Fatigue Test.

9-9.1 Garment material flexural fatigue testing shall be conducted in accordance with ASTM F392, *Standard Test Method for Flex Durability of Flexible Barrier Materials*, with the following modifications:

(a) 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 a full flex and twisting action.

(b) Permeation resistance testing, as specified in Section 9-6, shall be substituted for pinhole counting.

(c) Anisotropic materials shall be tested in both machine and transverse directions.

9-9.2 Only one specimen for permeation resistance testing shall be taken from each sample subjected to flexing conditions. The permeation test specimen shall be taken from the exact center of the flexed sample so that the center of the permeation test and the center of the flexed sample shall coincide. For composite materials, only the chemical protection layer shall be tested for chemical permeation resistance.

9-9.3 The average normalized breakthrough detection time in minutes for the abraded samples shall be reported. An average normalized breakthrough detection time of less than 60 minutes shall constitute failing performance.

9-9.4 The average minimum permeation rate observed for flexible samples in $\mu g/cm^2/min$ shall be reported.

9-9.5 Any unusual visual observations for test specimens, such as delamination or tears, shall be reported.

9-10 Garment and Visor Material Burst Strength Test.

9-10.1 Material burst strength shall be measured in accordance with ASTM D751, *Standard Test Methods for Coated Fabrics*, Bursting Strength, using the Mullen burst machine.

9-10.2 The average test result shall be used to determine compliance.

9-11 Garment Material and Visor Puncture Propagation Tear Resistance Test.

9-11.1 Material puncture propagation tear resistance shall be measured in accordance with ASTM D2582, *Standard Test Method for Puncture-Propagation Tear Resistance of Plastic Film and Thin Sheeting.*

9-11.2 Puncture propagation tear resistance results shall be reported as the average for each material direction.

9-11.3 Failure of the material in any direction shall constitute failing performance.

9-12 Garment and Glove Material Cold Temperature Performance Test.

9-12.1 Garment and glove material cold temperature performance shall be measured in accordance with ASTM D747, *Standard Test Method for Apparent Bending Modulus of Plastics by Means of a Cantilever Beam*, with the following modifications:

(a) The test temperature shall be –25°C (–13°F).

(b) The bending moment shall be that applied when the specimen is bent to a 60 degree angular deflection and shall be calculated in in.-lb as follows:

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

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

9-12.2 Cold temperature performance results shall be reported as the average for each material direction.

9-12.3 Failure of the material in any direction shall constitute failing performance.

9-13 Visor Clarity Test.

9-13.1 Testing shall be conducted with a test subject. 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. Suits tested shall meet the sizing range of the test subject as determined in 3-1.4. The suit shall be donned in accordance with manufacturer's instructions.

9-13.2* Appropriate underclothing and a self-contained breathing apparatus shall be worn. For consistency in testing, a Scott 4.5 Air Pak SCBA facepiece shall be used.

9-13.3 The test shall be conducted using a standard 20-ft (6.1-m) eye chart with a normal lighting range of 100 footcandles to 150 footcandles at the chart and with the test subject positioned at a distance of 20 ft (6.1 m) from the chart.

9-13.4 The test subject shall then read the standard eye chart through the lens of the SCBA facepiece and suit visor to determine his or her visual acuity.

9-14 Visor Cold Temperature Bending Test.

9-14.1 Cold temperature bending of visors shall be evaluated in accordance with ASTM D2136, *Standard Test Method for Coated Fabrics—Low-Temperature Bend Test.*

9-14.2 Following this testing, sample visor specimens shall be examined for evidence of damage. Damage shall include any breakage, cracks, tears, or separations, but shall not include discoloration along the folded area.

9-14.3 Rigid visors that do not bend but show no evidence of damage shall be considered to have passed the test.

9-15 Glove and Footwear Upper Material Cut Resistance Test.

9-15.1 Each sample specimen to be tested shall be a rectangle at least 2 in. × $4^1/_2$ in. (5.1 cm × 11.4 cm). Multiple cut attempts shall be permitted to be made on each specimen. Glove samples for puncture resistance testing shall be taken from the palm of the glove or palm and back, if different. Footwear upper samples for puncture resistance testing shall be taken from areas of the footwear upper away from seams where the thickness is uniform.

9-15.2 During the test, the sample specimen shall be oriented so that the normal outer surface is the first to be contacted by the edge of the blade.

9-15.3 Three sample specimens shall be tested and two cuts shall be made on each sample specimen.

9-15.4 The static cut test apparatus shall consist of an L-shaped metal frame and pivoted arm that lowers a sharp-edged blade onto a sample specimen, as shown in Figure 9-15.4.

9-15.5 A locking mechanism shall be mounted on the L-frame upright to engage the pivoted arm and secure it in a neutral position above the sample specimen. The locking mechanism shall be used when the blade is being replaced or when the specimen is being moved into or out of the testing position.

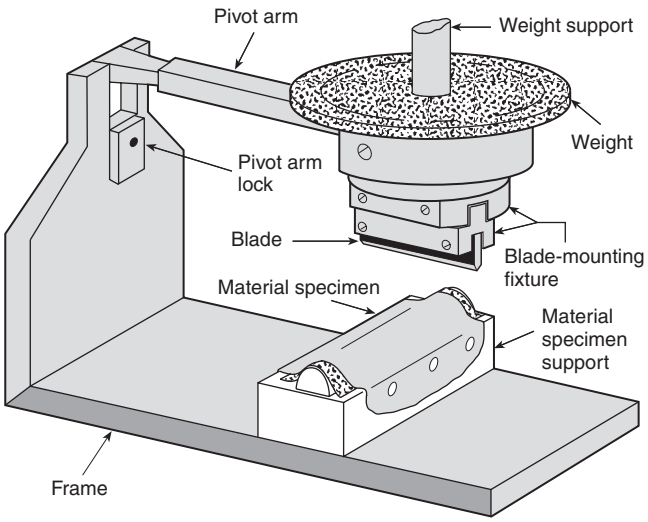

Figure 9-15.4 Static cut test apparatus.

9-15.6 The blade shall be mounted in a blade holder at the outer end of the pivoted arm, as shown in Figure 9-15.6. The blade shall be mounted so its sharp edge is tangential.

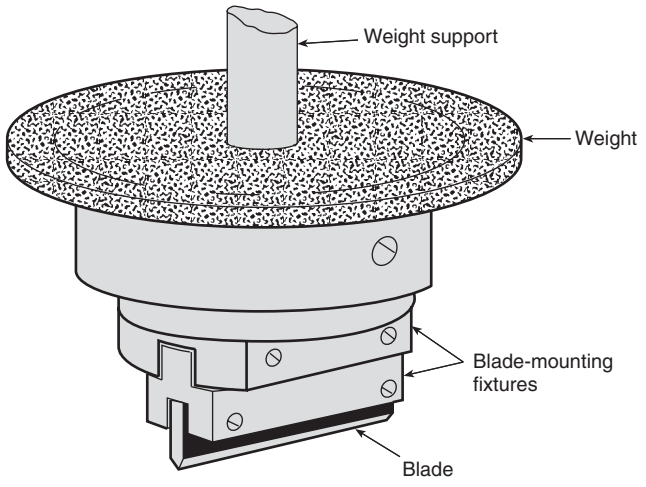

Figure 9-15.6 Test blade holder.

9-15.7 The pivoted arm shall be capable of supporting weights above the blade holder. Incremental weights of 2 lb (0.91 kg) each shall be supplied to allow a maximum force of 20 lb (9.1 kg) to be applied during testing. The pivoted arm, blade holder, and blade together shall weigh 2 lb (0.91 kg) and shall contribute to the force applied to the blade.

9-15.8 The sharp-edged blade shall be made of tool-hardened steel with an edge having a 60 degree inclined angle and a 0.001 in. (0.025 mm) radius, as shown in Figure 9-15.8.

9-15.8.1 The sharpness or geometry of the blade edge shall be closely monitored and controlled to prevent changes in cutting characteristics in order to ensure a consistent baseline for interpreting the cut data.

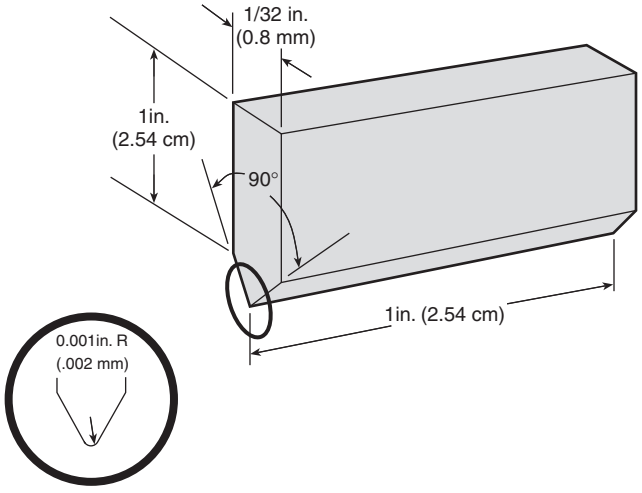

Figure 9-15.8 Test blade.

9-15.8.2 A test blade shall be either replaced or resharpened when the sharpness (geometry) of the blade edge changes.

9-15.9 The specimen support assembly shall consist of a 2 in. × 2 in. × 4 in. (5.1 cm × 5.1 cm × 10.2 cm) soft wooden block and a $^{3}/_{4}$-in. (1.9-cm) diameter, half-rounded, soft wooden rod mounted to the block, as shown in Figure 9-15.9.

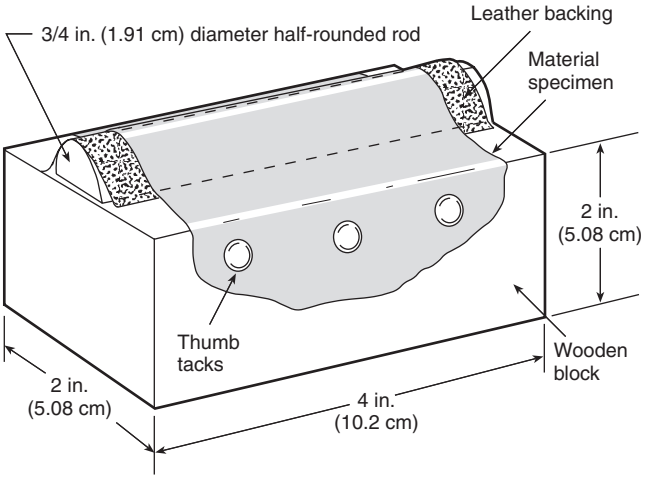

Figure 9-15.9 Material specimen support.

9-15.10 A 0.05-in. (0.13-cm) thick soft leather strip shall be draped over the rod and block to simulate the cushioning effects of hand skin and to protect the blade on a cut-through, as shown in Figure 9-15.9.

9-15.11 The sample specimen support shall be designed to be freestanding so that several parallel-cut attempts, spaced not less than $^{1}/_{8}$ in. (0.3 cm) apart, can be made on each sample specimen.

9-15.12 The sample specimen shall be draped over the leather strip covering the rod and block and then tacked tightly in place, but not stretched, as shown in Figure 9-15.9. The support assembly shall be positioned on the base of the L-frame, as shown in Figure 9-15.4.

9-15.13 The pivoted arm and blade holder shall be initially loaded with weights to the maximum force of 20 lb (9.1 kg). A blade shall be inserted in the holder and the pivoted arm shall be lowered to bring the blade edge into contact with the sample specimen surface.

9-15.14 The initial specimen-edge contact shall be made $^1/_8$ in. (0.3 cm) from the leading edge of the blade.

9-15.15 The specimen assembly shall be drawn smoothly under the weighted blade at a rate no greater than 20 in./min (50.8 cm/min) in a direction parallel to the blade edge. The support assembly shall be stopped when the specimen-edge contact reaches $^1/_8$ in. (0.3 cm) from the trailing edge of the blade.

9-15.16 The pivoted arm shall be lifted to remove the blade edge from the sample specimen, and the locking mechanism shall be engaged to secure the pivot arm.

9-15.17 The sample specimen shall be inspected visually to determine whether it was cut completely through at any point by the blade edge. Care shall be taken in inspecting the sample specimen surface for a cut. Grooving can occur, but this shall not constitute a cut.

9-15.18 If the sample specimen surface has been cut, the weight shall be reduced by 2 lb (0.91 kg) and the test procedure shall be repeated.

9-15.18.1 In repeating the test procedure, the sample specimen shall be repositioned so that the blade edge is $^1/_8$ in. (0.3 cm) to the side of the previous cut attempt.

9-15.18.2 The weights shall be reduced at 2-lb (0.91-kg) intervals and the test procedure repeated until the point of no cut is reached or the minimum of 2 lb (0.91 kg) is reached.

9-15.18.3 If available test sites on the sample specimen have been used, testing shall continue on an identical, fresh sample location.

9-15.18.4 The minimum force causing a cut shall be recorded.

9-15.18.5 The test procedure shall be repeated for the remaining sample specimens starting with a weight 4 lb (2 kg) heavier than the first noted for cut until two cuts have been made on a single sample specimen.

9-15.19 If the sample specimen has not been cut, a force of >20 lb (>9.1 kg) shall be recorded.

9-15.20 Additional sample specimens shall be tested until the requirement of 9-15.3 is met.

9-15.21 The force required for each surface cut shall be reported to the nearest 2 lb (1.0 kg) for each sample specimen. The average force for each sample specimen shall be calculated and reported.

9-16 Glove and Footwear Puncture Resistance Test.

9-16.1 Glove samples for puncture resistance testing shall be taken from the palm of the glove or palm and back, if different. Footwear upper samples for puncture resistance testing shall be taken from areas of the footwear upper away from seams where the thickness is uniform.

9-16.2 Material puncture resistance shall be measured in accordance with ASTM F1342, *Standard Test Method for Protective Clothing Material Resistance to Puncture.*

9-16.3 The average of all test replicates shall be used to determine compliance.

9-17 Glove Dexterity Test.

9-17.1 Glove dexterity shall be evaluated using the standardized procedure known as the Bennett hand-tool dexterity test.

9-17.2 Each sample glove shall be tested as a complete glove in new, as distributed, condition.

9-17.3 Three sample pairs of gloves shall be tested.

9-17.4 Each person used to perform the test shall practice until the baseline times of that person's last three repetitions vary no more than 6 percent. The average of these last three repetitions shall be used as the dexterity time for each test subject.

9-17.5 The average of each test subject's dexterity test time shall be reported.

9-18 Footwear Upper Material Flex Fatigue Resistance Test.

9-18.1 This test shall apply to all types of footwear configurations. If 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. However, the outer boot still shall be tested for flex fatigue resistance using this test.

9-18.2 Footwear upper material flex fatigue resistance testing shall be tested in accordance with FIA 1209, *Whole Shoe Flex.*

9-18.3 The test shall consist of 10,000 flexes.

9-18.4 Samples for the flexed footwear upper shall be taken in areas where the greatest flexing occurs, usually at the footwear quarter or vamp.

9-18.5 Permeation resistance testing shall be conducted on these samples as specified in Section 9-6. For composite materials, only the chemical-protection layer shall be tested.

9-18.6 The average normalized breakthrough detection times in minutes for the flexed samples shall be reported. An average normalized breakthrough detection time less than 60 minutes shall constitute failing performance.

9-18.7 The average minimum permeation rate observed for flexed samples in $\mu g/cm^2/min$ shall be reported.

9-18.8 Any visual observations for tested specimens, such as sample rupture, loss of luster, or deformation of the outside coating, shall be reported.

9-19 Footwear Sole Puncture Resistance Test.

9-19.1 Puncture resistance of footwear soles shall be measured in accordance with CSA Z195-M, *Standard for Protective Footwear, Occupational Health and Safety.*

9-19.2 The average measured puncture resistance shall be used to determine compliance with this standard.

9-20 Footwear Sole Abrasion Resistance Test.

9-20.1 Abrasion resistance of footwear soles shall be measured in accordance with ASTM D1630, *Standard Test Method for Rubber Property—Abrasion Resistance (NBS Abrader).*

9-20.2 The average measured abrasion rating shall be used to determine compliance with this standard.

9-21 Footwear Toe Compression and Impact Resistance Test.

9-21.1 The compression and impact resistance of footwear toes shall be measured in accordance with Section 1.4 of ANSI Z41, *Standard for Safety-Toe Footwear.*

9-21.2 The average measured compression and impact resistance forces shall be used to determine compliance with this standard.

9-22 Footwear Bottom Bending Resistance Test.

9-22.1 Samples for this test shall consist of the footwear sole separated from the footwear, but including the ladder shank if present.

9-22.2 The apparatus shall consist of a tensile testing machine, such as an Instron or equivalent, that challenges a specimen with a simulated ladder rung. A $1^1/_4$ in. diameter × 2.0 in. long (3.25 cm × 5 cm) noncompressible probe shall be mounted on the movable arm. The specimen support assembly shall consist of two 2.0 in. × 1.0 in. × 1.0 in. (5 cm × 2.5 cm × 2.5 cm) noncompressible blocks placed 2.0 in. (5 cm) apart, as shown in Figure 9-22.2.

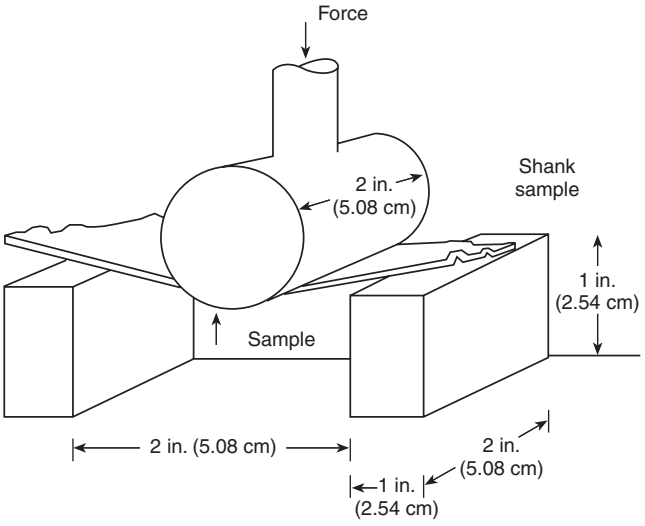

Figure 9-22.2 Ladder shank bend test set-up.

9-22.3 The footwear bottom shall be preconditioned for one hour, + 5/–0 minutes, at 70°F, ± 5°F (21°C, ± 2°C).

9-22.4 The footwear shall be placed on the mounting blocks as it would be oriented toward the ladder when affixed into the footwear and subjected to force on its center with the test probe operated at 2.0 in./min (5 cm/min).

9-22.5 Deflection at 400 lb (182 kg) shall be recorded. The average of all sample measurements shall be used to determine compliance with this standard.

9-23 Footwear Sole Slip Resistance Test.

9-23.1 The slip resistance of footwear soles shall be measured in accordance with ASTM F489, *Standard Test Method for Static Coefficient of Friction of Shoe Sole and Heel Materials as Measured by the James Machine.*

9-23.2 Slip resistance shall be measured in both a wet and a dry condition, as specified in ASTM F489, *Standard Test Method for Static Coefficient of Friction of Shoe Sole and Heel Materials as Measured by the James Machine.*

9-23.3 The average measurements of slip resistance in both wet and dry conditions shall be used to determine compliance with this standard.

9-24 Seam and Closure Strength Test.

9-24.1 A seam representative of construction in the entire suit shall be used. Closure assembly samples shall include the seam of garment material-to-closure in addition to the closure.

9-24.2 Seam and closure strength shall be measured in accordance with ASTM D751, *Standard Test Methods for Coated Fabrics, Seam Strength.*

9-24.3 The average seam and closure strength measurements shall be used to determine compliance with this standard.

9-25 Closure Penetration Resistance Test.

9-25.1 Penetration resistance testing of suit closure assemblies shall be conducted in accordance with ASTM F903, *Standard Test Method for Resistance of Protective Clothing Materials to Penetration by Liquids*, Procedure C, using the following modifications:

(a) All tests shall be conducted at 77°F, ± 5°F (25°C, ± 3°C).

(b) A minimum of three suit closure assemblies shall be tested for each liquid listed in ASTM F1001, *Standard Guide for Chemicals to Evaluate Protective Clothing Materials*, and any additional liquid chemicals or specific chemical mixtures for which the manufacturer is certifying the suit.

(c) The suit closure assembly to be tested shall be preconditioned by 50 cycles of completely opening and completely closing the closure assembly.

(d) The test cell shall be modified to accommodate the shape of the suit closure assembly without affecting other parts of the test procedure. The plexiglass shield shall be omitted from the test cell.

9-25.2* An observation to determine specimen penetration shall be made at the end of the chemical contact period. Any visually observed liquid penetration at the end of the test for any specimen shall constitute failure of this test.

9-25.3* Use of blotting paper at the end of the test shall be permitted to assist in the visual observation of liquid penetration. Visually observed chemical on the blotting paper shall constitute failure of this test.

9-25.4 The report shall include the pass/fail results for each chemical tested and an identification of location where penetration occurs, if discernible.

9-26 Exhaust Valve Inward Leakage Test.

9-26.1 All suit exhaust valves to be tested shall be conditioned at 90°F, ± 5°F (30°C, ± 3°C) at a relative humidity of 50 percent, ± 5 percent, for a minimum period of four hours. Valves shall be tested not more than five minutes after removal from conditioning.

9-26.2 The test fixture used to measure exhaust valve inward leakage shall have the following characteristics:

(a) The fixture shall allow mounting of an exhaust valve such that an airtight seal is achieved between the valve body and the fixture.

(b) The fixture shall provide for the application of suction from a vacuum pump capable of sustaining a 1.0 in. water gauge vacuum (–25.4 mm Hg water column height).

(c) The fixture shall include a pressure gauge or manometer capable of measuring pressures ranging from –1.0 in. to 3.0 in., ± 0.25 in. water gauge (–25.4 mm Hg to 76.2 mm Hg, ± 6.35 mm Hg water column height).

(d) 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 $in.^3$/min to 6.10 $in.^3$/min, ± 0.61 $in.^3$/min (100 ml/min, ± 1 ml/min).

9-26.3 With the exhaust valve mounted in the test fixture, a suction of 1.0 in. water gauge pressure (–25.4 mm Hg water column height) 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.

9-26.4 The flow rate into the valve shall be noted and reported for each exhaust valve tested.

9-27 Overall Ensemble Flash Test.

9-27.1 Each protective suit selected shall be tested for gastight integrity in accordance with ASTM F1052, *Standard Practice for Pressure Testing of Gas-Tight Totally Encapsulating Chemical-Protective Suits.*

9-27.2 Additional protective clothing components and equipment that are necessary to provide full body flash protection to the wearer shall be tested in conjunction with the protective suit.

9-27.3 A human form mannequin shall be used to support the protective suit during chemical flash fire testing. The mannequin shall be coated with a suitable flame-retardant coating.

9-27.4 A one-piece flame-retardant coverall shall be placed over the mannequin.

9-27.5 The protective suit to be tested shall be placed on the mannequin, over the flame-resistant clothing, in accordance with the manufacturer's instructions.

9-27.6 A flash chamber shall be constructed, as illustrated in Figure 9-27.6, and shall include the following:

(a) It shall have an internal width and depth of 6.0 ft, ± 0.3 ft (1.9 m, ± 0.1 m) and a height of 8.0 ft, ± 3 ft (2.3 m, ±0.1 m).

(b) It shall be constructed of 2 in. × 4 in. (5.08 cm × 10.16 cm) framing lumber or other suitable structural material. A fire wall, at least $^3/_4$ in. (2.0 cm) thick, or other suitable flame-resistant paneling shall be used on the opposite two walls of the chamber. Half-inch (1.3-cm), heat-tempered safety glass shall be used on the remaining walls to allow for multiple viewing points during testing. At least one of the glass walls shall be attached by a means that allows for easy removal of the mannequin. Both glass walls shall be configured to achieve gastight seals with the chamber.

(c) All fire wall seams shall be taped and the interior walls of the chamber coated with a suitable flame-retardant material.

(d) It shall have a port for filling the chamber with propane gas located as shown in Figure 9-27.6. The port shall allow isolation of the propane source through a valve. The port shall be leak-free with respect to the outside environment.

(e) It shall have one port for electric ignitors, located as shown in Figure 9-27.6. The ports shall be leak-free with respect to the outside environment.

(f) It shall have a top that allows containment of propane gas within the chamber during filling and venting of flash pressure after ignition.

(g) A suitable stand should be constructed that allows the mannequin to be positioned 12 in., ± 1 in. (30.5 cm, ±2.5 cm) above the chamber floor.

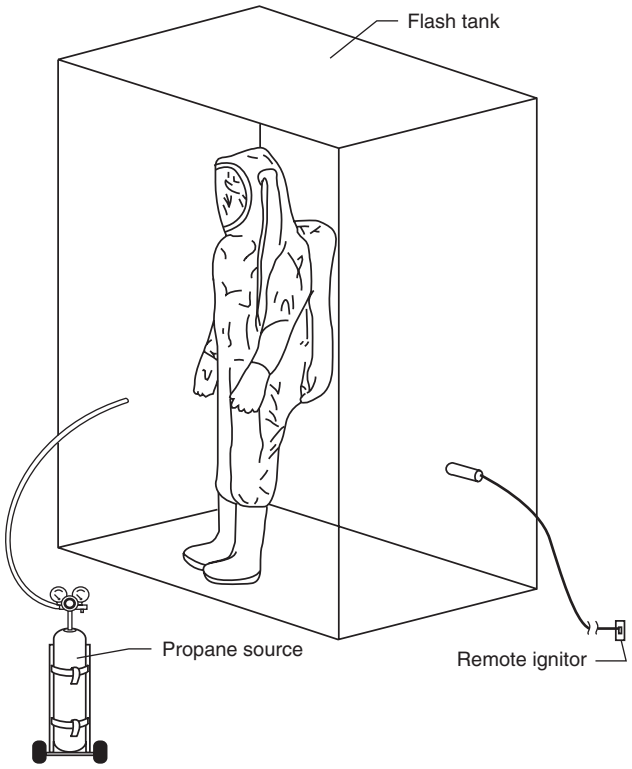

Figure 9-27.6 Overall ensemble chemical flash chamber.

9-27.7 The suited mannequin shall be placed on the stand in the center of the flash chamber in an upright stationary position.

9-27.8 Propane gas at 99 percent purity or better shall be metered into the chamber at a concentration to produce a visible chemical flash fire lasting 7 seconds, ± 1 second. The appropriate metering requirements for introducing propane into the chamber shall be determined in a pretest calibration

trial without the suited mannequin in the chamber. The concentration of the propane shall be permitted to be checked by a combustible gas meter or similar detector.

9-27.9 The flash chamber shall be viewed at both vantage points, front and back, throughout the test. Video documentation also shall be conducted from the front vantage point.

9-27.10 The chamber atmosphere shall be remotely ignited 30 seconds, ± 5 seconds, after the chamber has been filled with propane gas.

9-27.11 The suited mannequin shall not be removed until all surfaces have cooled to ambient temperature.

9-27.12 Without removing the suit from the mannequin, a gastight integrity test shall be performed on the suit in accordance with ASTM F1052, *Standard Practice for Pressure Testing of Gas-Tight Totally Encapsulating Chemical-Protective Suits*, after the chemical flash fire exposure. Passing performance for this test shall be meeting the "pass" requirements for the gastight integrity test following the simulated chemical flash fire.

9-27.13 The protective suit shall be removed from the mannequin and examined visually for physical signs of damage from thermal exposure. An illustration of the protective suit shall be prepared that shows the location of any damage. Separate illustrations shall be prepared for overcovers if tested with the protective suit. Damage shall include, but shall not be limited to:

(a) Charring,

(b) Blistering,

(c) Evidence of material melting,

(d) Delamination, and

(e) Destruction of any suit components.

This damage shall be documented in the technical data package.

9-27.14 Following gastight integrity testing, the suit shall be donned by a test subject and evaluated as specified in Section 9-13.

9-27.15 All testing shall be performed at a temperature of 75°F, ± 20°F (24°C, ± 11°C) and a relative humidity of 70 percent, ± 25 percent. Tests shall not be conducted outdoors during precipitation.

9-28 Thermal Protective Performance Test.

9-28.1 All samples to be tested shall be preconditioned first by placement in a circulating air oven for not less than four hours at 120°F, ±5 °C, (49°C, ± 2°C) and then conditioned in accordance with Section 4, Atmospheric Conditions for Testing, of Federal Test Method Standard 191A, *Textile Test Methods*, with a relative humidity of 65 percent, ± 5 percent. Samples shall be tested not more than five minutes after removal from conditioning.

9-28.2 Thermal protective performance (TPP) testing shall be performed in accordance with ASTM D4108, *Standard Test Method for Thermal Protective Performance of Materials for Clothing, Open-Flame Method*, with the following modifications:

(a) Specimens shall consist of protective clothing composites measuring 6 in. × 6 in., ± $^1/_{16}$ in. (152.4 mm × 152.4 mm, ± 1.6 mm) consisting of all layers used in the construction of the chemical-protective suit.

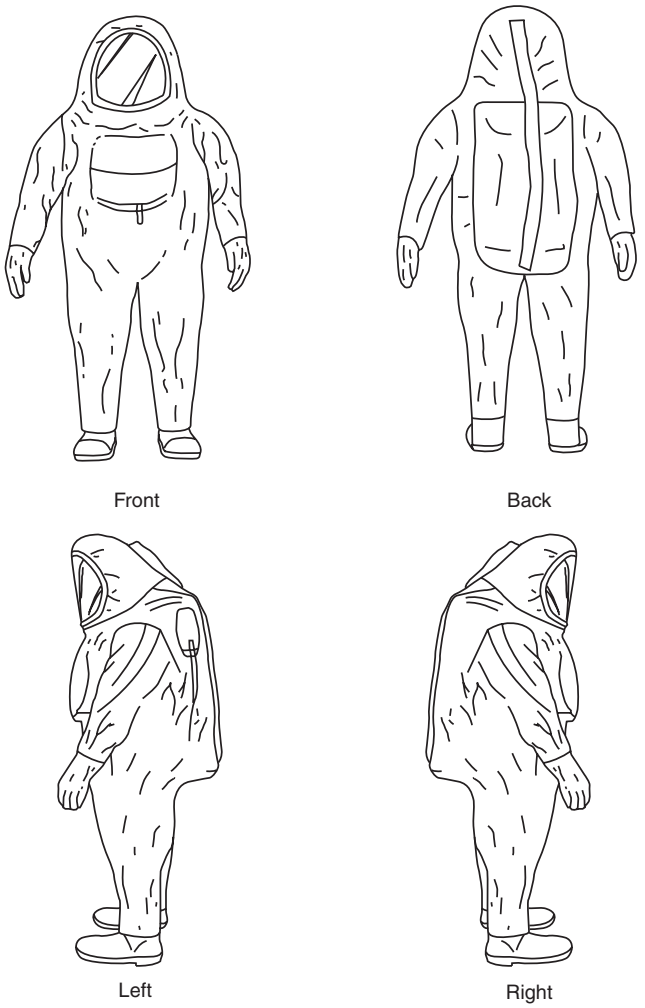

Figure 9-27.13 Suit diagram (for noting damaged locations).

(b) Apparatus shall consist of specimen holder assembly, specimen holder assembly support, thermal flux source, protective shutter, sensor assembly, and recorder.

(c) The specimen holder assembly shall consist of upper and lower mounting plates. Specimen holder maintaining plates shall be 8 in. × 8 in., ± $^1/_{16}$ in., × $^1/_4$ in., ± $^1/_{32}$ in. (203.2 mm × 203.2 mm, ± 1.6 mm, × 6.4 mm, ±0.8 mm). The lower specimen mounting plate shall have centered a 4 in. × 4 in., ±1/16 in. (101.6 mm × 101.6 mm, ±1.6 mm) hole. The upper specimen mounting plate shall have centered a $5^1/_8$ in. × $5^1/_8$ in., ±1/16 in. (130.2 mm × 130.2 mm, ±1.6 mm) hole. The lower specimen mounting plate shall have a 1 in., ± $^1/_{16}$ in., high × $^1/_8$ in., ± $^1/_{32}$ in., thick (25.4 mm, ± 1.6 mm, × 3.2 mm, ±0.8 mm) steel post welded to each corner $^1/_4$ in., ± $^1/_{16}$ in., (6.4 mm, ± 1.6 mm) from each side and perpendicular to the plane of the plate. The upper sample mounting plate shall have a corresponding hole in each corner so that the upper specimen mounting plate fits over the lower specimen mounting plate.

(d) Specimen holder assembly support shall consist of a steel frame that rigidly holds and positions in a reproducible manner the specimen holder assembly and specimen relative to the thermal flux. Specimen holder assembly support shall

be securely clamped at the edges to prevent specimen shrinkage. The sensor assembly shall consist of $5^1/_4$ in. × $5^1/_4$ in. × $^1/_2$ in. (133.3 mm × 133.3 mm × 12.8 mm) heat-resistant block that fits without binding into the hole of upper specimen mounting plate and shall be uniformly weighted such that complete sensor assembly, including copper calorimeter, weighs 2.2 lb, ± 0.022 lb (1000 g, ± 10 g).

(e) Thermal flux source shall consist of a convective thermal flux source and a radiant thermal flux source. The convective thermal flux source shall consist of two Meker or Fisher burners affixed beneath the specimen holder assembly opening and subtended at a nominal 45 degree angle from the vertical so that the flames converge at a point immediately beneath the specimen. The radiant thermal flux source shall consist of nine quartz infrared tubes affixed beneath and centered between the burners.

(f) A protective shutter shall be placed between the thermal flux source and the specimen. The protective shutter shall be capable of completely dissipating thermal load from thermal flux source of the time periods before and after specimen exposure. The protective shutter shall be controlled by means of an automatic timer with a resolution of not less than 0.10 second.

(g) Specimens shall be exposed to a thermal flux of 2.0 cal/cm^2/sec, ± 0.1 cal/cm^2/sec as measured with the copper calorimeter. The copper calorimeter shall be the only heat sensor used in setting the 2.0 cal/cm^2/sec exposure condition. The total heat flux shall be calculated directly from the temperature response of the copper calorimeter and calorimeter constants. Other heat-sensing devices shall not be used to reference or adjust the heat flux read by the copper calorimeter. The 2.0 cal/cm^2/sec exposure shall be determined directly and only from the voltage output of the thermocouples, using the measured temperature rise of the copper calorimeter, the area and mass of the calorimeter, and the heat capacity of copper to calibrate the incoming heat flux. The radiant load shall be set on 1.0 cal/cm^2/sec as measured using a calibrated commercial radiometer.

(h) The sensor assembly shall be fitted into the opening in the top plate of the specimen holder and shall be in contact with the surface of the thermal barrier normally facing the wearer.

(i) If the individual results vary more than ± 5 percent from the average result, the results shall be discarded and another set of specimens shall be tested.

(j) The individual test results of each specimen shall be reported. The average value for each sample and pass/fail result shall be calculated and reported.

9-29 Material Static Charge Accumulation Resistance Test.

9-29.1 The outside surface of the chemical protection layer, plus any surfaces external to that layer, of each primary suit material, except the visor, shall be tested. The visor and the inside surface of the chemical protection layer shall be tested for documentation purposes only. For composite materials, interior surfaces shall be tested using the actual material surfaces. For example, in a two-layer material composite, the external side of the inner layer and the internal side of the outer layer shall be tested. The felt PTFE pad on the rubbing wheel shall be replaced with one of the material layers.

9-29.2 A total of five specimens, each 8.0 in., ± 0.2 in. (20.4 cm, ± 0.4 cm) square, shall be cut from the material to be tested.

9-29.3 Test specimens shall be conditioned at the standard temperature of 75°F, ± 5°F (24°C, ± 3°C) and the standard relative humidity of 45 percent, ± 5 percent.

9-29.4 The following test equipment shall be used:

9-29.4.1* Triboelectric Test Device. The triboelectric test device shall consist of a grounded aluminum frame with two cutouts in the front faceplate.

(a) The lower right cutout shall house the static detector head that is connected to an electrometer.

(b) The upper left cutout shall be for the rubbing wheel used to generate the triboelectric charge.

(c) This rubbing wheel shall be connected to a $^1/_8$ horsepower electric drive motor. A manual lever shall be used to slide the motor/rubbing wheel combination forward so that the wheel gently makes intimate contact with the test specimen at the proper time.

(d) The test pressure shall be held constant during the test by means of a weight and cord system. In this system, a cord shall be attached to the motor assembly, shall run over a pulley wheel, and a 3.0-lb, ± 0.2 lb (1.36-kg, ± 0.05 kg) weight shall be attached to the end of the cord.

(e) The test specimen shall be mounted taut in a grounded aluminum sample holder.

9-29.4.2* Rubbing Wheel. The rubbing wheel shall have a diameter of 5.0 in., ± 0.1 in. (12.7 cm, ± 0.2 cm). The standard wheel shall be constructed with a phenolic plastic (such as Micarta) back, a 1-in. (2.54-cm) thick foam cushion, and a felt PTFE rubbing surface. Rubbing wheels shall be cleaned with a dry cloth after the completion of tests on a given material.

9-29.4.3 Data Gathering System. A digital oscilloscope with memory shall be used for gathering data.

(a) The oscilloscope trigger shall be initiated with a 6 V battery connected to the oscilloscope trigger circuit through a microswitch on the sliding mechanism of the rubbing wheel.

(b) When the rubbing wheel is moved away from the test specimen (thus ceasing the charge generation), the microswitch shall initiate the oscilloscope trigger. The detector head senses the electrostatic field and the electrometer generates a dc voltage proportional to the electrostatic field sensed by the detector head. This voltage shall be fed into the oscilloscope input and shall be displayed on the oscilloscope y axis versus time. The zero time shall be the time the microswitch circuit triggers the oscilloscope sweep that occurs at the cessation of sample rubbing.

(c) The oscilloscope presentation also shall be permitted to be recorded on an x-y plotter directly connected to the oscilloscope.

(d) The oscilloscope shall also be permitted to have a digital interface to send the data to a digital computer for further analysis and storage.

9-29.4.4* Static Eliminator. A static eliminator shall be used that is capable of removing a 25,000 V charge from a 7 in. × $^5/_8$ in. (20 cm × 1.6 cm) square material specimen within 30 seconds. The static eliminator shall be placed in the test chamber or other testing area.

9-29.5 The following test procedure shall be used:

9-29.5.1 A clean rubbing wheel shall be placed in the test apparatus.

9-29.5.2 The triboelectric test apparatus shall be conditioned at the standard temperature of 75°F, ± 5°F (24°C, ± 3°C) and the standard relative humidity of 45 percent, ± 5 percent, for a minimum of 24 hours.

9-29.5.3 The electrometer and oscilloscope shall be turned on and allowed to warm up for 30 minutes.

9-29.5.4 The test specimen shall be mounted in the sample holder.

9-29.5.5 The test operator shall verify or install the proper weights on the cord. [The standard mass is 3.0 lb (1.36 kg.)]

9-29.5.6 The static eliminator shall be turned on for 30 seconds to remove any residual charge on the test specimen and rubbing wheel.

9-29.5.7 The rubbing wheel motor shall be turned on and adjusted to 200 rpm.

9-29.5.8 The oscilloscope shall be adjusted for the display needed.

9-29.5.9 The electrometer shall be zeroed.

9-29.5.10 The sample holder shall be raised and locked into position in front of the rubbing wheel.

9-29.5.11 The control lever shall be moved to initiate rubbing of the test specimen and shall continue to rub the sample for precisely 10 seconds. During the rubbing, the oscilloscope circuit shall be armed and the electrometer shall be ungrounded.

9-29.5.12 The rubbing wheel shall be retracted and the sample holder shall be permitted to drop in front of the detector head to initiate the measurement of the electrostatic field.

9-29.5.13 Voltage versus time shall be measured for the peak voltage at 0.5, 1.0, 2.0, 3.0, 4.0, and 5.0 seconds. Alternatively, the voltage shall be permitted to be measured continuously using a data logger for at least 5.0 seconds.

9-29.5.14 The test shall be repeated with a fresh sample each time, beginning with 9-29.5.2.

9-29.6 For each specimen, the peak charge generated, the corresponding charge after 5.0 seconds, and the time required for the charge to reach 10 percent or the maximum charge measured shall be recorded.

9-29.7 The average measured voltage at five seconds for each surface tested shall be used individually to determine pass/fail with this standard.

9-30 Liquefied Gas Permeation Resistance Test.

9-30.1 Permeation resistance of liquefied gases shall be measured as specified in Section 9-6.

9-30.2 The test cell and test chemical shall be maintained at a temperature sufficient to keep the test chemical as a liquid such that a $^1/_2$-in. (1.3-cm) liquid layer is maintained at all times during the test.

9-30.3 The permeation test shall be conducted for a minimum of one hour.

9-31 Garment, Glove, and Footwear Material Embrittlement Test.

9-31.1 Garment, glove, and footwear material embrittlement shall be measured in accordance with ASTM D2136, *Standard Test Method for Coated Fabrics—Low-Temperature Bend Test*, with the following modifications:

(a) Testing shall be conducted in a freezer having a temperature no higher than –13°F (–25°C).

(b) The material specimen shall first be placed on a flat sheet of dry ice with outer surface of the material in contact with the dry ice for a period of 15 minutes under a pressure of 0.5 psi (3.5 kPa).

(c) The material specimen shall be removed from the dry ice after 15 minutes of contact and shall be immediately placed in the test apparatus.

(d) The bending action of the test apparatus shall be immediately activated while the sample is still in the freezer.

(e) Permeation resistance testing as specified in Section 9-6 shall be substituted for a visual examination of the specimen for interpreting failure.

9-31.2 Only one specimen for permeation resistance testing shall be taken from each sample subjected to embrittlement conditioning. The permeation test specimen shall be taken from the exact center of the folded sample so that the center of the permeation test and the center of the folded sample coincide.

9-31.3 The average normalized breakthrough detection time in minutes for the folded samples shall be reported.

9-31.4 The average minimum permeation rate observed for folded samples in $\mu g/cm^2/min$ shall be reported.

9-31.5 Any visual observations, such as delamination, breakage, or cracking for tested specimens, shall be reported.

9-32 Glove and Footwear Gastight Integrity Test.

9-32.1 The gastight integrity of complete gloves or footwear shall be measured in accordance with ASTM F1052, *Standard Practice for Pressure Testing of Gas-Tight Totally Encapsulating Chemical-Protective Suits*, with the following modifications:

(a) Test gloves or footwear shall be substituted for encapsulated chemical-protective suits.

(b) A test fixture shall be designed that provides a gastight seal between the glove cuff (or footwear top line) and the fixture; the fixture shall have a valved port to allow air introduction and pressure measurement.

9-32.2 Glove or footwear tests shall be reported as pass or fail. Tests for which gloves or footwear sustain a pressure drop greater than 20 percent shall be classified as failures.

9-32.3 If the gastight integrity of gloves and footwear is assessed when attached to the vapor-protective suit, then the results for the overall vapor-protective suit shall be used in lieu of individual results for gloves and footwear.

Chapter 10 Referenced Publications

10-1 The following documents or portions thereof are referenced within this standard and shall be considered part of the requirements of this document. The edition indicated for each reference is the current edition as of the date of the NFPA issuance of this document.

10-1.1 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

NFPA 1992, *Standard on Liquid Splash-Protective Suits for Hazardous Chemical Emergencies*, 1994 edition.

NFPA 1993, *Standard on Support Function Protective Clothing for Hazardous Chemical Operations*, 1994 edition.

10-1.2 Other Publications.

10-1.2.1 ANSI Publications. American National Standards Institute, 1450 Broadway, New York, NY 10018.

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

ANSI Z89.1, *Protective Headwear for Industrial Workers*, 1986.

10-1.2.2 ASTM Publications. American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.

ASTM D747, *Standard Test Method for Apparent Bending Modulus of Plastics by Means of a Cantilever Beam*, 1990.

ASTM D751, *Standard Test Methods for Coated Fabrics*, 1989.

ASTM D1630, *Standard Test Method for Rubber Property—Abrasion Resistance (NBS Abrader)*, 1983.

ASTM D2136, *Standard Test Method for Coated Fabrics—Low-Temperature Bend Test*, 1989.

ASTM D2582, *Standard Test Method for Puncture-Propagation Tear Resistance of Plastic Film and Thin Sheeting*, 1992.

ASTM D4108, *Standard Test Method for Thermal Protective Performance of Materials for Clothing, Open-Flame Method*, 1987.

ASTM D4157, *Standard Test Method for Abrasion Resistance of Textile Fabrics (Oscillatory Cylinder Method)*, 1992.

ASTM F392, *Standard Test Method for Flex Durability of Flexible Barrier Materials*, 1993.

ASTM F489, *Standard Test Method for Static Coefficient of Friction of Shoe Sole and Heel Materials as Measured by the James Machine*, 1988.

ASTM F739, *Standard Test Method for Resistance of Protective Clothing Materials to Permeation by Liquids or Gases Under Conditions of Continuous Contact*, 1991.

ASTM F903, *Standard Test Method for Resistance of Protective Clothing Materials to Penetration by Liquids*, 1990.

ASTM F1001, *Standard Guide for Chemicals to Evaluate Protective Clothing Materials*, 1989.

ASTM F1052, *Standard Practice for Pressure Testing of Gas-Tight Totally Encapsulating Chemical-Protective Suits*, 1991.

ASTM F1154, *Standard Practices for Qualitatively Evaluating the Comfort, Fit, Function, and Integrity of Chemical-Protective Suit Ensembles*, 1988.

ASTM F1301, *Standard Practice for Labeling Chemical Protective Clothing*, 1990.

ASTM F1342, *Standard Test Method for Protective Clothing Material Resistance to Puncture*, 1991.

ASTM F1359, *Standard Practice for Determining the Liquid-Tight Integrity of Chemical Protective Suits or Ensembles Under Static Conditions*, 1991.

10-1.2.3 Bennett Dexterity Test. The Psychology Corporation, 555 Academic Court, San Antonio, TX 78204.

10-1.2.4 CSA Publication. Canadian Standards Association, 178 Rexdale Boulevard, Toronto, Canada M9W 1R3.

CSA Z195-M, *Standard for Protective Footwear, Occupational Health and Safety*, 1984.

10-1.2.5 FIA Publication. Footwear Industry of America, 3700 Market Street, Philadelphia, PA 19104.

FIA 1209, *Whole Shoe Flex.*

10-1.2.6 GSA Publication. General Services Administration, Specifications Activity, Printed Materials Supply Division, Building 197, Naval Weapons Plant, Washington, DC 20407.

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

Appendix A Explanatory Material

This Appendix is not a part of the requirements of this NFPA document but is included for informational purposes only.

A-1-1.1 The requirements of this standard were developed taking into consideration the needs of emergency response personnel for hazardous chemical emergencies. This application might entail a variety of chemical, physical, and other hazards. Other protection needs should warrant a thorough review of the requirements in this standard, such as routine industrial operations, to determine their applicability.

There are no requirements in this standard that address reuse or multiple wearings of vapor-protective suits. Users are cautioned that exposure of vapor-protective suits to chemicals might require disposal.

A-1-1.2 At the time this standard was prepared, the characteristics of a dust or particulate flash fire had not been defined by the committee. Therefore, the committee has chosen not to assume that these exposures are similar to a chemical flash fire nor are the requirements for chemical flash fire protection adequate as minimum requirements for dust or particulate flash fire protection.

A-1-1.3 Organizations responsible for specialized chemical response functions including radiological, biological, cryogenic, or fire fighting applications should use protective clothing and equipment specifically designed for those activities.

A-1-1.4 It is strongly recommended that purchasers of vapor-protective suits consider the following:

(a) Emergency response personnel must wear many items of protective clothing and equipment. Any interference by one item of another's use might result in inefficient operations or unsafe situations.

(b) Different breathing apparatus, communications systems, cooling devices, and other protective equipment might not be accommodated equally by each vapor-protective suit.

(c) Specification of additional reinforcement in high-wear or load-bearing areas, such as the knees, elbows, shoulders, and back, might be necessary. Reinforcing materials should be the same as the garment material. Purchasers are cautioned that additional weight caused by excessive reinforcement could lead to fatigue or injury to the wearer and change or shorten the life of the garment.

A-1-3 Approved. The National Fire Protection Association does not approve, inspect, or certify any installations, procedures, equipment, or materials; nor does it approve or evaluate testing laboratories. In determining the acceptability of installations, procedures, equipment, or materials, the authority having jurisdiction may base acceptance on compliance with NFPA or other appropriate standards. In the absence of such standards, said authority may require evidence of proper installation, procedure, or use. The authority having jurisdiction may also refer to the listings or labeling practices of an organization concerned with product evaluations that is in a position to determine compliance with appropriate standards for the current production of listed items.

A-1-3 Authority Having Jurisdiction. The phrase "authority having jurisdiction" is used in NFPA documents in a broad manner, since jurisdictions and approval agencies vary, as do their responsibilities. Where public safety is primary, the authority having jurisdiction may be a federal, state, local, or other regional department or individual such as a fire chief; fire marshal; chief of a fire prevention bureau, labor department, or health department; building official; electrical inspector; or others having statutory authority. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the authority having jurisdiction. In many circumstances, the property owner or his or her designated agent assumes the role of the authority having jurisdiction; at government installations, the commanding officer or departmental official may be the authority having jurisdiction.

A-1-3 Chemical Flash Fire. The committee realized that a policy of wearing protective clothing was needed that recognized the significant threat to fire fighters who might be exposed to flash fires in either structural fire fighting or hazardous chemical environments. It is hoped that fire fighters utilize awareness training on burn injuries caused by the ignition of the environment. There is a distinct difference between chemical flash fires and flashovers occurring in structural fire fighting environments.

Flashover is a phenomenon that requires heat and generates temperatures in the range of 1200°F to 1500°F (649°C to 816°C). A chemical flash fire requires an ignition source and a chemical atmosphere that contains a concentration above the lower explosive limit of the chemical. Chemical flash fires generate heat from 1000°F to 1900°F (538°C to 1038°C). A structural fire flashover, as a rule, is confined to a designated area with walls as a boundary. A chemical flash fire depends on the size of the gas or vapor cloud, and, when ignited, the flame front expands outward in the form of a fireball. The resulting effect of the fireball's energy with respect to radiant heat significantly enlarges the hazard areas around the gas released.

A-1-3 Chemical-Protective Suit. For the purposes of this standard, the chemical-protective suit is an ensemble of clothing items designed to provide complete protection to the wearer in combination with the wearer's respiratory protection equipment. This means that both suit and respiratory equipment must be worn in combination to achieve the protection dictated by this standard.

A-1-3 Cryogenic Gas. Examples of cryogenic gases include helium, nitrogen, and oxygen. This is not an inclusive list of cryogenic gases.

A-1-3 Hazardous Chemical Emergencies. Hazardous chemical emergencies are a special subset of activities during hazardous materials incidents. They are characterized by activity where significant hazards exist to personnel or the environment. Emergency activity takes place in the hot zone as opposed to support functions, which take place in the warm and cold zones.

A-1-3 Liquefied Gas. Examples of liquefied gases include ammonia, 1,2-butadiene, chlorine, ethylene oxide, hydrogen chloride, liquefied petroleum gas, and methyl chloride. This is not an inclusive list of liquefied gases. Testing in this standard is only conducted for a limited number of liquefied gases. Users should consult the technical data package to determine which liquefied gases have been tested with the suit's primary materials.

A-1-3 Listed. The means for identifying listed equipment may vary for each organization concerned with product evaluation, some of which do not recognize equipment as listed unless it is also labeled. The authority having jurisdiction should utilize the system employed by the listing organization to identify a listed product.

A-1-3 Vapor-Protective Suit with Additional Chemical Flash Fire Escape Protection. Suits meeting these requirements are intended to offer the wearer protection for escape only in situations that might result in chemical flash fires. The subcommittee, in developing requirements for this area, did not consider or imply any protection beyond that necessary for allowing emergency responders to survive the thermal effects of a chemical flash fire with no loss of suit gastight integrity.

A-1-3 Vapor-Protective Suit with Additional Liquefied Gas Protection. Suits meeting these requirements are intended to offer the wearer limited protection for exposure to liquefied gases. The subcommittee, in developing requirements for this area, considered a maximum exposure time of 15 minutes for maintaining all protective qualities of the suit.

A-2-1.1 The compliance of vapor-protective suits in meeting this standard is determined by the NFPA battery of chemicals. Each vapor-protective suit meeting the requirements of this standard will have a list of chemicals or chemical mixtures associated with it.

Vapor-protective suits by definition also meet the requirements of NFPA 1992, *Standard on Liquid Splash-Protective Suits for Hazardous Chemical Emergencies*, and NFPA 1993, *Standard on Support Function Protective Clothing for Hazardous Chemical Operations*.

A-2-2.1 The certification organization should have a sufficient breadth of interest and activity so that the loss or award of a specific business contract would not be a determining factor in the financial well-being of the agency.

A-2-2.3 The contractual provisions covering certification programs should contain clauses advising the manufacturer that, if requirements change, the product should be brought into compliance with the new requirements by a stated effective date through a compliance review program involving all currently listed products.

With these clauses, certifiers would not be able to move quickly to protect their name, marks, or reputation. A product safety certification program would be deficient without these contractual provisions and the administrative means to back them up.

A-2-2.4 Investigative procedures are important elements of an effective and meaningful product safety certification program. A preliminary review should be carried out on products submitted to the certification organization before any major testing is undertaken.

A-2-2.7 Such factory inspections should include, in most instances, witnessing of production tests. With certain products, the certification organization inspectors should select samples from the production line and submit them to the main laboratory for countercheck testing. With other products, it might be desirable to purchase samples in the open market for test purposes.

A-2-3.5 Manufacturers are not limited in their approaches for designing vapor-protective suits compliant with this standard. If the suit design uses combinations of materials or garments to meet one part of the standard, then the same combinations must be assessed for all parts of the standard. For example, if a two-part visor is used such that the visor materials meet the chemical-resistance requirement, the outer visor cannot be removed to meet the light transmission requirement. The same configuration must be used for all performance requirements.

A-2-5.1 Purchasers and users should be aware that no reliable nondestructive methods exist to determine the level of contamination for exposed vapor-protective suits or their materials. Users might not be able to determine how effective decontamination methods are in removing chemical contamination from the vapor-protective suit. Vapor-protective suits that have received a significant exposure to a chemical or chemical mixture, in the estimation of the responsible supervisor, should be disposed of.

A-2-5.2 Examples of other clothing items that might be required to be worn for meeting performance criteria in this standard include, but are not limited to, over garments, over gloves, and over boots. Purchasers must realize that all items specified by the manufacturer and used to determine compliance with this standard must be worn together. Otherwise, the certification of the garment is voided.

A-2-6 Purchasers should consider testing prospective suits by evaluating their comfort, function, fit, and integrity as specified in ASTM F1154, *Standard Practices for Qualitatively Evaluating the Comfort, Fit, Function, and Integrity of Chemical-Protective Suit Ensembles*. These practices entail having a test subject don the suit and wear it during a series of exercises. Two exercise batteries are used. The first includes a number of in-place exercises such as toe touches, deep knee bends, and cross arm reaches, which are intended to assess suit subject mobility and create stresses on different parts of the suit. The second involves more realistic activities such as crawling, climbing a ladder, turning a valve, operating a hand truck, and coiling a hose. These tasks attempt to simulate actions that an emergency responder might undertake during a hazardous chemical emergency.

A-2-6.1 Purchasers should follow the instructions provided by the manufacturer for completing the logbook for their own means of recording suit use and maintenance and also for documenting levels of contamination when returning suits to the manufacturer.

A-2-6.3 The manufacturer should prepare the logbook so that it provides for at least the following data entries:

(a) Dates of each inspection, inspection findings, and the name of the inspector;

(b) Dates of each use, the length of use, and the user's name;

(c) Names of chemicals the suit is exposed to, including the length and concentration of exposure;

(d) Dates of all repairs, including a description of the repairs and the name of the person making the repairs;

(e) Dates and types of decontamination to which the suit is subjected and the name of the person or facility responsible for the decontamination;

(f) Dates the suit is taken out of service and the reason for action; and

(g) Dates the suit is returned to the manufacturer and the reason for the return.

A-3-1.1 Purchasers should use the technical data package to compare suit performance data when purchasing vapor-protective suits. The purchaser should determine the relative ranking of performance data to aid in this selec- tion process.

A-3-1.2 Purchasers should request that all documentation and performance data be provided in a format that will allow easy comparison of products to aid selection. A recommended format for presenting this data is given in Appendix B. Appendix C provides a description of the test methods and performance criteria used in this standard and in related standards NFPA 1992, *Standard on Liquid Splash-Protective Suits for Hazardous Chemical Emergencies*, and NFPA 1993, *Standard on Support Function Protective Clothing for Hazardous Chemical Operations*.

A-3-1.4 Manufacturers should determine the size range of their ensembles by matching human dimensions with available suit sizes. These determinations should account for other clothing and equipment to be worn by the wearer as recommended by the manufacturer. Assessment of acceptable fit should be determined by using ASTM F1154, *Standard Practices for Qualitatively Evaluating the Comfort, Fit, Function, and Integrity of Chemical-Protective Suit Ensembles*.

A-3-1.5 Purchasers should use donning and doffing times as a measure of design quality as they affect the ability of a hazardous materials team to respond quickly. Donning times over 10 minutes should be considered excessive.

A-3-2.1 Manufacturers should specify other items that are required for meeting performance requirements in terms of listing the type and identification of each item.

A-3-2.4 The dexterity test involves measuring the time needed for a test subject to complete a series of fine and gross hand manipulations representative of tasks expected during hazardous chemical emergencies. Testing is conducted both bare handed and with sample gloves. Test results are reported as the time necessary for the test subject to complete the test over a series of three trials. The impairment of dexterity by wearing gloves can be determined by comparing how much longer it takes different test subjects to perform the test with gloves than without gloves. Since the general dexterity and coordination for performing the test might vary with test subjects, end users should compare the percentage increase in the test time and not the actual test time for bare-handed and gloved tests.

A-4-1.7 Purchasers should be strongly cautioned to use all parts and components of the certified system in order to provide the minimum acceptable performance required by this standard. It is important that the users do not take it upon themselves to determine which components are required for a specific mission, since the performance contributions of individual components are not readily apparent, although they might appear to be.

For example, certification allows for the use of an inner chemical-protective garment with an overcover to achieve acceptable performance. Some of these overcovers are constructed using aluminized fabric, which is often mistakenly believed to provide flash fire protection. In fact, the overcovers, in some cases, are required even to provide adequate abrasion resistance and basic flame contact protection. Unless marked in accordance with 5-1.1 or 7-1.1, the combined aluminized overcover and chemical-protective suit do not provide limited flash fire protection as defined in this standard. Users are cautioned to examine the product labels closely in order to determine system capabilities and should not rely on the physical appearance of the clothing articles.

Garments certified as using separable components must be configured so that a physical reminder is present in the event of separation. The use of tabs, straps, or other physical attachment points provides such a reminder. Separable boots and gloves are not included in this requirement.

A-4-9 Exhaust valves should be periodically examined for evidence of damage. Ideally, this examination should take place each time the suit is pressure tested for vaportight integrity. During the examination, exhaust valves should:

(a) Be free of any lint or other particles that might interfere with valve closure;

(b) Show no evidence of discoloration or physical degradation; and

(c) Have intact gaskets for installation into the suit.

Care should be taken for properly reinstalling exhaust valves back into the suit.

A-9-6.3 The minimum detectable permeation rate in a closed-loop system is dependent on analytical sensitivity, surface area in the test cell, volume of the collection medium (total), and length of time for accumulation of permeant. Paragraph 9-6.3 specifies the permeation rate at 0.10 $\mu g/cm^2/min$ and the length of accumulation at one hour. Thus, the required analytical sensitivity depends on the surface area and collection volume. For example, if the surface area is 20.27 cm^2 and the total collection volume is 100 ml, then the analytical sensitivity required to detect permeation after one hour is (0.10 $\mu g/cm^2/min \times 60$ min) $\times$ 20.27 $cm^2/100$ ml = 1.2 $\mu g/ml$. Yet, if the surface area is 20.27 cm^2 and the collection volume is only 10 ml, then the required analytical sensitivity is (0.10 $\mu g/cm^2/min \times 60$ min) $\times$ 20.27 $cm^2/10$ ml = 12 $\mu g/ml$. Since this standard specifies a minimum detectable permeation rate of 0.10 $\mu g/cm^2/min$ and one hour accumulation time, analytical sensitivity is a function of the test cell surface area and collection volume. This is true for liquid and gas closed-loop systems.

A-9-6.5 Normalized breakthrough detection times are determined at a standard permeation rate of 0.10 $\mu g/cm^2/min$ following the practice adopted by ASTM Committee F23 on Protective Clothing. This facilitates performance comparisons among materials and removes a measurement bias introduced by the sensitivity of the analytical detection methods used in this test. This rate is achievable by existing technique for most chemicals and is consistent with experience with incumbent materials.

A-9-13.2 A Scott Air Pack 4.5 facepiece, model # 804191-01, is available from Scott Aviation, 225 Erie Street, Lancaster NY 14086.

A-9-25.2 This test is intended for the observation of bulk liquid penetration only. The test is defined to distinguish between bulk liquid penetration and liquid accumulation that is the result of permeation. Current technology does not permit a closure that provides broad chemical resistance combined with the practicality of easy donning and doffing.

A-9-25.3 Blotting material suitable for this test can be obtained from AATCC, P.O. Box 12215, Research Triangle Park, NC 27709.

A-9-29.4.1 Engineering drawings for the test apparatus can be obtained by contacting NFPA.

A-9-29.4.2 A 1-in. (2.54-cm) ester-type polyurethane foam cushion (#2118), available from Boyd Corporation, 13885 Romona Ave., Chino, CA 91710 (714-591-9325), has been found satisfactory in performing this test. No. 2357 polytetrafluoroethylene (PTFE) felt, available from Tex Tech Industries, Inc., 152 Industrial Park Road, Middletown, CT 06457, has been found satisfactory in performing this test.

A-9-29.4.4 It is also recommended to place the test apparatus on an anti-static mat. A Simco Model ATMB Portable Static Eliminator or Model A300 Static Eliminator has been found satisfactory and is available from Simco, Inc., 2257 Penn Road, Hatfield, PA 19440.

Appendix B

This Appendix is not a part of the requirements of this NFPA document but is included for informational purposes only.

Table B-1 Recommended Format for Report Compliance Information in Technical Data Package

Product Name: Model No.: Classification: EPA Level: Integrity: Compliance: Available Sizes:	**Manufacturer**
Garment Material: Thickness: Weight: Tensile Strength: Burst Strength: Tear Resistance: Puncture/Tear Resistance: Bending Moment @ –13°F (–25°C):	**Gloves** Material: Thickness: Interface: Available Sizes:
Seams Type: Seam Strength:	**Footwear** Type: Material: Thickness: Interface: Toe Type: Sole Type: Available Sizes:
Visor Material: Thickness: Interface Light Transmission: Haze:	
Closure Type: Length: Orientation: Interface: Cover: Crosswise Strength:	**Exhaust Valves** Number: Type: Location: Installation: Cover: Cracking Pressure: Inward Leakage:
Fittings Respirator: Cooling System: Inflation:	**Other**

Table B-2(a) NFPA 1991 Primary Material and Seam Chemical Resistance

	Garment	Visor	Gloves	Boots	Seam
Chemical	**BT[1](PR)[2]**	**BT (PR)**	**BT (PR)**	**BT (PR)**	**BT (PR)**
Acetone					
Acetonitrile					
Ammonia (gas)					
Carbon disulfide					
Chlorine (gas)					
Dichloromethane					
Diethylamine					
Dimethylformamide					
Ethyl acetate					
Hexane					
Methanol					
Nitrobenzene					
Sodium hydroxide (50%)					
Sulfuric acid (98%)					
Tetrachloroethylene					
Tetrahydrofuran					

Table B-2(b) NFPA 1991 Primary Suit Material Flame Resistance[3]

Test Parameter	Garment	Visor	Gloves	Boots
Ignition time < 3 sec				
Ignition time < 12 sec				
Burn time (sec)				
Burn distance (in.)				

NOTE 1: BT = Shortest measured normalized breakthrough detection time in minutes using ASTM F739 interpreted at a permeation rate of 0.10 $\mu g/cm^2/min$. If breakthrough is not detected, result is reported as greater than the duration of test.

NOTE 2: PR = Highest measured permeation rate in $\mu g/cm^2/min$. Permeation rate is not reported if no normalized breakthrough detection time is detected.

NOTE 3: Tests conducted using a modified form of FTMS 191A, Method 5903, with folded material edge instead of cut edge and two separate flame exposures (3 seconds and 12 seconds).

Appendix C

Comparison of NFPA 1991, 1992, and 1993 Requirements, Test Methods, and Performance Criteria

Requirement	NFPA Standard			Test Method and Description	Application and Criteria
	1991	1992	1993		
Base Requirements					
Protective pockets or covers shall be used over exhaust valves.	4-1.1			***Design Requirement:*** Visual inspection.	Protects exhaust valves from direct chemical splashes to valve sealing surface.
Overall suit shall provide gastight integrity.	4-1.2			***ASTM F1052:*** The suit is inflated to 3 in. water gauge pressure, which is then reduced to 2 in. The pressure in the suit is observed after 2 minutes.	The internal suit pressure must remain above 1.6 in. water gauge pressure after 2 minutes. Lower ending test pressures indicate air leakage out of the suit and lack of overall suit gastight integrity.
Overall suit shall provide watertight integrity.	4-1.3	4-1.1	4-1.2	***NFPA Test Protocol:*** The suit is placed on a mannequin dressed with an inner water-absorptive garment. The suited mannequin is placed in a special shower stall that has five different water nozzles. Surfactant-treated water is sprayed at the suited mannequin in several orientations for 1 hour. The suit is then removed from the mannequin and the inner garment and suit interior examined for signs of water penetration.	In NFPA 1991, this test is used to evaluate the effectiveness of exhaust valve covers in preventing water penetration through the valves. In NFPA 1992 and 1993, the test is used to assess watertight integrity of the suit or garment, particularly seams, closures, and interfaces, with other clothing or equipment (e.g., suit sleeve to glove attachment).
Overall suit shall provide gastight integrity following simulated single use.	4-1.4			***ASTM F1154/F1052:*** The chemical-protective suit is worn by a test subject who follows the exercise protocols in ASTM F1154 to simulate use. Gastight integrity of the suit is determined before and after the test.	This test is intended to simulate stress on the suit from a single wearing. Suits must not impede any wearer actions and must maintain acceptable gastight integrity following the test.
Overall suit shall provide watertight integrity following simulated single use.		4-1.2		***ASTM F1154/F1359:*** The chemical-protective suit is worn by a test subject who follows the exercise protocols in ASTM F1154 to simulate use. Liquidtight integrity of the suit is determined before and after the t est.	This test is intended to simulate stress on the suit from a single wearing. Suits must not impede any wearer actions and must maintain acceptable liquidtight integrity following the test.
Overall suit shall provide sufficient exhaust flow and shall not overpressurize in event of SCBA failure.	4-1.5			***NFPA Test Protocol/ASTM F1052:*** Fixtures are added onto the suit for introducing high volume air and measuring internal suit pressure. Air is introduced into the suit at a rate of 500 L/min, and the internal suit pressure is monitored. Gastight integrity of the suit is determined before and after the test.	This test simulates high volume airflows into the suit that might occur as the result of SCBA failure. Suits must accommodate this flow without a buildup of pressure and must maintain gastight integrity. Pressures inside the suit must not exceed 1.5 in. water gauge pressure, as this pressure has been determined to cause reductions in wearer mobility. In addition, the suit must meet gas integrity requirements as established above.
Overall suit shall accommodate head protective devices.	4-1.6	4-1.3	4-1.3	***Design Requirement:*** Visual inspection.	Chemical-protective suits must accommodate head-protective caps worn inside the suit that conform to ANSI Z89.1

Comparison of NFPA 1991, 1992, and 1993 Requirements, Test Methods, and Performance Criteria

Requirement	NFPA Standard			Test Method and Description	Application and Criteria
	1991	1992	1993		
Base Requirements					
Overall suit shall be provided as a single and integrated unit.	4-1.7	4-1.4		***Design Requirement:*** Visual inspection.	This requirement is intended to ensure that multilayered suits are provided as a single unit to be worn by the end user.
Primary materials shall resist chemical *permeation*.	4-2.1 4-2.2			***ASTM F739:*** A material sample disc is placed in a test cell dividing the cell into two separate chambers. Chemical is introduced into one chamber while air or water in the other chamber is sampled for chemical that permeates the material sample. The time at which chemical is first detected and the rate at which chemical permeates is reported. The test is conducted for 21 liquid and gaseous chemicals listed in ASTM F1001.	The normalized breakthrough detection time must be 1-hour or greater for all test chemicals. The 1-hour criterion was selected to represent a worst case exposure for the emergency responder. While the permeation rate must be reported, no criterion is established for this measurement.
Primary materials shall resist chemical *penetration*.		4-2.1 4-2.2	4-1.4 4-1.5 4-2.1 4-2.2 4-3.4 4-3.5 4-4.7 4-4.8	***ASTM F903:*** A material sample is placed in a test cell forming a closed chamber on the external side of the material. Chemical is introduced into the closed chamber contacting the material sample. After 5 minutes exposure, the pressure is raised to 2 psig for 1 minute and then reduced to ambient pressure for the remainder of 1 hour.The opposite side of the material is then viewed for evidence of visible liquid penetration. The test is conducted for the eight liquid chemicals in ASTM F1001 that are not suspected/actual carcinogens or skin-toxic chemicals.	Materials must show no penetration within the 1-hour test period for all battery chemicals. The 1-hour contact of the chemical with the material was chosen to represent a worst case exposure. Pressure is applied at 1 minute to simulate liquid under pressure from a burst pipe. The test is intended to demonstrate how well the material prevents liquid transfer to the suit interior. **MATERIALS SHOWING LIQUID PENETRATION CAN STILL ALLOW CHEMICAL PERMEATION.**
Primary materials shall resist ignition and burning resulting from flame impingement.	4-2.3	4-2.3		***NFPA Test Protocol (Modification of Method 5903.1, FTMS 191A):*** A folded material sample is placed in a vertical flame chamber. A flame of specified characteristics is applied to the material's folded edge for 3 seconds. If the sample ignites, the test is discontinued. If the sample does not ignite, the flame is reapplied to the same specimen for 12 seconds. If the sample ignites during this subsequent exposure, the time the material continues to burn and the distance burned are measured. Observations of burning behavior are also recorded.	Materials fail if they ignite during the first 3-second flame exposure. Samples that ignite during the subsequent 12-second exposure can only burn for 10 seconds or less and have burn distances less than 4 in. This requirement is intended to eliminate the use of materials that contribute to the suit wearer's hazards. **THIS REQUIREMENT DOES NOT IMPLY PROTECTION FROM OPEN FLAME OR OTHER SEVERE HEAT EXPOSURES.**
Garment materials shall resist chemical *permeation* after abrasion.	4-3.1			***ASTM D4157/F739:*** A sample of material is placed on an oscillating drum-like abrading machine. A special coarse sandpaper is used to abrade the material for 25 back and forth cycles at a specified tension and pressure. Circular specimens are then cut out of the abraded material and tested for chemical permeation resistance as described above.	Abraded primary materials must show normalized breakthrough detection times of 1 hour or greater for all test chemicals. The type of abrasion provided by the test simulates abrasion that might occur from crawling on an asphalt surface. The amount of abrasion was selected to be consistent with a single wearing of the suit.