



Designation: F2704 – 10

Standard Specification for Air-Fed Protective Ensembles¹

This standard is issued under the fixed designation F2704; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reappraisal. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reappraisal.

1. Scope

1.1 This specification establishes design, performance, classification, documentation, labeling, and certification requirements for protective ensembles that deliver air to the wearer by means of an air line or powered air purifying respirator (PAPR).

1.2 As a prerequisite to this specification, regulations within Title 42 Federal Code of Regulations, Part 84 are used to establish the conformance of the air-fed protective ensemble to respiratory protection requirements.

1.3 This specification addresses protective ensembles used for environments involving chemical, biological, and radiological particulate hazards.

1.4 This specification sets specific criteria for air-fed protective ensembles used to prevent exposure substances such as but not limited to chemical hazards, infectious microorganisms requiring Biosafety Level 4 protection, and environments where it is possible radiological particulates will be found.

1.5 This specification can be used for classification of the protective ensemble.

1.6 The values stated in SI units or in other units shall be regarded separately as standard. The values stated in each system must be used independently of the other, without combining values in any way.

1.7 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*²

D751 Test Methods for Coated Fabrics

¹ This specification is under the jurisdiction of ASTM Committee F23 on Personal Protective Clothing and Equipment and is the direct responsibility of Subcommittee F23.30 on Chemicals.

Current edition approved Aug. 1, 2010. Published September 2010. DOI:10.1520/F2704-10.

² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

- D1630 Test Method for Rubber Property—Abrasion Resistance (Footwear Abrader)**
- D1776 Practice for Conditioning and Testing Textiles**
- D2582 Test Method for Puncture-Propagation Tear Resistance of Plastic Film and Thin Sheeting**
- D3787 Test Method for Bursting Strength of Textiles—Constant-Rate-of-Traverse (CRT) Ball Burst Test**
- D3884 Guide for Abrasion Resistance of Textile Fabrics (Rotary Platform, Double-Head Method)**
- D4157 Test Method for Abrasion Resistance of Textile Fabrics (Oscillatory Cylinder Method)**
- D5034 Test Method for Breaking Strength and Elongation of Textile Fabrics (Grab Test)**
- D5151 Test Method for Detection of Holes in Medical Gloves**
- D5587 Test Method for Tearing Strength of Fabrics by Trapezoid Procedure**
- F392 Test Method for Flex Durability of Flexible Barrier Materials**
- F489 Test Method for Using a James Machine (Withdrawn 2005)³**
- F739 Test Method for Permeation of Liquids and Gases through Protective Clothing Materials under Conditions of Continuous Contact**
- F903 Test Method for Resistance of Materials Used in Protective Clothing to Penetration by Liquids**
- F1052 Test Method for Pressure Testing Vapor Protective Suits**
- F1154 Practices for Qualitatively Evaluating the Comfort, Fit, Function, and Durability of Protective Ensembles and Ensemble Components**
- F1342 Test Method for Protective Clothing Material Resistance to Puncture**
- F1359 Test Method for Liquid Penetration Resistance of Protective Clothing or Protective Ensembles Under a Shower Spray While on a Mannequin**
- F1494 Terminology Relating to Protective Clothing**
- F1671 Test Method for Resistance of Materials Used in Protective Clothing to Penetration by Blood-Borne Pathogens Using Phi-X174 Bacteriophage Penetration as a Test System**

³ The last approved version of this historical standard is referenced on www.astm.org.

F1790 Test Method for Measuring Cut Resistance of Materials Used in Protective Clothing with CPP Test Equipment

F2010 Test Method for Evaluation of Glove Effects on Wearer Hand Dexterity Using a Modified Pegboard Test

F2061 Practice for Chemical Protective Clothing: Wearing, Care, and Maintenance Instructions

F2413 Specification for Performance Requirements for Protective (Safety) Toe Cap Footwear

2.2 Federal Standards:⁴

21 CFR Part 7, Subpart C Recall Procedures

42 CFR Part 84 Approval of Respiratory Protective Devices

2.3 ISO Standards:⁵

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

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

ISO Guide 65:1996 General requirements for bodies operating product certification systems

ISO 9001:2000 Quality management systems — requirements.

ISO 17011:2004 General requirements for accreditation bodies accrediting conformity assessment bodies

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

ISO 17491:2001 Protective Clothing – Protection Against Gaseous and Liquid Chemicals – Determination of Resistance of Protective Clothing by Liquids and Gases

2.4 NFPA Standard:⁶

NFPA 991:2005 Standard on Vapor-Protective Ensembles for Hazardous Materials Emergencies

3.1.4 *authority having jurisdiction, n*—an organization, office, or individual responsible for enforcing the requirements of a code or standard, or for approving equipment, materials, an installation, or a procedure.

3.1.5 *barrier material, n*—The layer of a protective clothing item that is designated as providing permeation or penetration resistance against chemicals or other hazardous substances.

3.1.5.1 *Discussion*—In this specification, the barrier material refers to the layer of the protective ensemble element that is designed to act as a barrier to a hazardous substance that the ensemble is intended to protect against.

3.1.6 *blood-borne pathogen, n*—an infectious bacterium or virus, or other disease inducing microbe carried in the blood or other potentially infectious body fluids (also liquid-borne pathogen).

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

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

3.1.9 *manufacturer, n*—the entity that directs and controls any of the following: compliant product design, compliant product manufacturing, or compliant product quality assurance; or the entity that assumes the liability for the compliant product or provides the warranty for the compliant product.

3.1.10 *protective ensemble, n*—the combination of protective clothing with respiratory protective equipment, hoods, helmets, gloves, boots, communication systems, cooling devices, and other accessories intended to protect the wearer from a potential hazard when worn together.

3.2 For definitions of other protective clothing-related terms used in this test method, refer to Terminology **F1494**.

4. Significance and Use

4.1 As with other hazardous materials protective ensembles, air-fed protective ensembles include clothing and equipment items needed for dermal and respiratory protection, including protective suits, gloves, footwear, and eye/face protection. Unlike other protective ensembles, air-fed protective ensembles do not use separate respiratory protective devices such as self-contained breathing apparatus (SCBA) or non-powered air-purifying respirators (APR's).

4.1.1 Those types of respirators normally have a tight fitting face piece that provides inhalation hazard protection and dermal exposure protection to the face, eyes, nose, and mouth.

3. Terminology

3.1 Definitions:

3.1.1 *airborne pathogen, n*—an infectious bacterium or virus, or other disease inducing microbe that is suspended in air.

3.1.2 *air-fed protective ensemble, n*—a protective ensemble with respiratory protective equipment that provides a source of air directly into the ensemble without the use of a tight-fitting facepiece worn by the individual inside the ensemble.

3.1.2.1 *Discussion*—The respiratory protective equipment is either an airline that is connected to the suit wall of the ensemble that can include a distribution means inside the ensemble or a powered air-purifying respirator that is connected to the suit wall and that can also have a means for distributing air inside the ensemble.

3.1.3 *approved, v*—acceptable to the authority having jurisdiction.

⁴ Available from U.S. Government Printing Office Superintendent of Documents, 732 N. Capitol St., NW, Mail Stop: SDE, Washington, DC 20401, <http://www.access.gpo.gov>.

⁵ Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, <http://www.ansi.org>.

⁶ Available from National Fire Protection Association (NFPA), 1 Batterymarch Park, Quincy, MA 02169-7471, <http://www.nfpa.org>.

4.1.2 Air-fed protective ensembles are worn without the use of a separate respirator. The entire suit serves as the respiratory protective device and also provides dermal exposure protection. The wearer breathes supplied air or filtered air pumped into the protective suit.

4.2 Air-fed protective ensembles are used to protect workers in a number of applications.

4.2.1 These include, but are not limited to: chemical and pharmaceutical manufacturing, remediation of hazardous materials sites, use against highly infectious biological agents in BioSafety Level 4 laboratories, and for protection of workers involved in nuclear facilities, where it is possible radioactive particles will be encountered.

4.3 The requirements of this specification have been partly based on the NFPA 1991 Standard, which establishes criteria for vapor-protective ensembles used in hazardous materials emergencies. NFPA 1991 establishes requirements for a protective ensemble that encapsulates the wearer and the breathing apparatus.

4.3.1 In this specification, a breathing apparatus is not worn inside the suit, but instead breathing air is connected to the suit either via an external airline or respiratory protective equipment that is externally connected to the suit wall. Extensive criteria for the integrity of the overall ensemble are applied through design and performance criteria. This allows for different configurations of a protective ensemble that incorporates a hooded visor, protective gloves, protective footwear, and the respiratory protective equipment.

4.4 The qualification of the respiratory protective equipment is addressed by the applicable requirements for respirators established in 42 CFR Part 84. As such, the entire air-fed ensemble is subject to certification by NIOSH in addition to meeting the requirements in this specification.

4.5 This specification establishes classifications for the protective ensemble. The classifications include one that is determined by the configuration of the protective ensemble and one that concerns the use of the protective ensemble.

4.5.1 A protective ensemble can be classified as a “Airline Protective Ensemble” or a “PAPR-Based Air-Fed Protective Ensemble”. Under each of these classifications, protective ensembles can be further classified as “Limited Use” and “Multiple-Use”.

4.5.2 These classifications account for differences in the configuration of the air supply and material strength and durability. These classifications do not account for the decontamination effectiveness of multiple use ensembles.

4.6 In recognition of the potential diverse applications to which the protective ensemble can be used, documentation requirements are provided for manufacturers to base claims for permeation resistance of ensemble materials against specific chemicals or for claims of ensemble material performance against bloodborne (or liquidborne) pathogens. Similar requirements are established for the respiratory protective equipment, when this equipment is based on the use of filters, cartridges, or canisters.

4.7 An extensive section is provided in the specification addressing the certification of air-fed protective ensembles.

This certification section is based on provisions established in NFPA 1991 and other National Fire Protection Association product standards for emergency services protective clothing and equipment.

5. Classification

5.1 Protective ensembles shall be classified as either an “Airline Protective Ensemble” or a “PAPR-Based Air-Fed Protective Ensemble” depending on the type of respiratory protective equipment that is provided with the ensemble.

5.2 Protective ensembles shall additionally be classified as limited use or multiple-use.

5.2.1 Limited use protective clothing items shall be subject to the labeling requirement in 12.6.1. Multiple-use garments shall be subject to additional conditions as part of testing as specified in Sections 10 and 11, labeling requirements as specified in 12.6.2, and technical information requirements as specific in 14.1.6 and 14.1.7. In order to qualify as a multiple-use ensemble, all elements of the ensemble shall meet every applicable multiple-use requirement.

5.3 All protective ensembles classified to this specification shall meet the applicable design requirements specified in Section 6, performance requirements specified in Section 7, documentation requirements as specified in Section 8, applicable labeling requirements specified in Section 12, user information requirements specified in Section 13, and technical information requirements in Section 14.

6. Design Requirements

6.1 Protective Ensembles and Suits

6.1.1 Ensemble Coverage

6.1.1.1 Air-fed protective ensembles shall be designed and configured to protect the wearer’s torso, head, arms, legs, hands, and feet, and shall completely enclose the wearer.

6.1.2 Ensemble Components

6.1.2.1 Air-fed protective ensembles shall consist of a suit with hood, gloves, footwear, and respiratory protective equipment.

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

6.1.2.3 The visor shall be constructed of a transparent material that qualifies as a barrier layer.

6.1.2.4 Air-fed protective ensembles shall be permitted to be constructed using an outer garment designed to be worn over the suit element where such additional garments are necessary to meet the suit and ensemble requirements of this standard.

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

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

6.1.2.7 Other than outer gloves and outer boots, air-fed protective ensembles shall be designed so that all separate

ensemble components necessary to meet the applicable requirements of this specification, are attached and provided from the manufacturer as a single and integrated unit.

6.1.3 *Respiratory Protective Equipment and Exhaust Valves*

6.1.3.1 Air-fed protective ensembles shall be provided with respiratory protective equipment that includes either an airline connection to the suit and associated components for the distribution of air to the suit interior, or a powered air-purifying respirator that is connected to the ensemble with pass-throughs into the ensemble to enable the distribution of air inside the ensemble.

6.1.3.2 Respiratory equipment used as part of the air-fed protective ensemble shall meet the applicable requirements in 42 CFR Part 84.

6.1.3.3 Areas of connection or pass-throughs to the suit or ensemble shall be reinforced with additional material for a minimum of 50 mm (2 in.) away from the outer edge of the connection or pass-through.

6.1.3.4 Air-fed protective ensembles shall be equipped with one or more one-way exhaust valve(s).

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

6.1.3.6 The mounting mechanism of exhaust valves that are intended to be removable and are not permanently attached to the suit shall be designed to allow their removal for inspection and reinstallation or replacement from the air-fed protective ensemble.

6.1.3.7 Protective covers or pockets constructed shall be provided to protect the exhaust valves from direct chemical splashes to the seat of the exhaust valve(s). The pockets or covers shall allow access to the valves for inspection and removal when not permanently attached to the suit.

6.1.4 *Materials of Construction*

6.1.4.1 The air-fed protective ensemble suit with hood and visor, gloves, and footwear shall be constructed of materials that shall provide the protection from contamination and physical hazards. These materials shall be configured as a separate layer or as a composite.

6.1.4.2 The materials used in the construction of the air-fed protective ensemble shall include a barrier material.

6.1.4.3 The barrier layer shall be designed to prevent the permeation or penetration of outside contaminants and provide overall integrity of the protective ensemble.

6.1.4.4 The barrier material shall be permitted to depend on the other materials to provide the physical protection.

6.1.5 *Sizing*

6.1.5.1 Air-fed protective ensembles shall be offered in at least four unique and different sizes.

6.1.6 *Hardware Quality*

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

6.2 *Protective Gloves*

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

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

6.2.3 Gloves shall be permitted to be either single gloves or a glove system consisting of multiple gloves.

6.2.4 Where single gloves are used, the gloves shall be constructed of a barrier material.

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

6.2.6 Where glove systems are used, one of the gloves shall be constructed of a barrier material to prevent the permeation or penetration of outside contaminants and provide overall integrity of the protective ensemble.

6.2.7 Gloves shall be attached to the sleeve of the suit in the air-fed ensemble using interface components or directly welded to the suit to provide overall integrity of the protective ensemble.

6.2.8 The interface of glove to air-fed protective suit sleeve shall be designed to permit its removal and replacement of the gloves attached to each suit sleeve within 30 minutes unless the gloves are permanently attached to the suit.

6.2.9 Gloves or glove systems shall be offered in a minimum of four unique sizes.

6.2.10 All external hardware and fittings used in the glove to suit interface shall be free of rough spots, burrs, or sharp edges that could tear materials.

6.3 *Protective Footwear*

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

6.3.2 Footwear shall be permitted to be either a single boot, a footwear system consisting of a bootie and an outer boot, or a footwear system consisting of an inner boot with a boot cover.

6.3.3 The footwear or footwear system shall provide protection not less than 200 mm (8 in.) in height when measured from the plane of the sole bottom.

6.3.4 The footwear or footwear system shall be constructed using materials that shall provide the protection from chemical and physical hazards. These materials shall be configured as a separate layer or as a composite.

6.3.5 The footwear or footwear system shall be attached to the air-fed protective ensemble using interface components to provide overall integrity of the protective ensemble.

6.3.6 *Single Boot Footwear*

6.3.6.1 Where the footwear is designed as a single boot, the boot shall be constructed of a barrier material that is designed to prevent the permeation or penetration of outside contaminants and provide overall integrity of the protective ensemble.

6.3.7 *Bootie and Outer Boot Footwear System*

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

6.3.7.2 Where the footwear is designed as a bootie in combination with an outer boot, the bootie shall be constructed of barrier material that is designed to prevent the permeation or

penetration of outside contaminants and provide overall integrity of the protective ensemble.

6.3.8 *Inner Boot and Boot Cover Footwear System*

6.3.8.1 Boot covers, where provided, shall be designed to provide coverage of the entire inner boot.

6.3.8.2 Where the footwear is designed as an inner boot with a boot cover, the inner boot shall be constructed of barrier material that is designed to prevent the permeation or penetration of outside contaminants and provide overall integrity of the protective ensemble.

6.3.9 *Footwear or Footwear System Hardware*

6.3.9.1 All external hardware and fittings used in the footwear, footwear system, and interface with the suit shall be free of rough spots, burrs, or sharp edges that could tear materials.

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

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

7. Performance Requirements

7.1 *Protective Ensemble*

7.1.1 Complete air-fed protective ensembles, consisting of suit with hood, gloves, footwear, and respiratory protective equipment shall be tested for the performance properties and shall meet the criteria for the respective ensemble class as specified in **Table 1**.

7.1.2 Exhaust valves installed in air-fed protective ensembles shall be tested for mounting strength as specified in **11.6** and shall have a failure force greater than 135 N (30 lbf).

7.1.3 External fittings installed in air-fed protective ensembles shall be tested for pull-out strength as specified in **11.7** and shall have a failure force greater than 1000 N (225 lbf).

7.2 *Protective Suit*

7.2.1 Suit materials and seams joining suit materials used in the construction of the suit, including the hood but excluding the visor, shall be tested for the performance properties and shall meet the criteria for the respective ensemble class as specified in **Table 2**.

7.2.2 Visor materials and seams joining the visor material to suit materials used in the construction of the suit shall be tested for the performance properties and shall meet the criteria for the respective ensemble class as specified in **Table 3**.

7.2.3 Where a visor is rigid that cannot be tested for burst strength or puncture propagation tear resistance, the tests for burst strength and puncture propagation tear resistance shall not be required.

7.3 *Protective Gloves*

7.3.1 Gloves and glove materials shall be tested for the performance properties and shall meet the criteria for the respective ensemble class as specified in **Table 4**.

7.4 *Protective Footwear*

7.4.1 *Single Boot Footwear*

7.4.1.1 The boot shall meet be classified for impact resistance, compression resistance, and puncture resistance as specified in Specification **F2413**.

NOTE 1—Specification **F2413** established two classifications each for impact and compression resistance. The choice of the appropriate classification is based on a hazard assessment.

7.4.1.2 The boot shall be tested for the performance properties and shall meet the criteria for the respective ensemble class as specified in **Table 5**.

7.4.2 *Bootie and Outer Boot Footwear System*

7.4.2.1 The outer boot shall be classified for impact resistance, compression resistance, and puncture resistance as specified in Specification **F2413**.

NOTE 2—Specification **F2413** established two classifications each for impact and compression resistance. The choice of the appropriate classification is based on a hazard assessment.

7.4.2.2 The outer boot shall be tested for the performance properties and shall meet the criteria for the respective ensemble class as specified in **Table 5**.

7.4.2.3 The bootie shall be tested for the performance properties and shall meet the criteria for the respective ensemble class as specified in **Table 2**. The bootie shall be permitted to have a lower classification than the suit material.

7.4.3 *Inner Boot and Boot Cover Footwear System*

7.4.3.1 The inner boot shall meet be classified for impact resistance, compression resistance, and puncture resistance as specified in Specification **F2413**.

NOTE 3—Specification **F2413** established two classifications each for impact and compression resistance. The choice of the appropriate classification is based on a hazard assessment.

7.4.3.2 The inner boot shall be tested for the performance properties and shall meet the criteria for the respective ensemble class as specified in **Table 5**.

TABLE 1 Protective Ensemble Performance Requirements

Performance Property	Test Method (paragraph)	Criteria
Maintenance of positive pressure	ASTM F1052 (11.1)	Ending pressure \leq 80 mm water gauge pressure Test subjects complete all tasks
Ergonomic impact on wearer	ASTM F1154 (11.2)	Test subjects are able to read eye chart to 20/35 through visor Test subjects are able to withdraw and reinsert hands into gloves or glove system Test subjects are able to execute emergency doffing within 60 seconds
Air flow capacity	(11.3)	Ensemble internal pressure \leq 100 mm water gauge pressure Ending pressure after evaluation \geq 80 mm water gauge pressure
Liquid inward leakage	ASTM F1359 (11.4)	No liquid penetration to interior of ensemble
Sulfur hexafluoride inward leakage	ISO 17491 (11.5)	No liquid accumulation in outer gloves or outer boots Inward leakage \leq 0.2 %

TABLE 2 Protective Suit Material and Seam Performance Requirements

Performance Property	Test Item	Test Method (paragraph)	Limited Use	Multiple Use
Liquid penetration resistance	Material and seams ^A	ASTM F903 (11.8)	Pass	Pass
Tensile strength	Material only ^B	ASTM D5034 (11.9)	≥ 100 N	≥ 225 N
Tear resistance	Material only ^B	ASTM D5587 (11.10)	≥ 20 N	≥ 40 N
Burst strength	Material only ^C	ASTM D3787 (11.11)	≥ 150 N	≥ 300 N
Puncture Propagation Tear resistance	Material only ^C	ASTM D2582 (11.12)	≥ 5 N	≥ 12 N
Abrasion resistance	Material only ^C	ASTM D3884 (11.13)	≥ 500 cycles	≥ 2,000 cycles
Seam strength	Seams only ^B	ASTM D751 (11.14)	≥ 40 N	≥ 100 N
Closure strength	Closure only	ASTM D751 (11.14)	≥ 100 N	≥ 225 N

^A Applied to the barrier material and seams only; different preconditions applied to limited use and multiple use materials.

^B Applied to each material layer or material layer seam used in the construction of the suit and hood.

^C Where combinations of materials are used as a composite, applied to the combination of the layers in the order as found in the construction of the suit or hood.

TABLE 3 Protective Suit Visor Material and Seam Performance Requirements

Performance Property	Test Item	Test Method (paragraph)	Limited Use	Multiple Use
Liquid penetration resistance	Material and seams ^A	ASTM F903 (11.8)	PASS	PASS
Burst strength	Material only ^B	ASTM D3787 (11.11)	≥ 150 N	≥ 300 N
Puncture Propagation Tear resistance	Material only ^B	ASTM D2582 (11.12)	≥ 5 N	≥ 10 N
Seam strength	Seams only ^C	ASTM D751 (11.14)	≥ 40 N	≥ 100 N

^A Applied to the barrier material and seams only; different preconditioning applied to limited use and multiple use materials.

^B Where combinations of materials are used as a composite in the construction of the suit visor, applied to the combination of the layers in the order as found in the construction of the suit visor.

^C Applied to each material layer or material layer seam used in the construction of the suit and hood.

TABLE 4 Protective Glove, Glove Material, and Glove Seam Performance Requirements

Performance Property	Test Item	Test Method (paragraph)	Limited Use	Multiple Use
Liquid leakage	Whole gloves ^A	ASTM D5151 (11.15)	PASS	PASS
Liquid penetration resistance	Seams only ^B	ASTM F903 (11.8)	PASS	PASS
Cut resistance	Material only ^C	ASTM F1790 (11.17)	≥ 50 g	≥ 200 g
Puncture resistance	Material only ^C	ASTM F1342 (11.16)	≥ 8 N	≥ 30 N
Abrasion resistance	Material only ^C	ASTM D3884 (11.13)	≥ 500 cycles	≥ 2000 cycles
Hand function	Whole gloves ^D	ASTM F2010 (11.18)	≤ 150%	≤ 300%

^A Where a glove system is used consisting of two or more gloves, applied only to the glove providing the barrier material.

^B Applied to the barrier material and seams only.

^C Where a glove system is used consisting of two or more layers, applied to all glove materials in the order as found in the construction of the glove system.

^D Applied to the whole glove system.

[ASTM F2704-10](https://standards.iteh.ai/catalog/standards/sist/26d5467-0581-4541-926f-51050bb0ecde/astm-f2704-10)

<https://standards.iteh.ai/catalog/standards/sist/26d5467-0581-4541-926f-51050bb0ecde/astm-f2704-10>

TABLE 5 Protective Footwear Performance Requirements

Performance Property	Test Item	Test Method (paragraph)	Limited Use	Multiple Use
Liquid leakage	Whole footwear ^A	ASTM D5151 (11.15)	PASS	PASS
Liquid penetration resistance	Seams only ^B	ASTM F903 (11.8)	PASS	PASS
Cut resistance	Upper material only	ASTM F1790 (11.17)	≥ 200 g	≥ 400 g
Puncture resistance	Upper material only	ASTM F1342 (11.16)	≥ 20 N	≥ 50 N
Abrasion resistance	Upper material only	ASTM D3884 (11.13)	≥ 1000 cycles	≥ 4000 cycles
Sole slip resistance	Sole material only	ASTM F489 (11.20)	≥ 0.75	≥ 0.75
Sole abrasion resistance	Sole material only	ASTM D1630 (11.19)	≥ 65 Index	≥ 65 Index

^A Where a footwear system is used, applied to the outer boot for a footwear system consisting of bootie with outer boot or applied to the boot cover for a footwear system consisting of inner boot with boot cover.

^B Applied to the barrier material and seams of the footwear cover only when the footwear system consists of an inner boot with boot cover.

7.4.3.3 The boot cover shall be tested for the performance properties and shall meet the criteria for the respective ensemble class as specified in **Table 2**. The boot cover shall be permitted to have a lower classification than the suit material.

8. Documentation Requirements

8.1 Chemical Protection

8.1.1 Where the manufacturer makes specific claims for permeation resistance of materials used in the construction of air-fed protective ensembles against specific chemicals, testing shall be performed on the suit material, suit seams, hood material (if different), visor material and visor seams, glove or glove system material and seams, and footwear system materials as specified in **11.21** for each chemical. Acceptable