NFPA® 1970

Standard on Protective Ensembles for Structural and Proximity Firefighting, Work Apparel, Open-Circuit Self-Contained Breathing Apparatus (SCBA) for Emergency Services, and Personal Alert Safety Systems (PASS)

2025 Edition

NFPA, 1 Batterymarch Park, Quincy, MA 02169-7471
An International Codes and Standards Organization

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NFPA® 1970

Standard on

Protective Ensembles for Structural and Proximity Firefighting, Work Apparel, Open-Circuit Self-Contained Breathing Apparatus (SCBA) for Emergency Services, and Personal Alert Safety Systems (PASS)

2025 Edition

This edition of NFPA 1970, *Standard on Protective Ensembles for Structural and Proximity Firefighting, Work Apparel, Open-Circuit Self-Contained Breathing Apparatus (SCBA) for Emergency Services, and Personal Alert Safety Systems (PASS)*, was prepared by the Technical Committee on Structural and Proximity Firefighting Protective Clothing and Equipment, and acted on by the NFPA membership during the 2024 NFPA Technical Meeting held June 20, 2024. It was issued by the Standards Council on August 29, 2024, with an effective date of September 18, 2024.

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

This edition of NFPA 1970 was approved as an American National Standard on September 18, 2024.

Origin and Development of NFPA 1970

The first edition of NFPA 1970 consolidates four standards — NFPA 1971, *Standard on Protective Ensembles for Structural Firefighting and Proximity Firefighting*; NFPA 1975, *Standard on Emergency Services Work Apparel*; NFPA 1981, *Standard on Open-Circuit Self-Contained Breathing Apparatus (SCBA) for Emergency Services*; and NFPA 1982, *Standard on Personal Alert Safety Systems (PASS)* — as part of the emergency response and responder safety (ERRS) document consolidation project (nfpa.org/errs), which was approved by the NFPA Standards Council in April 2019.

NFPA 1970 comprises four chapters of general information and requirements applicable to the entire standard and four sets of five chapters applicable to each product type. Chapter 1 establishes administrative guidance for the entire standard, including an application statement in Section 1.3 that assists users with locating the specific content from each of the combined standards. Product-specific administrative information is found in the first chapter that applies to each product type (Chapters 5, 10, 15, and 20). Chapter 2 contains a list of all mandatory references, and Chapter 3 contains all definitions. Chapter 4 combines the certification requirements that are common to all product types, while the unique certification requirements for each product type are in dedicated chapters (Chapters 5, 10, 15, and 20).

The requirements for structural and proximity firefighting protective ensembles are in Chapters 5 through 9. Throughout the development of this edition, there was a determined focus on protection against exposure to hazardous substances and contamination, including new requirements for restricted substances, ease of cleaning, and ease of helmet disassembly for cleaning. Further, performance criteria and a test method for evaporative resistance (breathability) were added for certain ensemble elements to promote better cooling in warm environments. Liquid and particulate protection was applied to garments instead of ensembles, particulate protection was made mandatory for structural firefighting hoods, and a new liquid barrier test replaced the bacterial resistance test for garments. Glove sizing was revised to allow for better fit for women. In addition, there were many general improvements and clarifications throughout these chapters.

The requirements for emergency services work apparel are in Chapters 10 through 14. No significant changes over the last edition of NFPA 1975 were made.

The requirements for open-circuit self-contained breathing apparatus are in Chapters 15 through 19. Some of the changes over the last edition of NFPA 1981 include the addition of cleaning instructions in manufacturer information to complement those for textiles, new requirements to ensure that wired connections are compatible with PASS devices, and updated EOSTI activation pressures and HUD interface icons.

The requirements for personal alert safety systems (PASS) are in Chapters 20 through 24. Some of the changes over the last edition of NFPA 1982 include revised label requirements to decrease the label font size to align with that for radios, a new allowance to provide user information digitally, and many improvements to clarity and consistency.

Finally, a tremendous accomplishment for this edition came through the Hazardous Locations Harmonization Task Group, which included committee members from the technical committees responsible for NFPA 1970 and NFPA 1930. The task group was able to align the requirements for nonincendive and intrinsically safe electronic equipment and systems worn or carried by firefighters, including protective clothing, SCBA, PASS devices, and portable radios.

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Committee Scope: This Committee shall have primary responsibility for documents on the design, performance, testing, and certification of protective clothing and protective equipment manufactured for fire and emergency services organizations and personnel, to protect against exposures encountered during emergency incident operations. This Committee shall also have the primary responsibility for documents on the selection, care, and maintenance of such protective clothing and protective equipment by fire and emergency services organizations and personnel.

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Committee Scope: This committee shall have primary responsibility for documents on the design, performance, testing, and certification of electronic safety equipment used by fire and emergency services personnel during emergency incident operations, and shall also have primary responsibility for documents on the selection, care, and maintenance of electronic safety equipment.

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Committee Scope: This Committee shall have primary responsibility for documents on respiratory equipment, including breathing air, for fire and emergency services personnel during incidents involving hazardous or oxygen deficient atmospheres. This Committee shall also have primary responsibility for documents on the selection, care, and maintenance of respiratory protection equipment and systems by fire and emergency services organizations and personnel.

Technical Committee on Special Operations Protective Clothing and Equipment

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Committee Scope: This Committee shall have primary responsibility for documents on special operations protective clothing and protective equipment, except respiratory equipment, that provides hand, foot, torso, limb, head, and interface protection for firefighters and other emergency services responders during incidents involving special operations functions including, but not limited to, structural collapse, trench rescue, confined space entry, urban search and rescue, high angle/mountain rescue, vehicular extraction, swift water or flooding rescue, contaminated water diving, and air operations. This Committee shall also have primary responsibility for documents on station/work uniform garments that are not of themselves primary protective garments but can be combined with a primary protective garment to serve dual or multiple functions. Additionally, this Committee shall have primary responsibility for documents on the selection, care, and maintenance of special operations protective clothing and equipment by fire and emergency services organizations and personnel.

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

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

Committee Scope: This Committee shall have primary responsibility for documents on protective ensembles, except respiratory protection, that provides head, limb, hand, foot, torso, and interface protection for firefighters and other emergency services responders during incidents involving structural firefighting operations or proximity firefighting operations. Structural firefighting operations include the activities of rescue, fire suppression, and property conservation during incidents involving fires in buildings, enclosed structures, vehicles, marine vessels, or like properties. Proximity firefighting operations include the activities of rescue, fire suppression, and property conservation during incidents involving commercial and military aircraft fires, bulk flammable gas fires, bulk flammable and combustible liquids fires, combustible metal fires, exotic fuel fires, and other such fires that produce very high levels of radiant heat as well as convective and conductive heat. Additionally, this Committee shall have primary responsibility for documents on the selection, care, and maintenance of structural and proximity firefighting protective ensembles by fire and emergency services organizations and personnel.

Contents

NFPA 1970

Standard on

Protective Ensembles for Structural and Proximity Firefighting, Work Apparel, Open-Circuit Self-Contained Breathing Apparatus (SCBA) for Emergency Services, and Personal Alert Safety Systems (PASS)

2025 Edition

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

A reference in brackets [ ] following a section or paragraph indicates material that has been extracted from another NFPA document. Extracted text may be edited for consistency and style and may include the revision of internal paragraph references and other references as appropriate. Requests for interpretations or revisions of extracted text shall be sent to the technical committee responsible for the source document.

Information on referenced and extracted publications can be found in Chapter 2 and Annex H.

Chapter 1 Administration

1.1 Scope.

1.1.1* This standard provides minimum design, performance, testing, and certification requirements for the following:

(1) New structural and proximity firefighting protective ensembles and ensemble elements that include coats, trousers, coveralls, helmets, gloves, footwear, and hoods, which further include optional requirements for structural firefighting protective garments and proximity firefighting garments that provide limited protection from liquid and particulate hazards
(2) New nonprimary work apparel and individual garments composing work apparel, which further include optional requirements for the following where such options are specified or claimed to be used in the construction of work apparel:
    (a) Flame resistance
    (b) Water resistance
    (c) Insect repellency
(3) New compressed breathing air open-circuit self-contained breathing apparatus (SCBA) and compressed breathing air combination open-circuit self-contained breathing apparatus and supplier air respirators (SCBA/SARs)
(4) New personal alert safety systems (PASS) for emergency services personnel that include stand-alone PASS, integrated PASS, and RF PASS in addition to PASS or RF PASS devices certified to an earlier edition of NFPA 1982 that incorporate parts, components, or software to meet the 2025 edition of NFPA 1970

1.1.1.1 This standard provides minimum design, performance, testing, and recognition requirements for new components that are utilized to construct structural and proximity firefighting ensembles and ensemble elements and nonprimary work apparel.

1.1.2 This standard shall also specify requirements for the thermal stability of textiles used in the construction of work apparel.

1.1.3 This standard shall also specify minimum requirements for the design, performance, and testing of replacement parts, components, and add-on accessories for SCBA and combination SCBA/SARs certified as compliant to earlier editions of NFPA 1981.

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

1.2 Purpose.

1.2.1 The purpose of this standard is to specify minimum requirements for the following:

(1) Establishing minimum levels of protection for firefighting personnel assigned to fire department operations, including but not limited to structural firefighting, proximity firefighting, rescue, emergency medical, and other emergency first responder functions
(2) Providing emergency services personnel with work apparel that will not contribute to burn injury severity, which further establishes the following:
    (a) Optional flame resistance requirements and tests to verify the flame resistance of textiles where the authority having jurisdiction specifies the use of flame-resistant textiles for the construction of work apparel, or where the manufacturer represents work apparel textiles as flame resistant
    (b) Optional liquid resistance requirements and tests to verify the liquid resistance of textiles where the authority having jurisdiction specifies the use of liquid-resistant textiles for the construction of work apparel, or where the manufacturer represents work apparel textiles as having liquid-resistant properties
    (c) Optional insect repellency requirements and tests to verify the insect repellency of textiles where the authority having jurisdiction specifies the use of insect-repellent textiles for the construction of work apparel, or where the manufacturer represents work apparel textiles as having insect-repellent properties

(3) Establishing minimum levels of protection for emergency services personnel from atmospheres that are categorized as immediately dangerous to life and health (IDLH)
(4) Establishing minimum requirements for PASS that are intended for use by emergency services personnel during emergency operations and that emit an audible signal to summon aid in the event the user becomes incapacitated or needs assistance, which further establishes minimum requirements for the following:
  (a) Optional RF PASS that are capable of transmitting an alarm signal and receiving an evacuation alarm via an RF signal
  (b) The base station used in optional RF PASS for the receipt of an alarm signal and the transmission of an evacuation alarm via an RF signal

1.2.2 This standard shall not be intended to serve as a detailed manufacturing or purchasing specification but shall be permitted to be referenced in purchase specifications as minimum requirements.

1.2.3* This standard shall address optional, nonmandatory testing for full structural and proximity firefighting protective ensembles in different areas of overall systems performance as addressed in Annex G.

1.3* Application. This standard shall be applied as follows:

(1) Chapters 1 through 9 and Annexes A, B, G, and H constitute NFPA 1971.
(2) Chapters 1 through 4, 10 through 14, and Annexes A, C, and H constitute NFPA 1975.
(3) Chapters 1 through 4, 15 through 19, and Annexes A, D, and H constitute NFPA 1981.
(4) Chapters 1 through 4, 20 through 24, and Annexes A, E, F, and H constitute NFPA 1982.

1.4 Units.

1.4.1 In this standard, values for measurement are followed by an equivalent in parentheses, but only the first stated value shall be regarded as the requirement.

1.4.2 Equivalent values in parentheses shall not be considered as the requirement, as these values are approximate.

Chapter 2 Referenced Publications

2.1 General. The documents or portions thereof listed in this chapter are referenced within this standard and shall be considered part of the requirements of this document.

2.2 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 1550, *Standard for Emergency Responder Health and Safety*, 2024 edition.

NFPA 1802, *Standard on Two-Way, Portable RF Voice Communications Devices for Use by Emergency Services Personnel in the Hazard Zone*, 2021 edition.

NFPA 1851, *Standard on Selection, Care, and Maintenance of Protective Ensembles for Structural Fire Fighting and Proximity Fire Fighting*, 2020 edition.

NFPA 1852, *Standard on Selection, Care, and Maintenance of Open-Circuit Self-Contained Breathing Apparatus (SCBA)*, 2019 edition.

NFPA 1951, *Standard on Protective Ensembles for Technical Rescue Incidents*, 2020 edition.

NFPA 1972, *Helmets for Structural Fire Fighting*, 1992 edition (withdrawn).

NFPA 1973, *Gloves for Structural Fire Fighting*, 1993 edition (withdrawn).

NFPA 1974, *Protective Footwear for Structural Fire Fighting*, 1992 edition (withdrawn).

NFPA 1976, *Standard on Protective Ensemble for Proximity Fire Fighting*, 2000 edition (withdrawn).

NFPA 1989, *Standard on Breathing Air Quality for Emergency Services Respiratory Protection*, 2019 edition.

NFPA 2500, *Standard for Operations and Training for Technical Search and Rescue Incidents and Life Safety Rope and Equipment for Emergency Services*, 2022 edition.

2.3 Other Publications.

2.3.1 AAMI Publications. Association for the Advancement of Medical Instrumentation, 901 N. Glebe Road, Suite 300, Arlington, VA 22203.

ANSI/AAMI PB70, *Liquid barrier performance and classification of protective apparel and drapes intended for use in health care facilities*, 2012.

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

AATCC LP1, *Home Laundering: Machine Washing*, 2021.

AATCC TM35, *Test Method for Water Resistance: Rain Test*, 2018e2.

AATCC TM42, *Test Method for Water Resistance: Impact Penetration Test*, 2017e.

AATCC TM61, *Test Method for Colorfastness to Laundering: Accelerated*, 2013, reaffirmed 2020.

AATCC TM70, *Test Method for Water Repellency: Tumble Jar Dynamic Absorption Test*, 2015, reaffirmed 2020.

AATCC TM127, *Test Method for Water Resistance: Hydrostatic Pressure*, 2018.

AATCC TM135, *Test Method for Dimensional Changes of Fabrics after Home Laundering*, 2018.

AATCC TM158, *Test Method for Dimensional Changes on Drycleaning in Perchloroethylene: Machine Method*, 2016e.

2.3.3 AFPS Publications. German Product Safety Committee (Ausschuss für Produktsicherheit, AfPS), Federal Institute for Occupational Safety and Health (BAuA), Postbox 17 02 02, D-44061 Dortmund, Germany.

AfPS GS 2019:01, *Testing and assessment of Polycyclic Aromatic Hydrocarbons (PAHs) in the awarding of GS Marks — Specification pursuant to Article 21 (1) No. 3 of the Product Safety Act (ProdSG)*, 2020.

2.3.4 ASA Publications. Acoustical Society of America, 1305 Walt Whitman Road, Suite 110, Melville, NY 11747-4300.

ANSI/ASA S1.4, *Specification for Sound Level Meters,* 1983, reaffirmed 2006.

ANSI/ASA S1.13, *Measurement of Sound Pressure Levels in Air*, 2020.

ANSI/ASA S3.2, *Method for Measuring the Intelligibility of Speech Over Communication Systems*, 2020.

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

ASTM A666, *Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar*, 2015.

ASTM B117, *Standard Practice for Operating Salt Spray (Fog) Apparatus*, 2019.

ASTM B152/B152M, *Specification for Copper Sheet, Strip Plate, and Rolled Bar*, 2019.

ASTM D471, *Standard Test Method for Rubber Property — Effect of Liquids*, 2016a, reapproved 2021.

ASTM D737, *Standard Test Method for Air Permeability of Textile Fabrics*, 2018.

ASTM D751, *Standard Test Methods for Coated Fabrics*, 2019.

ASTM D975, *Standard Specification for Diesel Fuel*, 2021.

ASTM D1003, *Standard Test Method for Haze and Luminous Transmittance of Transparent Plastics*, 2021.

ASTM D1683/D1683M, *Standard Test Method for Failure in Sewn Seams of Woven Fabrics*, 2017, reapproved 2018.

ASTM D1776/D1776M, *Standard Practice for Conditioning and Testing Textiles*, 2020.

ASTM D1777, *Standard Test Method for Thickness of Textile Materials*, 1996, reapproved 2019.

ASTM D3359, *Standard Test Methods for Rating Adhesion by Tape Test,* 2017.

ASTM D3776/D3776M, *Standard Test Methods for Mass Per Unit Area (Weight) of Fabric*, 2020.

ASTM D3940, *Standard Test Method for Bursting Strength (Load) and Elongation of Sewn Seams of Knit or Woven Stretch Textile Fabrics*, 1983.

ASTM D4157, *Standard Test Method for Abrasion Resistance of Textile Fabrics (Oscillatory Cylinder Method)*, 2013, reapproved 2017.

ASTM D4966, *Standard Test Method for Abrasion Resistance of Textile Fabrics (Martindale Abrasion Test Method)*, 2012, reapproved 2016.

ASTM D5034, *Standard Test Method for Breaking Strength and Elongation of Textile Fabrics (Grab Test)*, 2021.

ASTM D5035, *Standard Test Method for Breaking Force and Elongation of Textile Fabrics (Strip Method)*, 2011, reapproved 2019.

ASTM D5169, *Standard Test Method for Shear Strength (Dynamic Method) of Hook and Loop Touch Fasteners*, 1998, reapproved 2021.

ASTM D5170, *Standard Test Method for Peel Strength ("T" Method) of Hook and Loop Touch Fasteners*, 1998, reapproved 2021.

ASTM D5587, *Standard Test Method for the Tearing Strength of Fabrics by Trapezoid Procedure*, 2015, reapproved 2019.

ASTM D6413/D6413M, *Standard Test Method for Flame Resistance of Textiles (Vertical Test)*, 2015.

ASTM D6775, *Standard Test Method for Breaking Strength and Elongation of Textile Webbing, Tape and Braided Material*, 2013, reapproved 2017.

ASTM D6797, *Standard Test Method for Bursting Strength of Fabrics Constant-Rate-of-Extension (CRE) Ball Burst Test*, 2015.

ASTM D7138, *Standard Test Method to Determine Melting Temperature of Synthetic Fibers*, 2016.

ASTM D7359, *Standard Test Method for Total Fluorine, Chlorine and Sulfur in Aromatic Hydrocarbons and Their Mixtures by Oxidative Pyrohydrolytic Combustion followed by Ion Chromatography Detection (Combustion Ion Chromatography-CIC)*, 2023.

ASTM E162, *Standard Test Method for Surface Flammability of Materials Using a Radiant Heat Energy Source*, 2021.

ASTM E809, *Standard Practice for Measuring Photometric Characteristics of Retroreflectors*, 2021.

ASTM E991, *Standard Practice for Color Measurement of Fluorescent Specimens Using the One-Monochromator Method*, 2021.

ASTM E1164, *Standard Practice for Obtaining Spectrometric Data for Object-Color Evaluation*, 2012, reapproved 2017e1.

ASTM E2152, *Standard Practice for Computing the Colors of Fluorescent Objects from Bispectral Photometric Data*, 2012, reapproved 2017.

ASTM E2153, *Standard Practice for Obtaining Bispectral Photometric Data for Evaluation of Fluorescent Color*, 2001, reapproved 2017.

ASTM F392/F392M, *Standard Practice for Conditioning Flexible Barrier Materials for Flex Durability*, 2011, reapproved 2015.

ASTM F903, *Standard Test Method for Resistance of Materials Used in Protective Clothing to Penetration by Liquids*, 2018.

ASTM F1060, *Standard Test Method for Evaluation of Conductive and Compressive Heat Resistance (CCHR)*, 2018.

ASTM F1342/F1342M, *Standard Test Method for Protective Clothing Material Resistance to Puncture*, 2022.

ASTM F1359/F1359M, *Standard Test Method for Liquid Penetration Resistance of Protective Clothing or Protective Ensembles Under a Shower Spray While on a Manikin*, 2022.

ASTM F1671/F1671M, *Standard 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*, 2022.

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

ASTM F1868, *Standard Test Method for Thermal and Evaporative Resistance of Clothing Materials Using a Sweating Hot Plate*, 2017.

ASTM F1939, *Standard Test Method for Radiant Heat Resistance of Flame Resistant Clothing Materials with Continuous Heating*, 2015, reapproved 2020.

ASTM F2010/F2010M, *Standard Test Method for Evaluation of Glove Effects on Wearer Finger Dexterity Using a Modified Pegboard Test*, 2018.

ASTM F2299/F2299M, *Standard Test Method for Determining the Initial Efficiency of Materials Used in Medical Face Masks to Penetration by Particulates Using Latex Spheres*, 2003, reapproved 2017.

ASTM F2412, *Standard Test Methods for Foot Protection*, 2018a.

ASTM F2413, *Standard Specification for Performance Requirements for Protective (Safety) Toe Cap Footwear*, 2018.

ASTM F2731, *Standard Test Method for Measuring the Transmitted and Stored Energy of Firefighter Protective Clothing Systems*, 2018.

ASTM F2894, *Standard Test Method for Evaluation of Materials, Protective Clothing, and Equipment for Heat Resistance Using a Hot Air Circulating Oven*, 2021.

ASTM F2913, *Standard Test Method for Measuring the Coefficient of Friction for Evaluation of Slip Performance of Footwear and Test Surfaces/Flooring Using a Whole Shoe Tester*, 2019.

ASTM F2961, *Standard Test Method for Characterizing Gripping Performance of Gloves Using a Torque Meter*, 2015.

ASTM G155, *Standard Practice for Operating Xenon Arc Lamp Apparatus for Exposure of Materials*, 2021.

2.3.6 CENELEC Publications. CENELEC, European Committee for Electrotechnical Standardization, CEN-CENELEC Management Centre, Rue de la Science, B-1040, Brussels, Belgium.

BS EN 136, *Respiratory protective devices — Full face masks — Requirements, testing, marking*, 1998, Corrigendum, 2004.

2.3.7 CPSC Publications. Consumer Product Safety Commission, 4330 East-West Highway, Bethesda, MD 20814.

CPSC-CH-C1001-09.4, *Standard Operating Procedure for Determination of Phthalates*, January 17, 2018.

CPSC-CH-E1002-08.3, *Standard Operating Procedure for Determining Total Lead (Pb) in Nonmetal Children's Products*, Revision November 15, 2012.

2.3.8 CSA Group Publications. CSA Group, 178 Rexdale Blvd., Toronto, ON M9W 1R3, Canada.

CSA Z195, *Protective Footwear*, 2014.

2.3.9 DIN Publications. Deutsches Institut für Normung e.V. (German Institute for Standardization), Am DIN-Platz, Burggrafenstraße 6, 10787 Berlin.

DIN 54231, *Textiles — Detection of disperse dyestuffs*, 2005.

2.3.10 EBU Publications. EBU (European Broadcasting Union) Department of Technology & Innovation, L'Ancienne-Route 17A, Postal Box 45, 1218 Le Grand-Saconnex, Geneva, Switzerland.

EBU R 068, *Alignment level in digital audio production equipment and in digital audio recorders*, 2000.

2.3.11 EN Publications. European Committee for Standardization, Rue de la Loi 200, 1049 Bruxelles, Belgium.

EN 14582, *Characterization of waste — Halogen and sulfur content — Oxygen combustion in closed systems and determination methods*, 2016.

EN 16711-2, *Textiles — Determination of metal content — Part 2: Determination of metals extracted by acidic artificial perspiration solution*, 2016.

EN 17131, *Textiles and textile products — Determination of Dimethylformamide (DMF), method using gas chromatography*, 2013.

EN 17137, *Textiles — Determination of the content of compounds based on chlorobenzenes and chlorotoluenes*, 2018.

EN 17134-2, *Textiles and textile products — Determination of biocide additives — Part 2: Chlorophenol-based preservatives, method using gas chromatography*, 2023.

EN 17681-1, *Textiles and textile products — Organic fluorine — Part 1: Determination of non-volatile compounds by extraction method using liquid chromatography*, 2022.

EN 17681-2, *Textiles and textile products — Organic fluorine — Part 2: Determination of volatile compounds by extraction method using gas chromatography*, 2022.

EN 62321-6, *Determination of certain substances in electrotechnical products — Part 6: Polybrominated biphenyls and polybrominated diphenyl ethers in polymers by gas chromatography-mass spectrometry (GC-MS)*, 2015.

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

FIA 1209, *Whole Shoe Flex*, 1984.

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

IEC 60268-16, *Sound System Equipment — Part 16: Objective Rating of Speech Intelligibility by Speech Transmission Index*, 2011.

2.3.14 ISEA Publications. International Safety Equipment Association, 1101 Wilson Boulevard, Suite #1425, Arlington, VA 22209-1762.

ANSI/ISEA 107, *High-Visibility Safety Apparel*, 2020.

ANSI/ISEA Z87.1, *Occupational and Educational Personal Eye and Face Protection Devices*, 2020.

2.3.15 ISO Publications. International Organization for Standardization, ISO Central Secretariat, BIBC II, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland.

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

ISO 3071, *Textiles — Determination of pH of aqueous extract*, 2020.

ISO 4649, *Rubber, vulcanized or thermoplastic — Determination of abrasion resistance using a rotating cylindrical drum device*, 2017.

ISO 6401, *Plastics — Poly (vinyl chloride) — Determination of residual vinyl chloride monomer — Gas chromatographic method*, 2022.

ISO 6530, *Protective clothing — Protection against liquid chemicals — Test method for resistance of materials to penetration by liquids*, 2005.

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

ISO/CIE 10526, *CIE standard illuminants for colorimetry*, 2007.

ISO 14184-1, *Textiles — Determination of formaldehyde — Part 1: Free and hydrolyzed formaldehyde (water extraction method)*, 2011.

ISO 14362-1, *Textiles — Methods for determination of certain aromatic amines derived from azo colorants — Part 1: Detection of the use of certain azo colorants accessible with and without extracting the fibres*, 2017.

ISO 14362-3, *Textiles — Methods for determination of certain aromatic amines derived from azo colorants — Part 3: Detection of the use of certain azo colorants, which may release 4-aminoazobenzene*, 2017.

ISO 14389, *Textiles — Determination of phthalate content — Tetrahydrofuran method*, 2014.

ISO 16900-5, *Respiratory protective devices — Methods of test and test equipment — Part 5: Breathing machine, metabolic simulator, RPD headforms and torso, tools and verification tools*, 2016.

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

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

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

ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories*, 2005, Technical Corrigendum, 2006.

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

ISO 17492, *Clothing for protection against heat and flame — Determination of heat transmission on exposure to both flame and radiant heat*, 2018.

ISO 17493, *Clothing and equipment for protection against heat — Test method for convective heat resistance using a hot air circulating oven*, 2016.

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

ISO 17881-1, *Textiles — Determination of certain flame retardants — Part 1: Brominated flame Retardants*, 2016.

ISO 17881-2, *Textiles — Determination of certain flame retardants — Part 2: Phosphorus flame retardants*, 2016.

ISO 18254-1, *Textiles — Method for the detection and determination of alkylphenol ethoxylates (APEO) — Part 1: Method using HPLC-MS*, 2016.

ISO 19577, *Footwear — Critical substances potentially present in footwear and footwear components — Determination of Nitrosamines*, 2019.

ISO 21084, *Textiles — Method for determination of alkylphenols (AP)*, 2019.

ISO 22818, *Textiles — Determination of short-chain chlorinated paraffins (SCCP) and middle- chain chlorinated paraffins (MCCP) in textile products out of different matrices by use of gas chromatography negative ion chemical ionization mass spectroscopy (GC-NCI&-MS)*, 2021.

ISO 23702, *Leather — Organic fluorine — Part 1: Determination of the non-volatile compound content by extraction method using liquid chromatography/tandem mass spectrometry detector (LC-MS/MS)*, 2023.

ISO/TS 16179, *Footwear — Critical substances potentially present in footwear and footwear components — Determination of organotin compounds in footwear materials*, 2012.

ISO/TS 16189, *Footwear — Critical substances potentially present in footwear and footwear components — Test method to quantitatively determine dimethylformamide in footwear materials*, 2013.

IEC 61000-4-21, *Testing and measurement techniques — Reverberation chamber test methods*, 2011.

2.3.16 PIA Publications. Parachute Industry Association, 6499 S Kings Ranch Road #6-12, Gold Canyon, AZ 85118.

PIA-C-419, *Cloth, duck, unbleached, plied-yarns, army and numbered, Revision B*, March 13, 2011.

2.3.17 SAE Publications. SAE International, Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15096.

SAE J211, *Instrumentation for Impact Test*, 2014.

2.3.18 UL Publications. Underwriters Laboratories Inc., 333 Pfingsten Road, Northbrook, IL 60062-2096.

UL 913, *Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, III, Division 1, Hazardous (Classified) Locations*, 6th edition, 2002.

UL 121201, *Nonincendive Electrical Equipment for Use in Class I and II, Division 2 and Class III, Divisions 1 and 2 Hazardous (Classified) Locations*, 9th edition, 2017.

2.3.19 US Department of Defense Publications. Standardization Document Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094.

A-A-55126C, *Commercial Item Description, Fastener Tapes, Hook and Loop, Synthetic*, December 21, 2016.

A-A-55634C, *Commercial Item Description, Zippers (Fasteners, Slide, Interlocking)*, October 30, 2019.

2.3.20 US Government Publications. US Government Publishing Office, 732 North Capitol Street, NW, Washington, DC 20401-0001.

Statement of Standard for NIOSH CBRN SCBA Testing, 2002.

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

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

Title 47, Code of Federal Regulations, Subchapter A, General, Telecommunications, Chapter I, Federal Communications Commission, Part 15, Radio Frequency Devices.

NIOSH Firefighter Anthropometric Data Base (www.cdc.gov/niosh/data/datasets/rd-1007-2015-0/default.html).

2.3.21 Other Publications.

Merriam-Webster's Collegiate Dictionary, 11th edition, Merriam-Webster, Inc., Springfield, MA, 2020.

Test Operations Procedure (TOP) 10-2-022, *Chemical Vapor and Aerosol System-Level Testing of Chemical/Biological Protective Suits,* 2013.

US Department of Defense GL/PD 07-13C, *Purchase Description Coat, Army Combat Uniform,* US Army Natick Research, Development and Engineering Center, Attn: RDNS-WPW-C, Kansas Street, Natick, MA 01760-5019, 2011.

2.4 References for Extracts in Mandatory Sections.

NFPA 1801, *Standard on Thermal Imagers for the Fire Service*, 2021 edition.

Chapter 3 Definitions

3.1 General.

3.1.1 The definitions contained in this chapter shall apply to the terms used in this standard.

3.1.2 Where terms are not defined in this chapter or within another chapter, they shall be defined using their ordinarily accepted meanings within the context in which they are used.

3.1.3 *Merriam-Webster's Collegiate Dictionary*, 11th edition, shall be the source for the ordinarily accepted meaning.

3.2 NFPA Official Definitions.

3.2.1* Approved. Acceptable to the authority having jurisdiction.

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

3.2.3 Labeled. Equipment or materials to which has been attached a label, symbol, or other identifying mark of an organization that is acceptable to the authority having jurisdiction and concerned with product evaluation, that maintains periodic inspection of production of labeled equipment or materials, and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner. *(See also definition 3.3.139, Product Label.)*

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

3.2.5 Shall. Indicates a mandatory requirement.

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

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

3.3* General Definitions.

3.3.1 Accessories (Accessory). An item or items that could be attached to a certified product but are not necessary for the certified product to meet the requirements of the standard.

3.3.2 Alarm Signal. An audible warning that is identifiable as an indication that an emergency services person is in need of assistance.

3.3.2.1 *Evacuation Alarm.* An alarm initiated by a base station, transmitted to an RF PASS via an RF signal. The evacuation alarm warns emergency services personnel to evacuate the premises.

3.3.2.2 *Loss-of-Signal Alarm.* A visual signal that is initiated automatically when the RF communication between a base station and RF PASS is lost

3.3.3 Arch. The bottom curve of the foot from the heel to the ball.

3.3.4 Atmosphere-Supplying Respirator. A respirator that supplies the respirator user with breathing air from a source independent of the ambient atmosphere and includes self-contained breathing apparatus (SCBA) and supplied air respirators (SAR). *[See also 3.3.34, Combination SCBA/SAR; 3.3.185, Self-Contained Breathing Apparatus (SCBA); and 3.3.208, Supplied Air Respirator (SAR).]*

3.3.5 Barrier Hood. See 3.3.205, Structural Firefighting Protective Hood.

3.3.6 Barrier Material. The part of the composite that limits transfer from the face of the layer to the other side.

3.3.7 Basic Plane. The anatomical plane that includes the superior rim of the external auditory meatus, the upper edge of the external openings of the ear, and the inferior margin of the orbit, which is the lowest point of the floor of the eye socket.

3.3.8 Belt. An equipment item configured as a device that fastens around the waist only and is designated as a ladder belt or an escape belt.

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

3.3.10* Bitragion Coronal Arc. The arc between the right and left tragion as measured over the top of the head in a plane perpendicular to the midsagittal plane.

3.3.11* Bitragion Inion Arc. The arc between tragion as measured over the inion.

3.3.12 Body Fluid–Borne Pathogen. An infectious bacterium or virus carried in human, animal, or clinical body fluids, organs, or tissue.

3.3.13 Body Fluids. Fluids that are produced by the body including, but not limited to, blood, semen, mucus, feces, urine, vaginal secretions, breast milk, amniotic fluid, cerebrospinal fluid, synovial fluid, and pericardial fluid.

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

3.3.15 Breathing Air. See 3.3.41, Compressed Breathing Air.

3.3.16 Breathing Air Cylinder. The pressure vessel or vessels that are an integral part of the SCBA and that contain the breathing gas supply; can be configured as a single cylinder or other pressure vessel, or as multiple cylinders or pressure vessels.

3.3.17 Breathing Air/Gas Container. See 3.3.16, Breathing Air Cylinder.

3.3.18 Brim. A part of the shell of the helmet extending around the entire circumference of the helmet.

3.3.19 Brim Line. A horizontal plane intersecting the point of the front opening of the helmet at the midsagittal plane.

3.3.20 Cargo Pockets. Pockets located on the protective garment exterior.

3.3.21 CBRN. An abbreviation for chemicals, biological agents, and radiological particulates hazards. *(See also 3.3.22, CBRN Terrorism Agents.)*

3.3.22* CBRN Terrorism Agents. Chemicals, biological agents, and radiological particulates that could be released as the result of a terrorist attack. *(See also 3.3.27, Chemical Terrorism Agents; 3.3.9, Biological Terrorism Agents; and 3.3.163, Radiological Particulate Terrorism Agents.)*

3.3.23 Certification/Certified. A system whereby a certification organization determines that a manufacturer has demonstrated the ability to produce a product that complies with the requirements of this standard, authorizes the manufacturer to use a label on listed products that comply with the requirements of this standard, and establishes a follow-up program conducted by the certification organization as a check on the methods the manufacturer uses to determine continued compliance of labeled and listed products with the requirements of this standard. *(See also 3.3.121, NIOSH Certified.)*

3.3.24 Certification Mark or Label. The authorized identification symbol or logo of the certification organization.

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

3.3.26 Char. The formation of a brittle residue when material is exposed to thermal energy.

3.3.27 Chemical Terrorism Agents. Liquid, solid, gaseous, and vapor chemical warfare agents and toxic industrial chemicals used to inflict lethal or incapacitating casualties, generally on a civilian population, as a result of a terrorist attack. *(See also 3.3.28, Chemical Warfare (CW) Agents, and 3.3.221, Toxic Industrial Chemicals.)*

3.3.28 Chemical Warfare (CW) Agents. Liquid, solid, and gaseous chemical agents (most are liquids) traditionally used during warfare or armed conflict to kill or incapacitate an enemy.

3.3.29 Chin Strap. An adjustable strap for the helmet that fits under the chin to secure the helmet to the head.

3.3.30 Closed-Circuit SCBA. A recirculation-type SCBA in which the exhaled gas is rebreathed by the wearer after the carbon dioxide has been removed from the exhalation gas and the oxygen content within the system has been restored from sources such as compressed breathing air, chemical oxygen, liquid oxygen, or compressed gaseous oxygen.

3.3.31 Coat. See 3.3.197, Structural Firefighting Protective Coat, and 3.3.153, Proximity Firefighting Protective Coat.

3.3.32 Collar. The portion of the coat or coverall that encircles the neck.

3.3.33 Collar Lining. The part of collar fabric composite that is next to the skin when the collar is closed in the raised position.

3.3.34* Combination SCBA/SAR. An atmosphere-supplying respirator that supplies a respirable atmosphere to the user from a combination of two breathing air sources that both are independent of the ambient environment. *[See also 3.3.4, Atmosphere-Supplying Respirator; 3.3.185, Self-Contained Breathing Apparatus (SCBA); and 3.3.208, Supplied Air Respirator (SAR).]*

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

3.3.36 Compliant Product(s). Garments or equipment that are certified to the applicable NFPA standard.

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

3.3.38 Component Supplier. The entity that manufactures a material, part, or subassembly used in the construction of the compliant product.

3.3.39 Component Supplier Facility. A facility that is involved in the production of a material, part, or subassembly used in the construction of the compliant product.

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

3.3.41* Compressed Breathing Air. A respirable gas mixture derived from either normal atmospheric air or from manufactured synthetic air, stored in a compressed state in storage cylinders and respirator breathing air cylinders, and supplied to the user in a gaseous form.

3.3.42 Coronal Plane. The anatomical plane perpendicular to both the basic and midsagittal planes and containing the midpoint of a line connecting the superior rims of the right and left auditory meatuses.

3.3.43 Coverall. See 3.3.198, Structural Firefighting Protective Coverall, and 3.3.154, Proximity Firefighting Protective Coverall.

3.3.44 Crown. The portion of the helmet that covers the head above the reference plane.

3.3.45 Crown Straps. The part of the helmet suspension that passes over the head.

3.3.46 Cylinder. See 3.3.16, Breathing Air Cylinder.

3.3.47 Demand SCBA. See 3.3.120, Negative Pressure SCBA.

3.3.48 Dielectric Test Plane. A plane that runs diagonally through the headform from the intersection of the test line and midsagittal plane in the front of the headform to the intersection of the reference plane and midsagittal plane in the rear of the headform.

3.3.49* Drag Rescue Device (DRD). A component integrated within the protective coat element to aid in the rescue of an incapacitated firefighter.

3.3.50 DRD. See 3.3.49, Drag Rescue Device (DRD).

3.3.51 Drip. To run or fall in drops or blobs.

3.3.52 Ear Covers. An interface component of the protective helmet element that provides limited protection to the helmet/coat interface area.

3.3.53 Element(s). See 3.3.58, Ensemble Elements.

3.3.54* Emblems. Shields, heraldry, lettering, or printing that designates a product, a governmental entity, or a specific organization, rank, title, position, or other professional status that is painted, screened, embroidered, sewn, glued, bonded, or otherwise attached to a product in a permanent manner.

3.3.55 End-of-Service-Time Indicator (EOSTI). A warning device on an SCBA that alerts the user that the reserve air supply is being utilized.

3.3.56 Energy Absorbing System. Materials or systems used to attenuate impact energy.

3.3.57 Ensemble. See 3.3.199, Structural Firefighting Protective Ensemble, and 3.3.155, Proximity Firefighting Protective Ensemble.

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

3.3.59* Entry Firefighting. Extraordinarily specialized firefighting operations that can include the activities of rescue, fire suppression, and property conservation at incidents involving fires producing extreme levels of radiant, conductive, and convective heat.

3.3.60 Fabric Component. Any single or combination of natural or synthetic material(s) that are pliable and that are made by weaving, felting, forming, or knitting.

3.3.61 Facepiece. The component of an SCBA that covers the wearer's nose, mouth, and eyes.

3.3.62* Faceshield. The component of the helmet that provides limited protection to a portion of the wearer's face.

3.3.63 Faceshield/Goggle. The term that applies to the helmet component that is a faceshield, or goggle, or both.

3.3.64 Facial Feature Headform. The medium size reference headform specified in ANSI/ISEA Z87.1, *Occupational and Educational Personal Eye and Face Protection Devices.*

3.3.65 Findings. All materials used in the construction of items, excluding textiles and interlinings.

3.3.66* Flame Resistance. The property of a material whereby combustion is prevented, terminated, or inhibited following the application of a flaming or nonflaming source of ignition, with or without subsequent removal of the ignition source. Flame resistance can be an inherent property of a material, or it can be imparted by specific treatment. *(See also 3.3.96, Inherent Flame Resistance.)*

3.3.67 Fluorescence. The process by which radiant flux of certain wavelengths is absorbed and reradiated, nonthermally in other, usually longer, wavelengths.

3.3.68 Follow-Up Program. The sampling, inspection, tests, or other measures conducted by the certification organization on a periodic basis to determine the continued compliance of labeled and listed products that are being produced by the manufacturer to the requirements of this standard.

3.3.69* Footwear. See 3.3.201, Structural Firefighting Protective Footwear, and 3.3.157, Proximity Firefighting Protective Footwear.

3.3.70 Functional. The ability of an element or component of an element to continue to be utilized for its intended purpose.

3.3.71 Garment(s). See 3.3.202, Structural Firefighting Protective Garment(s), 3.3.158, Proximity Firefighting Protective Garment, and 3.3.235, Work Apparel Garment.

3.3.72 Gas. Matter in a gaseous state at standard temperature and pressure.

3.3.73 Gauntlet. An interface component of the protective glove element that provides limited protection to the coat/glove interface area.

3.3.74 Glove. See 3.3.203, Structural Firefighting Protective Glove, and 3.3.159, Proximity Firefighting Protective Glove.

3.3.75 Glove Body. The part of the glove that extends from the tip of the fingers to the wrist crease or to a specified distance beyond the wrist crease.

3.3.76 Glove Liner. The innermost component of the glove body composite that comes into contact with the wearer's skin.

3.3.77 Glove Wristlet. See 3.3.236, Wristlet.

3.3.78 Goggles. The component of the helmet that provides protection to the wearer's eyes and a portion of the wearer's face.

3.3.79 Grading. The process of proportioning components for construction of an element.

3.3.80* Gusset. The part of the protective footwear that is a relatively flexible material joining the footwear upper (quarter) and the tongue, which is intended to provide expansion of the footwear front to enable donning of the footwear while maintaining continuous moisture integrity of the footwear.

3.3.81 Hardware. Nonfabric components of the protective clothing and equipment including, but not limited to, those made of metal or plastic.

3.3.82 Harness. An equipment item; an arrangement of materials secured about the body used to support a person.

3.3.83* Hazardous (Classified) Location (HazLoc). A location where fire or explosion hazards might exist due to flammable or combustible material (e.g., flammable gases, flammable liquid-produced vapors, combustible liquid-produced vapors, combustible dusts, or ignitible fibers/flyings).

3.3.83.1 *Intrinsic Safety (IS).* Type of protection where any spark or thermal effect is incapable of causing ignition of a mixture of flammable or combustible material in air under prescribed test conditions.

3.3.83.1.1 ***Associated Apparatus.*** Electrical equipment that contains both intrinsically safe circuits and nonintrinsically safe circuits and is constructed so that the nonintrinsically safe circuits cannot adversely affect the intrinsically safe circuits.

3.3.83.1.2 ***Intrinsically Safe Apparatus.*** Electrical equipment in which all the circuits are intrinsically safe circuits.

3.3.83.1.3 ***Intrinsically Safe Circuit.*** A circuit in which any spark or thermal effect is incapable of causing ignition of a mixture of flammable or combustible material in air under prescribed test conditions.

3.3.83.1.4 ***Intrinsically Safe System.*** An assembly of interconnected intrinsically safe apparatus, associated apparatus, and interconnecting cables, in that those parts of the system that are used in hazardous (classified) locations are intrinsically safe circuits.

3.3.83.2 ***Nonincendive (NI).*** Type of protection applied to electrical equipment such that, in normal operation and in certain specified regular expected occurrences, it is not capable of igniting a surrounding atmosphere of flammable or combustible material.

3.3.83.2.1 ***Associated Equipment.*** Electrical equipment that contains both nonincendive circuits and other than nonincendive circuits and is constructed so that the other than nonincendive circuits cannot adversely affect the nonincendive circuits.

3.3.83.2.2 ***Maximum External Capacitance, Co.*** Maximum value of capacitance in a circuit that can be connected to the connection facilities of associated equipment functioning as a source.

3.3.83.2.3 ***Maximum External Inductance, Lo.*** Maximum value of inductance in a circuit that can be connected to the connection facilities of associated equipment functioning as a source.

3.3.83.2.4 ***Maximum Input Current, Ii.*** Maximum current that can be applied to the connection facilities of nonincendive equipment functioning as a sink.

3.3.83.2.5 ***Maximum Input Voltage, Ui.*** Maximum voltage that can be applied to the connection facilities of nonincendive equipment functioning as a sink.

3.3.83.2.6 ***Maximum Internal Capacitance, Ci.*** Total equivalent internal capacitance that is considered as appearing across the connection facilities of nonincendive equipment functioning as a sink.

3.3.83.2.7 ***Maximum Internal Inductance, Li.*** Total equivalent internal inductance that is considered as appearing at the connection facilities of nonincendive equipment functioning as a sink.

3.3.83.2.8 ***Maximum Output Current, Io.*** Maximum output current in a circuit that can be provided by the connection facilities of associated equipment functioning as a source under normal operation.

3.3.83.2.9 ***Maximum Output Voltage, Uo.*** Maximum output voltage in a circuit that can appear under open-circuit conditions at the connection facilities of associated equipment functioning as a source under normal operation.

3.3.83.2.10 ***Nonincendive Circuit.*** A circuit, other than nonincendive field wiring, in which any arc or thermal effect produced under normal operating conditions is not capable of igniting a specified flammable or combustible material in air. The circuit is evaluated under prescribed test conditions.

3.3.83.2.11 ***Nonincendive Equipment.*** Equipment having electrical/electronic circuitry that is incapable, under normal operating conditions, of causing ignition of a specified flammable or combustible material in air due to arcing or thermal means.

3.3.83.2.12 ***Nonincendive System.*** An assembly of interconnected nonincendive equipment, associated equipment, and interconnecting cables, in that those parts of the system that are used in hazardous (classified) locations are nonincendive circuits.

3.3.84* Hazardous Materials. Substances (i.e., solid, liquid, or gas) that when released are capable of causing harm to people, the environment, and property.

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

3.3.86 Haze. Light that is scattered as a result of passing through a transparent object.

3.3.87 Head and Torso Simulator (HATS). A manikin with built-in ear and mouth simulators that provides a realistic reproduction of the acoustic properties of an average adult human head and torso.

3.3.88 Headband. The portion of the helmet suspension that encircles the head.

3.3.89 Headform. A device that simulates the configuration of the human head.

3.3.90 Heads-Up Display (HUD). Visual display of information and system condition status visible to the wearer.

3.3.91 Helmet. See 3.3.204, Structural Firefighting Protective Helmet, and 3.3.160, Proximity Firefighting Protective Helmet.

3.3.92 Helmet Cover. A removable helmet component that offers radiant reflective protection to the exterior of the helmet shell.

3.3.93 Helmet Shroud. The component element of the helmet that provides limited protection to the helmet/coat SCBA interface area.

3.3.94 Hood. See 3.3.205, Structural Firefighting Protective Hood.

3.3.95 Identical SCBA. SCBA that are produced to the same engineering and manufacturing specifications.

3.3.96 Inherent Flame Resistance. Flame resistance that is derived from the essential characteristic of the fiber or polymer.

3.3.97 Insect Repellency. A finish applied to textiles to provide a deterrent against bites from mosquitoes, midges, ants, ticks, and chiggers.

3.3.98 Insole. The inner component of the footwear upon which the foot rests.

3.3.99 Interface Area. An area of the body where the protective garments, helmet, gloves, footwear, or SCBA facepiece meet. Interface areas include, but are not limited to, the coat/helmet/SCBA facepiece area, the coat/trouser area, the coat/glove area, and the trouser/footwear area.

3.3.100 Interface Component(s). Any material, part, or subassembly used in the construction of the compliant product that provides limited protection to interface areas.

3.3.101 Interlining. Any textile that is incorporated into any garment as a layer between outer and inner layers.

3.3.102 Label. See 3.3.139, Product Label.

3.3.103 Ladder Shank. See 3.3.189, Shank.

3.3.104 Liner System. The moisture and thermal barrier components as used in a garment.

3.3.105 Liquid Borne Pathogen. See 3.3.12, Body Fluid–Borne Pathogen.

3.3.106 Lower Torso. The area of the body trunk below the waist, excluding the legs, ankles, and feet.

3.3.107 Major A Seam. See 3.3.183.1.

3.3.108 Major B Seam. See 3.3.183.2.

3.3.109 Major Seams. Classes of seams that designate minimum sewn seam requirements.

3.3.110 Manufacturer. The entity that directs or 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.

3.3.111 Manufacturing Facility. A facility that is involved in the production, assembly, final inspection, or labeling of the compliant end product.

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

3.3.113 Microphone Measurement Point (MMP). A point 1.5 m in front of and on the axis of the lip position of typical human mouth (or artificial mouth) and 1.5 m above the floor.

3.3.114 Midsagittal Plane. The plane, perpendicular to the basic and coronal planes, that bisects the head symmetrically.

3.3.115 Minor Seam. See 3.3.183.4, Minor Seam.

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

3.3.117 Moisture Barrier. The component of an element or item that principally prevents the transfer of liquids.

3.3.118 Mouth Reference Point (MRP). A point 50 mm in front of and on the axis of the lip position of a typical human mouth (or artificial mouth).

3.3.119 Nape Device. A component used to aid in helmet retention.

3.3.120 Negative Pressure SCBA. An SCBA in which the pressure inside the facepiece, in relation to the pressure surrounding the outside of the facepiece, is negative during any part of the inhalation or exhalation cycle when tested by NIOSH in accordance with 42 CFR 84.

3.3.121* NIOSH Certified. Tested and certified by the National Institute for Occupational Safety and Health (NIOSH) of the US Department of Health and Human Services in accordance with the requirements of 42 CFR 84, Subpart H.

3.3.122 Nonprimary Protective Garment. A garment or clothing that is not designed nor intended to be the barrier of protection from a specific hazard exposure.

3.3.123 Open-Circuit SCBA. An SCBA in which exhalation is vented to the atmosphere and not rebreathed.

3.3.124 Outer Shell. The outermost component of an element or item not including trim, hardware, reinforcing material, pockets, wristlet material, accessories, fittings, or suspension systems.

3.3.125* Particulate Blocking Layer. The layer(s) of an element or item that principally inhibits the ingress of particles.

3.3.126* Particulates. Finely divided solid matter that is dispersed in air.

3.3.127 PASS. Acronym for Personal Alert Safety Systems. See also 3.3.132, Personal Alert Safety Systems (PASS).

3.3.128 PASS Annunciator. The component designed to emit audible signals.

3.3.129* Passive Electrical Circuitry. Electrical circuitry that has no integral power source and is energized by a supplemental device.

3.3.130 Patches. See 3.3.54, Emblems.

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

3.3.132 Personal Alert Safety Systems (PASS). A device that continually senses for lack of movement of the wearer and automatically activates the alarm signal, indicating the wearer is in need of assistance; can also be manually activated to trigger the alarm signal.

3.3.132.1 ***Integrated PASS.*** A removable or nonremovable PASS that is an integral part of another item or items of protective clothing, protective equipment, or both.

3.3.132.1.1 ***Nonremovable.*** An integrated PASS that is not removable and cannot be used independently of the item or items with which it is integrated.

3.3.132.1.2 ***Removable.*** An integrated PASS that is removable so that it can be used independently of the item or items with which it is integrated.

3.3.132.2 ***RF PASS.*** A PASS that contains an optional RF transceiver that enables the PASS to automatically transmit an alarm signal and receive evacuation alarms via RF signals; responds to an evacuation alarm with an audible and visual signal.

3.3.132.2.1 ***Base Station.*** An RF transceiver used in conjunction with an RF PASS that monitors for an alarm signal and emits a visual signal when this alarm is received. The base station is capable of sending an evacuation alarm to the RF PASS.

3.3.132.3 ***Stand-Alone PASS.*** A PASS that is not an integral part of any other item of protective clothing or protective equipment.

3.3.133* PFAS. An abbreviation for perfluoroalkyl and polyfluoroalkyl substances, which are a class of organic chemicals containing at least one fully fluorinated carbon atom.

3.3.134 Pink Noise. Noise that contains constant energy per octave band.

3.3.135 Positive Pressure SCBA. An SCBA in which the pressure inside the facepiece, in relation to the pressure surrounding the outside of the facepiece, is positive during both inhalation and exhalation when tested by NIOSH in accordance with 42 CFR 84, Subpart H.

3.3.136 Prealarm Signal. An audible warning that is identifiable as an indication that a PASS is about to sound the alarm signal.

3.3.137 Pressure Demand SCBA. See 3.3.135, Positive Pressure SCBA.

3.3.138 Primary Protective Garment. A garment that is designed, certified, and intended to be the barrier of protection from a specific hostile environment.

3.3.139* Product Label. A marking provided by the manufacturer for each compliant product containing compliant statements, certification statements, manufacturer or model information, or similar data. The product label is not the certification organization's label, symbol, or identifying mark; however, the certification organization's label, symbol, or identifying mark is attached to or part of the product label.

3.3.140 Protective Clothing. See 3.3.196, Structural Firefighting Protective Clothing, and 3.3.155, Proximity Firefighting Protective Ensemble.

3.3.141 Protective Coat. See 3.3.197, Structural Firefighting Protective Coat, and 3.3.153, Proximity Firefighting Protective Coat.

3.3.142 Protective Coverall. See 3.3.198, Structural Firefighting Protective Coverall, and 3.3.154, Proximity Firefighting Protective Coverall.

3.3.143 Protective Ensemble. See 3.3.199, Structural Firefighting Protective Ensemble, and 3.3.155, Proximity Firefighting Protective Ensemble.

3.3.144 Protective Footwear. See 3.3.201, Structural Firefighting Protective Footwear, and 3.3.157, Proximity Firefighting Protective Footwear.

3.3.145 Protective Garment. See 3.3.202, Structural Firefighting Protective Garment(s), and 3.3.158, Proximity Firefighting Protective Garment.

3.3.146 Protective Gloves. See 3.3.203, Structural Firefighting Protective Glove, and 3.3.159, Proximity Firefighting Protective Glove.

3.3.147 Protective Helmet. See 3.3.204, Structural Firefighting Protective Helmet, and 3.3.160, Proximity Firefighting Protective Helmet.

3.3.148 Protective Hood. See 3.3.205, Structural Firefighting Protective Hood.

3.3.149 Protective Trousers. See 3.3.206, Structural Firefighting Protective Trousers, and 3.3.161, Proximity Firefighting Protective Trousers.

3.3.150 Protective Wristlet. See 3.3.236, Wristlet.

3.3.151* Proximity Firefighting. Specialized firefighting operations that can include the activities of rescue, fire suppression, and property conservation at incidents involving fires producing high levels of radiant heat as well as conductive and convective heat.

3.3.152 Proximity Firefighting Protective Clothing. See 3.3.155, Proximity Firefighting Protective Ensemble.

3.3.153 Proximity Firefighting Protective Coat. The element of the protective ensemble that provides protection to upper torso and arms, excluding the hands and head.

3.3.154 Proximity Firefighting Protective Coverall. The element of the protective ensemble that provides protection to the torso, arms, and legs, excluding the head, hands, and feet.

3.3.155 Proximity Firefighting Protective Ensemble. Multiple elements of compliant protective clothing and equipment that when worn together provide protection from some risks, but not all risks, of emergency incident operations.

3.3.156 Proximity Firefighting Protective Ensemble with Optional Liquid and Particulate Contaminant Protection. A compliant proximity firefighting protective ensemble that is also certified as an entire ensemble to meet the optional requirements for protection from liquid and particulate contaminants.

3.3.157 Proximity Firefighting Protective Footwear. The element of the protective ensemble that provides protection to the foot, ankle, and lower leg.

3.3.158 Proximity Firefighting Protective Garment. The coat, trouser, and coverall elements of the protective ensemble.

3.3.159 Proximity Firefighting Protective Glove. The element of the protective ensemble that provides protection to the hand and wrist.

3.3.160 Proximity Firefighting Protective Helmet. The element of the protective ensemble that provides protection to the head.

3.3.161 Proximity Firefighting Protective Trousers. The element of the protective ensemble that provides protection to the lower torso and legs, excluding the ankles and feet.

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

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

3.3.164 Rapid Intervention Crew/Company Universal Air Connection (RIC UAC). A system that allows emergency replenishment of breathing air to the SCBA of disabled or entrapped fire or emergency services personnel.

3.3.165 Rated Service Time. The period of time, stated on the SCBA's NIOSH certification label, that the SCBA supplied air to the breathing machine when tested to 42 CFR 84, Subpart H.

3.3.166 Recall System. Procedures by which a manufacturer identifies a product, provides notice or safety alert, and repairs or withdraws the product as the corrective action.

3.3.167* Recognized Component. Any material, part, or subassembly used in the construction of the compliant product that has undergone an evaluation by a certification organization that allows the manufacturer to label the item as recognized.

3.3.168 Reference Plane. A dimensionally defined plane parallel to the basic plane that is measured from the top of the applicable headform or the basic plane.

3.3.169 Reserve Air Supply. The period of time available for emergency egress, self-rescue, or assisted rescue.

3.3.170* Restricted Substance. A specific substance that poses a potential threat to human health or the environment, which can include, but is not limited to, an ingredient, treatment, or byproduct of manufacturing that is subject to specific concentration limits or being present in a material or component used in the construction of a protective element.

3.3.171* Restricted Substance Attestation Organization. An independent organization that provides test services for assuring supplier conformity of materials or components used in protective elements against the criteria in a recognized restricted substances list.

3.3.172 Retention System. The complete assembly by which the helmet is retained in position on the head.

3.3.173 Retroreflection/Retroreflective. The reflection of light in which the reflected rays are preferentially returned in the direction close to the opposite of the direction of the incident rays, with this property being maintained over wide variations of the direction of the incident rays.

3.3.174 Retroreflective Markings. A material that reflects and returns a relatively high proportion of light in a direction close to the direction from which it came.

3.3.175 RF Interference. An unwanted radio-frequency signal that is present in the vicinity of an RF PASS system that could impede reception of an alarm signal or evacuation alarm.

3.3.176 RF Transceiver. A radio system capable of both transmitting and receiving a modulated radio-frequency (RF) signal that is then converted to an audio and/or data signal; used to transmit and receive signals such as the alarm signal and the evacuation alarm for RF PASS.

3.3.177 RIC. Abbreviation for rapid intervention crew/company.

3.3.178 Safety Alert. The procedure by which a manufacturer notifies users, the marketplace, and distributors of potential safety concerns regarding a product.

3.3.179 Sample. (1) The ensemble, element, component, or composite that is conditioned for testing *(see also 3.3.192, Specimen)*; (2) ensembles, elements, items, or components that are randomly selected from the manufacturing facility's production line, from the manufacturer's or manufacturing facility's inventory, or from the open market.

3.3.180 SAR. Abbreviation for supplied air respirator. *[See 3.3.208, Supplied Air Respirator (SAR).]*

3.3.181 SCBA. Abbreviation for self-contained breathing apparatus. *[See 3.3.185, Self-Contained Breathing Apparatus (SCBA).]*

3.3.182 SCBA/SAR. Abbreviation for combination open-circuit SCBA and supplied air respirator. *[See 3.3.34, Combination SCBA/SAR; 3.3.185, Self-Contained Breathing Apparatus (SCBA); and 3.3.208, Supplied Air Respirator (SAR).]*

3.3.183 Seam. Any permanent attachment of two or more materials in a line formed by joining the separate material pieces.

3.3.183.1* ***Major A Seam.*** Outermost layer seam assemblies where rupture could reduce the protection of the garment by exposing the garment's inner layers.

3.3.183.2 ***Major B Seam.*** Inner layer seam assemblies where rupture could reduce the protection of the garment by exposing the next layer of the garment, the wearer's station/work uniform, other clothing, or skin.

3.3.183.3 ***Major Seam.*** Seam assemblies where rupture exposes the wearer to immediate danger.

3.3.183.4 ***Minor Seam.*** Remaining seam assemblies that are not classified as Major, Major A, or Major B seams.

3.3.184 Seam Assembly. The structure obtained when materials are joined by means of a seam.

3.3.185* Self-Contained Breathing Apparatus (SCBA). An atmosphere-supplying respirator that supplies a respirable air atmosphere to the user from a breathing air source that is independent of the ambient environment and designed to be carried by the user.

3.3.186 Separate/Separation. A material response evidenced by splitting or delaminating.

3.3.187 Service Life. The period for which compliant product may be useful before retirement.

3.3.188 Service Time. See 3.3.165, Rated Service Time.

3.3.189 Shank. The component of footwear that provides additional support to the instep.

3.3.190 Shell. See 3.3.124, Outer Shell.

3.3.191 Sound Pressure Level (SPL). The local pressure deviation from the ambient (average, or equilibrium) atmospheric pressure caused by a sound wave.

3.3.192 Specimen. The conditioned ensemble, element, item, or component that is tested. Specimens are taken from samples. *(See also 3.3.179, Sample.)*

3.3.193 Speech Transmission Index (STI). A measure of intelligibility of speech quality on a scale of intelligibility, whose values vary from 0 (completely unintelligible) to 1 (perfect intelligibility).

3.3.194 Structural Firefighting. The activities of rescue, fire suppression, and property conservation in buildings, enclosed structures, vehicles, marine vessels, or like properties that are involved in a fire or emergency situation.

3.3.195 Structural Firefighting Protective Barrier Hood. The optional interface element of the protective ensemble that provides limited thermal, physical, and barrier protection to the coat/helmet/SCBA facepiece interface area.

3.3.196 Structural Firefighting Protective Clothing. See 3.3.199, Structural Firefighting Protective Ensemble.

3.3.197 Structural Firefighting Protective Coat. The element of the protective ensemble that provides protection to the upper torso and arms, excluding the hands and head.

3.3.198 Structural Firefighting Protective Coverall. The element of the protective ensemble that provides protection to the torso, arms, and legs, excluding the head, hands, and feet.

3.3.199* Structural Firefighting Protective Ensemble. Multiple elements of compliant protective clothing and equipment that when worn together provide protection from some risks, but not all risks, of emergency incident operations.

3.3.200 Structural Firefighting Protective Ensemble with Optional Liquid and Particulate Contaminant Protection. A compliant structural firefighting protective ensemble that is also certified as an entire ensemble to meet the optional requirements for protection from liquid and particulate contaminants.

3.3.201 Structural Firefighting Protective Footwear. The element of the protective ensemble that provides protection to the foot, ankle, and lower leg.

3.3.202 Structural Firefighting Protective Garment(s). The coat, trouser, and coverall elements of the protective ensemble.

3.3.203 Structural Firefighting Protective Glove. The element of the protective ensemble that provides protection to the hand and wrist.

3.3.204 Structural Firefighting Protective Helmet. The element of the protective ensemble that provides protection to the head.

3.3.205 Structural Firefighting Protective Hood. The interface element of the protective ensemble that provides limited protection to the coat/helmet/SCBA facepiece interface area.

3.3.206 Structural Firefighting Protective Trousers. The element of the protective ensemble that provides protection to the lower torso and legs, excluding the ankles and feet.

3.3.207 Supplementary Voice Communications System. An optional electronic voice amplification communication system in addition to a nonelectronic transmission system.

3.3.208* Supplied Air Respirator (SAR). An atmosphere-supplying respirator for which the source of breathing air is not designed to be carried by the user; also known as an *airline respirator. [See also 3.3.4, Atmosphere-Supplying Respirator; 3.3.34, Combination SCBA/SAR; and 3.3.185, Self-Contained Breathing Apparatus (SCBA).]*

3.3.209 Surrogate Cylinder. A breathing air cylinder for testing only in which the mass of the breathing air is replaced by a substitute mass.

3.3.210 Suspension. The energy-attenuating system of the helmet that is made up of the headband and crown strap.

3.3.211 Sweatband. That part of a helmet headband, either integral or attached, that comes in contact with the wearer's forehead.

3.3.212 Synthetic Breathing Air. A manufactured breathing air that is produced by blending nitrogen and oxygen. *(See also 3.3.41, Compressed Breathing Air.)*

3.3.213 Tensile Strength. The force at which a fiber or fabric will break when pulled in one dimension.

3.3.214 Textile Fabric. A planar structure consisting of yarns or fibers.

3.3.215 Thermal Barrier. The component of an element or item that principally provides thermal protection.

3.3.216 Toe Cap. A reinforcement to the toe area of footwear designed to protect the toes from impact and compression.

3.3.217* Tongue. The part of the protective footwear that is provided for lace up protective footwear with a closure that extends from the vamp to the top line of the footwear between sides of the footwear upper and is exposed to the exterior environment when the footwear is correctly donned.

3.3.218 Top. The intersection between the midsagittal plane and the coronal plane extended to the helmet surface.

3.3.219 Top Line. The top edge of the protective footwear that includes the tongue, gusset, quarter, collar, and shaft.

3.3.220* Total Fluorine. A measurement that includes organic and inorganic fractions of fluorine.

3.3.221 Toxic Industrial Chemicals. Highly toxic solid, liquid, or gaseous chemicals that have been identified as mass casualty threats that could be used to inflict casualties, generally on a civilian population, during a terrorist attack.

3.3.222* Trim. Retroreflective and fluorescent materials attached to the outermost surface of the protective ensemble for visibility enhancement.

3.3.223 Trouser. See 3.3.206, Structural Firefighting Protective Trousers, and 3.3.161, Proximity Firefighting Protective Trousers.

3.3.224 UAC. Abbreviation for universal air connection.

3.3.225 Universal Air Connection (UAC). The male fitting, affixed to the SCBA, and the female fitting, affixed to the filling hose, to provide emergency replenishment of breathing air to an SCBA breathing air cylinder. Also known as Rapid Intervention Crew/Company Universal Air Connection.

3.3.226 Universal Emergency Breathing Safety System (UEBSS). A device on an SCBA that allows users to share their available air supply in an emergency situation through a standardized interoperable connection.

3.3.227* Upper. The part of the protective footwear including, but not limited to, the toe, vamp, quarter, shaft, collar, and throat, but excluding the sole with heel, puncture-resistant device, and insole.

3.3.228 Upper Torso. The area of body trunk above the waist and extending to the shoulder, excluding the arms and wrists, and hands.

3.3.229* Visibility Markings. Retroreflective and fluorescent conspicuity enhancements.

3.3.230 Voice Communications System. Nonelectronic transmission system to project sound.

3.3.231 Water Resistance. A finish or an inherent property that limits the absorption of water.

3.3.232 Wear Surface. The bottom of the footwear sole, including the heel.

3.3.233 Winter Liner. An optional component layer that provides added insulation against cold.

3.3.234 Work Apparel. Nonprimary protective garments certified as compliant with this standard that are intended to be worn by emergency services personnel while on duty.

3.3.235 Work Apparel Garment. Textile apparel that cover the torso and limbs or parts of limbs, excluding heads, hands, and feet.

3.3.236 Wristlet. The interface component of the protective element or item that provides limited protection to the protective coat/glove interface area.

Chapter 4 Certification

4.1 General Certification Requirements (NFPA 1971; NFPA 1975; NFPA 1981; NFPA 1982).

4.1.1 The process of certification of products as being compliant with NFPA 1971, NFPA 1975, NFPA 1981, or NFPA 1982, as incorporated within NFPA 1970 shall meet the requirements of Chapter 4, along with the associated certification requirements in Chapter 5, Chapter 10, Chapter 15, or Chapter 20.

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

4.1.2.1* Manufacturers shall not claim compliance with a portion(s) or segment(s) of the applicable requirements of this standard and shall not use the name or identification of this standard, NFPA 1971, NFPA 1975, NFPA 1981, or NFPA 1982, in any statements about their respective products unless the product is certified to the applicable standard incorporated in NFPA 1970.

4.1.3 All certification shall be performed by a certification organization that meets at least the requirements specified in Section 4.2, Certification Program, and that is accredited for personal protective equipment in accordance with ISO/IEC 17065, *Conformity assessment — Requirements for bodies certifying products, processes, and services*. The accreditation shall be issued by an accreditation body operating in accordance with ISO/IEC 17011, *Conformity assessment — General requirements for accreditation bodies accrediting conformity assessment bodies*.

4.1.4 All compliant products shall be labeled and listed. The listing shall uniquely identify the certified product by, at a minimum, style, model number, or part number.

4.1.4.1 The certification organization shall be required to identify the element or component in the certification listing as used by the manufacturer to identify the product to end users.

4.1.5 All compliant products shall also have a product label that meets the requirements specified in the applicable product label requirements.

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

4.2 Certification Program.

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

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

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

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

4.2.5* The contractual provisions between the certification organization and the manufacturer shall specify that certification is contingent on compliance with all applicable requirements of this standard.

4.2.5.1 The certification organization shall not offer or confer any conditional, temporary, or partial certifications.

4.2.5.2 Manufacturers shall not be authorized to use any label or reference to the certification organization on products that are not compliant with all applicable requirements of this standard.

4.2.6* The certification organization shall have laboratory facilities and equipment available for conducting tests to determine product compliance.

4.2.6.1 The certification organization laboratory facilities shall have in place a program and functioning for calibration of all instruments, and procedures shall be in use to ensure control of all testing.

4.2.6.2 The certification organization laboratory facilities shall follow good practice regarding the use of laboratory manuals, form data sheets, documented calibration and calibration routines, performance verification, proficiency testing, and staff qualification and training programs.

4.2.7 The certification organization shall require the manufacturer to establish and maintain a quality assurance program that meets the requirements of Section 4.5, Compliant Product Manufacturers' Quality Assurance Program.

4.2.7.1* The certification organization shall require the manufacturer to have a product recall system as specified in Section 4.9, Manufacturers' Safety Alert and Product Recall Systems, as part of the manufacturer's quality assurance program.

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

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

4.2.9* The certification organization shall have a follow-up inspection program of the manufacturer's manufacturing facilities of the compliant product with at least two random and unannounced visits per 12-month period to verify the product's continued compliance. Where portions of the production process are carried out by multiple facilities, the certification organization shall determine the appropriate follow-up program according to which facility or facilities most closely meet the definition for *manufacturing facility*, provided in 3.3.111.

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

4.2.9.2 Sample product shall be evaluated by the certification organization to verify the product's continued compliance to assure that the materials, components, and manufacturing quality assurance systems are consistent with the materials, components, and manufacturing quality assurance that were inspected and tested by the certification organization during initial certification and annual verification.

4.2.9.3 The certification organization shall be permitted to conduct specific testing to verify the product's continued compliance.

4.2.9.4 For products, components, and materials where prior testing, judgment, and experience of the certification organization have shown results to be in jeopardy of not complying with this standard, the certification organization shall conduct more frequent testing of sample product, components, and materials acquired in accordance with 4.2.9.1 against the applicable requirements of this standard.

4.2.10 The certification organization shall have in place a series of procedures, as specified in Section 4.7, Hazards Involving Compliant Product, that address report(s) of situation(s) in which a compliant product is subsequently found to be hazardous.

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

4.2.12 The certification organization shall be in a position to use legal means to protect the integrity of its name and label. The name and label shall be registered and legally defended.

4.3* Inspection and Testing.

4.3.1 For both initial certification and annual verification of compliant products, the certification organization shall conduct both inspection and testing as specified in Section 4.3, Inspection and Testing.

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

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

4.3.2.2 The accreditation of a certification organization's testing laboratory shall be issued by an accreditation body operating in accordance with ISO/IEC 17011, *Conformity assessment — General requirements for accreditation bodies accrediting conformity assessment bodies.*

4.3.3 A certification organization shall be permitted to utilize conditioning and testing results conducted by a product or component manufacturer for certification or annual verification provided the manufacturer's testing laboratory meets the requirements specified in 4.3.3.1 through 4.3.3.5.

4.3.3.1 The manufacturer's testing laboratory shall be accredited in accordance with the requirements of ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories.*

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

4.3.3.3 The accreditation of a manufacturer's testing laboratory shall be issued by an accreditation body operating in accordance with ISO/IEC 17011, *Conformity assessment — General requirements for accreditation bodies accrediting conformity assessment bodies.*

4.3.3.4 The certification organization shall approve the manufacturer's testing laboratory.

4.3.3.5 The certification organization shall determine the level of supervision and witnessing of the conditioning and testing for certification or annual verification conducted at the manufacturer's testing laboratory.

4.3.4 Sampling levels for testing and inspection shall be established by the certification organization and the manufacturer to ensure a reasonable and acceptable reliability at a reasonable and acceptable confidence level that products certified to this standard are compliant, unless such sampling levels are specified herein.

4.3.5 Inspection and evaluation by the certification organization shall include a review of all product labels to ensure that all required label attachments, compliance statements, certification statements, and other product information are at least as specified for the products identified in Chapter 6 (NFPA 1971), Chapter 11 (NFPA 1975), Chapter 16 (NFPA 1981), or Chapter 21 (NFPA 1982).

4.3.6 Inspection and evaluation by the certification organization shall include an evaluation of any symbols and pictorial graphic representations used on product labels or in user information, as permitted in 6.1.5 (NFPA 1971), 11.1.8 (NFPA 1975), 16.1.5 (NFPA 1981), or 21.1.4 (NFPA 1982) to ensure that the symbols are explained in the product's user information package.

4.3.7 Inspection by the certification organization shall include a review of the user information required by Sections 6.5 (NFPA 1971), 11.2 (NFPA 1975), 16.2 (NFPA 1981), or 21.2 (NFPA 1982) to ensure that the information has been developed and is available.

4.3.8 Inspection and evaluation by the certification organization for determining compliance with the design requirements specified in Chapter 7 (NFPA 1971), Chapter 12 (NFPA 1975), Chapter 17 (NFPA 1981), or Chapter 22 (NFPA 1982) shall be performed on whole or complete products.

4.3.9 Inspection and evaluation by the certification organization for determining compliance of recognized components per the requirements specified in 7.1.14, 7.4.9, 7.7.6, 7.10.10, and 7.13.7 shall be permitted to consist of a review of any available test data provided by the component supplier.

4.3.9.1 Data submitted by the component supplier shall be evaluated against the requirements in Table 8.21(a) to determine compliance of the recognized component.

4.3.9.2* This evaluation shall be required only for initial certification or if there is a change to the materials used in the recognized component.

4.3.9.3 The data submitted by the component supplier for the purposes of demonstrating compliance to these requirements must not be greater than five years from the initial certification date of that component to this standard.

4.3.9.4 The test data submitted by the component supplier for demonstrating compliance with the requirements in 7.1.14, 7.4.9, 7.7.6, 7.10.10, and 7.13.7 generated by a testing laboratory shall be accredited to ISO 17025, *General requirements for the competence of testing and calibration laboratories*.

4.3.9.5 Any test data that is required to demonstrate compliance with 7.1.14, 7.4.9, 7.7.6, 7.10.10, 7.13.7, and Section 8.21 that is not submitted by the component supplier shall be subjected to the requirements as outlined in those paragraphs.

4.3.9.6 Suppliers of recognized components shall be permitted to make specific claims related to the PFAS levels in their specific materials or components according to 6.1.7.5, which in turn can be applied by protective elements manufacturers as the basis of their optional claims according to 6.1.7.5.

4.3.9.6.1 Suppliers of recognized components shall be permitted to provide a certificate with test results demonstrating compliance with the optional claim where the organization performing the testing meets the following requirements:

(1) The test organization shall be independent from the supplier.
(2) The test organization is accredited in accordance with the requirements of ISO 17025, *General requirements for the competence of testing and calibration laboratories*, for performing total fluorine by combustion ion chromatography.
(3) The test organization shall provide a separate test report along with the certificate that meets the requirements of 6.5.11 and 6.5.11.1.

4.3.10* In lieu of the requirements in 4.3.9, compliance of recognized components to the requirements specified in 7.1.14, 7.4.9, 7.7.6, 7.10.10, 7.13.7, and Section 8.21 shall be permitted to be based on a certificate provided by a restricted substance attestation organization that meets the following requirements:

(1) The restricted substance attestation organization shall be independent from the supplier.
(2) The restricted substance attestation organization shall use a restricted substance list that is equivalent to or more rigorous than the specific criteria for restricted substances in Section 8.21.
(3) Laboratories conducting the evaluations of restricted substances shall be accredited in accordance with the requirements of ISO 17025, *General requirements for the competence of testing and calibration laboratories*, with analytical testing for restricted substances as part of its scope.
(4) A separate test report shall be provided, along with the certificate, that provides the results of all applicable restricted substances evaluations.

4.3.10.1* The certificate in 4.3.10 shall be required only for initial certification or if there is a change to the materials used in the recognized component.

4.3.11 Where the compliant product manufacturer utilizes a proprietary material or materials, the required testing shall be permitted to be part of the compliant product certification in lieu of the component being recognized.

4.4 Annual Verification. All products that are labeled as being compliant with this standard shall, on an annual basis, undergo a verification evaluation to all requirements as required by this standard.

4.5 Compliant Product Manufacturers' Quality Assurance Program.

4.5.1 The compliant product manufacturer shall provide and operate a quality assurance program that meets the requirements of Section 4.5, Compliant Product Manufacturers' Quality Assurance Program, and that includes a product recall system as specified in 4.2.7.1 and Section 4.9, Manufacturers' Safety Alert and Product Recall Systems.

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

4.5.3 All the following entities shall either be registered to ISO 9001, *Quality management systems — Requirements,* or shall be listed as a covered location under an ISO 9001 registered entity:

(1) Compliant product manufacturer
(2) Compliant product manufacturing facility
(3) Entity that directs and controls compliant product design
(4) Entity that directs and controls compliant product quality assurance
(5) Entity that provides the warranty for the compliant product
(6) Entity that puts their name on the product label and markets and sells the product as their own

4.5.3.1 Registration to the requirements of ISO 9001, *Quality management systems — Requirements*, shall be conducted by a registrar that is accredited for personal protective equipment in accordance with ISO 17021, *Conformity assessment – Requirements for bodies providing audit and certification of management systems.* The registrar shall affix the accreditation mark on the ISO registration certificate.

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

4.5.4* Any entity that meets the definition of *manufacturer* specified in 3.3.110, and therefore is considered to be the "manufacturer" but that does not manufacture or assemble the compliant product, shall meet the requirements specified in Section 4.5, Compliant Product Manufacturers' Quality Assurance Program.

4.5.5* Where the manufacturer uses subcontractors in the construction or assembly of the compliant product, the locations and names of all subcontractor facilities shall be documented, and the documentation shall be provided to the manufacturer's ISO registrar and the certification organization.

4.5.6 Where manufacturers construct custom-sized or special-fitting gloves for accommodating the special needs of individual firefighters, the manufacturer shall employ the same manufacturing methods as used in the construction of required glove sizes.

4.5.6.1 The manufacturer shall notify the certification organization as required in 4.2.8 and shall obtain written approval from the certification organization prior to proceeding with any modifications to an existing certified glove design.

4.5.6.2 Custom-fitting gloves shall be individually evaluated to verify the integrity of the glove moisture barrier using air or other similar method to ensure that the glove is constructed in a leak-free manner.

4.6* Recognized Component Supplier Quality Assurance Program.

4.6.1 General.

4.6.1.1 The supplier shall provide and maintain a quality assurance program that includes a documented inspection and product recall system.

4.6.1.2 The supplier shall have an inspection system to substantiate conformance to this standard.

4.6.1.3 The supplier shall be permitted to be registered to ISO 9001, *Quality Management Systems — Requirements,* in lieu of meeting the requirements of 5.4.2 through 5.4.6.

4.6.2 Instructions.

4.6.2.1 The supplier shall maintain written inspection and testing instructions.

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

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

4.6.3 Records.

4.6.3.1 The supplier shall maintain records of all "pass" and "fail" tests.

4.6.3.2 Records shall indicate the disposition of the failed materials or products.

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

4.6.5 Calibration Program. The supplier shall maintain, as part of the quality assurance program, a calibration program of all instruments used to ensure control of testing.

4.7 Hazards Involving Compliant Product.

4.7.1 The certification organization shall establish procedures to be followed where situation(s) are reported in which a compliant product is subsequently found to be hazardous. These procedures shall comply with the provisions of ISO Guide 27, *Guidelines for corrective action to be taken by a certification body in the event of misuse of its mark of conformity,* and as modified herein.

4.7.2* Where a report of a hazard involved with a compliant product is received by the certification organization, the validity of the report shall be investigated.

4.7.3 With respect to a compliant product, a hazard shall be a condition or create a situation that results in exposing life, limb, or property to an imminently dangerous or dangerous condition.

4.7.4 Where a specific hazard is identified, the determination of the action for the certification organization and the manufacturer to undertake shall take into consideration the severity of the hazard and its consequences to the safety and health of users.

4.7.5 Where it is established that a hazard is involved with a compliant product, the certification organization shall determine the scope of the hazard including products, model numbers, serial numbers, factory production facilities, production runs, and quantities involved.

4.7.6 The certification organization's investigation shall include, but not be limited to, the extent and scope of the problem as it might apply to other compliant products or compliant product components manufactured by other manufacturers or certified by other certification organizations.

4.7.7 The certification organization shall also investigate reports of a hazard where compliant product is gaining widespread use in applications not foreseen when the standard was written, such applications in turn being ones for which the product was not certified, and no specific scope of application has been provided in the standard, and no limiting scope of application was provided by the manufacturer in written material accompanying the compliant product at the point of sale.

4.7.8 The certification organization shall require the manufacturer of the compliant product, or the manufacturer of the compliant product component, if applicable, to assist the certification organization in the investigation and to conduct its own investigation as specified in Section 4.7, Hazards Involving Compliant Product.

4.7.9 Where the facts indicating a need for corrective action are scientifically supported and there is a manufacturer to be held responsible that has exhausted all appeal rights, the certification organization shall initiate corrective action immediately.

4.7.10* Where the facts are scientifically supported and corrective action is indicated but there is no manufacturer to be held responsible, the certification organization shall immediately notify relevant governmental and regulatory agencies and issue a notice to the user community about the hazard.

4.7.11* Where the facts are scientifically supported and corrective action is indicated, the certification organization shall take one or more of the following corrective actions:

(1) Parties authorized and responsible for issuing a safety alert shall be notified when, in the opinion of the certification organization, such a safety alert is necessary to inform the users.
(2) Parties authorized and responsible for issuing a product recall shall be notified when, in the opinion of the certification organization, such a recall is necessary to protect the users.
(3) The mark of certification shall be removed from the product.
(4) Where a hazardous condition exists and it is not practical to implement 4.7.11(1), 4.7.11(2), or 4.7.11(3), or the responsible parties refuse to take corrective action, the certification organization shall notify relevant governmental and regulatory agencies and issue a notice to the user community about the hazard.

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

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

4.8 Manufacturers' Investigation of Complaints and Returns.

4.8.1 Manufacturers shall provide corrective action in accordance with ISO 9001, *Quality management systems — Requirements,* for investigating written complaints and returned products.

4.8.2 Manufacturers' records of returns and complaints related to safety issues shall be retained for at least 5 years.

4.8.3 Where the manufacturer discovers, during the review of specific returns or complaints, that a compliant product or compliant product component can constitute a potential safety risk to end users that is possibly subject to a safety alert or product recall, the manufacturer shall immediately contact the certification organization and provide all information about its review to assist the certification organization with its investigation.

4.9 Manufacturers' Safety Alert and Product Recall Systems.

4.9.1 Manufacturers shall establish a written safety alert system and a written product recall system that describes the procedures to be used in the event that it decides, or is directed by the certification organization, to either issue a safety alert or to conduct a product recall.

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

(1) The establishment of a coordinator and responsibilities by the manufacturer for the handling of safety alerts and product recalls
(2) A method of notifying all dealers, distributors, purchasers, users, and NFPA about the safety alert or product recall that can be initiated within a 1-week period following the manufacturer's decision to issue a safety alert or to conduct a product recall, or after the manufacturer has been directed by the certification organization or NIOSH/NPPTL if the product is certified to NFPA 1981, to issue a safety alert or conduct a product recall
(3) Techniques for communicating the nature of the safety alert or product recall and, in particular, the specific hazard or safety issue found to exist
(4) Procedures for removing product that is recalled and for documenting the effectiveness of the product recall
(5) A plan for repairing, or replacing, or compensating purchasers for returned product

Chapter 5 Scope and Certification Requirements (NFPA 1971)

5.1 Administration.

5.1.1* Scope.

5.1.1.1 Chapters 5 through 9 of this standard shall specify the minimum design, performance, testing, and certification requirements for structural firefighting protective ensembles and ensemble elements that include coats, trousers, coveralls, helmets, gloves, footwear, interface components, and other components utilized to construct these elements.

5.1.1.2 Chapters 5 through 9 of this standard shall specify the minimum design, performance, testing, and certification requirements for proximity firefighting protective ensembles and ensemble elements that include coats, trousers, coveralls, helmets, gloves, footwear, and interface components, and other components utilized to construct these elements.

5.1.1.3* Chapters 5 through 9 of this standard shall also specify additional optional requirements for structural firefighting protective ensembles and proximity firefighting protective garments that will provide limited protection from liquid and particulate hazards.

5.1.1.3.1 Chapters 5 through 9 of this standard shall not specify requirements for protection against CBRN terrorism agents.

5.1.1.4 Chapters 5 through 9 of this standard shall specify requirements for new structural firefighting protective ensembles, new proximity firefighting protective ensembles, or new elements for both ensembles.

5.1.1.5* Chapters 5 through 9 of this standard shall not apply to firefighting overhaul operations as it relates to protective coats and trousers. Coats and trousers for overhaul shall meet the requirements of NFPA 1951. All other elements of the protective ensemble for structural firefighting shall apply.

5.1.1.6* Chapters 5 through 9 of this standard shall not specify requirements for any accessories that could be attached to the certified product, but are not necessary for the certified product to meet the requirements of this standard.

5.1.1.7* This standard shall not specify PPE requirements for nonstructural fire responses.

5.1.1.8 Other than the testing for certification of structural or proximity protective garments to the optional liquid and particulate hazard protection requirements, Chapters 5 through 9 shall not specify the respiratory protection that is necessary for protection with structural or firefighting protective ensembles.

5.1.1.9 Certification of compliant structural firefighting protective ensembles, compliant proximity firefighting protective ensembles, and compliant elements of both ensembles to the requirements of Chapters 5 through 9 of this standard shall not preclude certification to additional standards where the ensemble or ensemble element meets all the applicable requirements of each standard.

5.1.1.10 Chapters 5 through 9 of this standard shall not be construed as addressing all of the safety concerns associated with the use of compliant protective ensembles or ensemble elements. It shall be the responsibility of the persons and organizations that use compliant protective ensembles or ensemble elements to establish safety and health practices and determine the applicability of regulatory limitations prior to use.

5.1.1.11 Chapters 5 through 9 of this standard shall not be construed as addressing all of the safety concerns, if any, associated with the use of this standard by testing facilities. It shall be the responsibility of the persons and organizations that use this standard to conduct testing of protective ensembles or ensemble elements to establish safety and health practices and determine the applicability of regulatory limitations prior to using Chapters 5 through 9 for any designing, manufacturing, and testing.

5.1.1.12 Nothing in this standard shall restrict any jurisdiction or manufacturer from exceeding these minimum requirements.

5.1.2* Purpose.

5.1.2.1 The purpose of Chapters 5 through 9 of this standard shall be to establish minimum levels of protection for firefighting personnel assigned to fire department operations including, but not limited to, structural firefighting, proximity firefighting, rescue, emergency medical, and other emergency first responder functions.

5.1.2.1.1* To achieve this purpose, Chapters 5 through 9 of this standard shall establish minimum requirements for structural firefighting protective ensembles and ensemble elements designed to provide firefighting personnel limited protection from thermal, physical, environmental, biological, chemical, electrical, person-position, person-equipment, and other hazards encountered during structural firefighting operations.

5.1.2.1.2 To achieve this purpose, Chapters 5 through 9 of this standard shall establish minimum requirements for proximity firefighting protective ensembles and ensemble elements designed to provide firefighting personnel limited protection from thermal exposures where high levels of radiant heat as well as convective and conductive heat are released, and from physical, environmental, biological, chemical, electrical, person-position, person-equipment, and other hazards encountered during proximity firefighting operations. *(See also, A.5.1.2.1.1.)*

5.1.2.2 The purpose of Chapters 5 through 9 of this standard shall also be to establish a minimum level of protection for structural and proximity firefighting personnel from exposure to liquid and particulate contaminants as an option for compliant structural firefighting garments, for compliant proximity firefighting garments, and for compliant elements for both garments.

5.1.2.3* Controlled laboratory tests used to determine compliance with the performance requirements of Chapters 5 through 9 of this standard shall not be deemed as establishing performance levels for all situations to which personnel can be exposed.

5.1.2.4 Chapters 5 through 9 of this standard shall not be utilized as a detailed manufacturing or purchasing specification but shall be permitted to be referenced in purchase specifications as minimum requirements.

5.1.2.5 The purpose of this standard shall not be to establish minimum levels of protection for non-firefighting incidents such as, but not limited to, technical rescue, vehicle extrication, medical, search and rescue, wildland and urban interface, and nonfire roadway incidents.

5.1.3 Application.

5.1.3.1 Chapters 5 through 9 of this standard shall apply to the design, manufacturing, testing, and certification of new structural firefighting protective ensembles, new proximity firefighting protective ensembles, and new elements of both ensembles for protection from thermal, physical, environmental, and bloodborne pathogen hazards encountered during structural firefighting operations.

5.1.3.2* Chapters 5 through 9 of this standard shall apply to the design, manufacturing, testing, and certification of new structural firefighting protective ensembles, new proximity firefighting protective ensembles, and new garment elements of both ensembles for additional optional protection from liquid and particulate contaminants.

5.1.3.2.1 This standard shall also apply to the design, manufacturing, testing, and certification of new structural firefighting protective hoods and new proximity firefighting protective hoods for additional protection from particulate contaminants.

5.1.3.3 Chapters 5 through 9 of this standard shall not apply to any protective ensembles, ensemble elements, or protective clothing for any other types of firefighting operations.

5.1.3.4 Chapters 5 through 9 of this standard shall not apply to structural firefighting protective ensembles manufactured according to previous editions of NFPA 1971.

5.1.3.5 Chapters 5 through 9 of this standard shall not apply to structural firefighting protective clothing and equipment manufactured according to past editions of NFPA 1971, NFPA 1972, NFPA 1973, and NFPA 1974.

5.1.3.6 Chapters 5 through 9 of this standard shall not apply to proximity firefighting protective ensembles manufactured according to previous editions of NFPA 1976.

5.1.3.7 Chapters 5 through 9 of this standard shall not apply to proximity firefighting protective clothing and equipment manufactured according to past editions of NFPA 1976.

5.1.3.8 Chapters 5 through 9 of this standard shall not apply to any accessories that could be attached to the certified product, before or after purchase, but are not necessary for the certified product to meet the requirements of Chapters 5 through 9. *(See A.5.1.1.6.)*

5.1.3.9 Chapters 5 through 9 of this standard shall not apply to the use of structural firefighting protective ensembles, proximity firefighting protective ensembles, or elements of these ensembles since these requirements are specified in NFPA 1550.

5.1.4 Units.

5.1.4.1 In Chapters 5 through 9 of this standard, values for measurement are followed by an equivalent in parentheses, but only the first stated value shall be regarded as the requirement.

5.1.4.2 Equivalent values in parentheses shall not be considered as the requirement, as these values are approximate.

5.2 General.

5.2.1 The process of certification for structural and proximity ensembles as being compliant with Chapters 5 through 9 of this standard shall meet the requirements of Sections 4.1 through 4.9.

5.2.2 All compliant products that are labeled as being compliant with Chapters 5 through 9 of this standard shall meet or exceed all applicable requirements specified in Chapters 5 through 9 and shall be certified.

5.2.3 The certification organization shall not issue any new certifications based on the 2018 edition of NFPA 1971 after the NFPA effective date of the 2025 edition of NFPA 1970.

5.2.4 The certification organization shall not permit any manufacturer to continue to label any products that are certified as compliant with the 2018 edition of NFPA 1971 on the effective date of the 2025 edition of NFPA 1970, plus 12 months.

5.2.5 The certification organization shall require manufacturers to remove all certification labels and product labels indicating compliance with the 2018 edition of NFPA 1971 from all products that are under the control of the manufacturer on the effective date of the 2025 edition of NFPA 1970, plus 12 months, and the certification organization shall verify that this action is taken.

5.2.6 For calculating the results of garment composite testing in accordance with Section 9.7.2, the requirements of 5.2.6.1 through 5.2.6.11 shall apply. *(See also A.9.7.2.1.2.)*

5.2.6.1 A control fabric consisting of a 254 g/m^2 (7.5 oz/yd^2) woven 93 percent meta-aramid, 5 percent para-aramid, and 2 percent antistat fiber shall be tested in accordance with 9.7.2.5 and referred to as "Result A."

5.2.6.2 The moisture barrier layer and thermal barrier layer for a specific garment composite shall be tested in conjunction with the control fabric in accordance with 9.7.2.5 with all layers arranged in the order and orientation as worn.

5.2.6.3 The evaporative resistance of the control fabric with moisture barrier layer and thermal barrier layer shall be recorded and referred to as "Result B."

5.2.6.4 If a specific moisture barrier layer and thermal barrier layer combination has been previously tested, it shall not be necessary to perform the steps in 5.2.6.1 through 5.2.6.2 .

5.2.6.5 The outer shell layer for a specific composite shall be individually tested in accordance with 9.7.2.5 and referred to as "Result C."

5.2.6.6 If a specific outer shell has been previously tested, it shall not be necessary to perform the step in 5.2.6.5.

5.2.6.7 The difference, "Difference D," between the control fabric evaporative resistance of "Result A" and the garment composite evaporative resistance "Result B" shall be calculated according to the following equation:

[5.2.6.7]

$$\text{Difference D} = \text{Result B} - \text{Result A}$$

5.2.6.8 The sum, "Sum E," of the garment outer shell evaporative resistance "Result C" and calculated moisture barrier layer and thermal barrier layer combination evaporative resistance of "Difference D" shall be calculated according to the following equation:

[5.2.6.8]

Sum E = Result C + Difference D

5.2.6.9 The individual replicate evaporative resistances in m^2Pa/W shall be calculated, recorded, and reported along with the identification of the specific layers as follows:

(1) For "Result A": recorded and reported
(2) For "Result B": recorded and reported
(3) For "Result C": recorded and reported
(4) For "Difference D": calculated, recorded, and reported
(5) For "Sum E": calculated, recorded, and reported

5.2.6.10* The average evaporative resistance in m^2Pa/W for the garment outer shell "Result C," combination of moisture barrier layer and thermal barrier layer "Difference D," and calculated garment composite "Sum E" shall be calculated, recorded, and reported.

5.2.6.11 If the "Sum E" value compared to the original certification value is within 10 percent, the following shall apply:

(1) The model calculation shall be considered acceptable for the purposes of annual verification.
(2) Testing of the actual composite shall not be required.

5.3 Inspection and Testing.

5.3.1 Testing to determine product compliance with the performance requirements specified in Chapter 8 shall be conducted by the certification organization in accordance with the specified testing requirements of Chapter 9.

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

5.3.1.2 Testing shall be performed on specimens representative of materials and components used in the actual construction of the compliant product.

5.3.2 Where the certification organization has findings of noncompliance during initial certification or annual verification testing, the certification organization shall have procedures in place requiring the manufacturer to undertake a root cause analysis, providing a rationale for their noncompliant results, and a corrective action for how the subject element, material, or component is changed or specific problems with the testing that must be addressed in any retesting.

5.3.3 The certification organization shall only accept from the manufacturer, for evaluation and testing for certification, product or product components that are the same in every respect to the actual final product or product component.

5.3.4 The certification organization shall not allow any modifications, pretreatment, conditioning, or other such special processes of the product or any product component prior to the product's submission for evaluation and testing by the certification organization.

5.3.5 The certification organization shall not allow the substitution, repair, or modification, other than as specifically permitted in this standard, of any product or any product component during testing.

5.3.6 The certification organization shall not allow the substitution, repair, or modification, other than as specifically permitted in this standard, of any product or any product component during testing.

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

5.3.8 The certification organization shall test an ensemble element with the specific ensemble(s) with which it is to be certified.

5.3.9 Any change in the design, construction, or material of a compliant product shall necessitate new inspection and testing to verify compliance to all applicable requirements of this standard that the certification organization determines can be affected by such change. This annual verification shall be conducted before labeling the modified product as being compliant with this standard.

5.3.9.1 The manufacturer shall require the component manufacturer to provide a new unique product or component name and apply a separate listing for any retesting of an already qualified product that results in new performance properties that represents a significant change from the original test properties.

5.3.10 The manufacturer shall maintain all design and performance inspection and test data from the certification organization used in the certification of the manufacturer's compliant product. The manufacturer shall provide such data, upon request, to the purchaser or authority having jurisdiction.

5.3.11* For certification of structural firefighting helmet elements, a test series shall consist of 14 helmets.

5.3.11.1 A minimum of three test series shall be required for certification.

5.3.11.2 Each helmet shall be subjected to the specified environmental conditioning and test or tests.

5.3.12* For certification of proximity firefighting helmet elements, a test series shall consist of 14 helmets.

5.3.12.1 A minimum of three test series shall be required for certification.

5.3.12.2 Each helmet shall be subjected to the specified environmental conditioning and test or tests.

5.3.13 For certification of any garments with the optional liquid and particulate contaminant protection requirements, the garments and interface components shall be subjected to the specified environmental conditioning and test or tests.

5.4 Annual Verification.

5.4.1 The annual verification shall include the following:

(1) Inspection and evaluation to all design requirements as required by this standard on all manufacturer models and components, as follows:
    (a) For ensembles and ensemble elements being evaluated in accordance with Chapter 7, one specimen of each model containing a representation of available components shall be submitted.

(b) Where the ensemble or ensemble element is manufactured at multiple manufacturing facilities and the design is the same at all of those facilities, one sample from any one manufacturing facility shall be submitted.

(2) Testing to all performance requirements as required by this standard on all manufacturer models and components with the following protocol:

(a) Where a test method incorporates testing both before and after laundering conditioning specified in 9.1.12 and the test generates quantitative results, annual verification testing shall be limited to the conditioning that yielded the worst-case test result during the initial certification for the model or component.

(b)* Where a test method incorporates testing both before and after laundering conditioning specified in 9.1.12 and the test generates nonquantitative results (e.g., pass/fail for melt/drip), annual verification shall be limited to a single conditioning procedure in any given year, with subsequent annual verifications cycling through the remaining conditioning procedures to ensure that all required conditionings are included over time.

(c) Where a test method requires the testing of three specimens, a minimum of one specimen shall be tested for annual verification.

(d) Where a test method requires the testing of five or more specimens, a minimum of two specimens shall be tested for annual verification.

(e) Minor seams shall only be tested in accordance with Section 9.3.4 during initial certification.

5.4.2 At least one sample of each compliant product and component shall be tested for overall performance as specified in Chapter 8 according to the following protocol:

(1) Where a test method incorporates testing both before and after laundering conditioning specified in 9.1.12 and the test generates quantitative results, annual verification testing shall be limited to the conditioning that yielded the worst-case test result during the initial certification for the model or component.

(2)* Where a test method incorporates testing both before and after laundering conditioning specified in 9.1.12 and the test generates nonquantitative results (e.g., pass/fail for melt/drip), annual verification shall be limited to a single conditioning procedure in any given year. Subsequent annual verifications shall cycle through the remaining conditioning procedures to ensure that all required conditionings are included over time.

(3) Where a test method requires the testing of less than five specimens, a minimum of one specimen shall be tested for annual verification, unless otherwise specified in this standard.

(4) Where a test method requires the testing of five or more specimens, a minimum of two specimens shall be tested for annual verification, unless otherwise specified in this standard.

(5) Testing of garments for the optional liquid and particulate contaminant protection shall only be performed during initial certification.

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

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

5.4.5 Samples of manufacturer models and components for annual verification shall be acquired as part of the follow-up program in accordance with 4.2.9 and shall be permitted to be used toward annual verification.

5.4.6 The manufacturer shall maintain all design and performance inspection and test data from the certification organization used in the annual verification of manufacturer models and components. The manufacturer shall provide such data, upon request, to the purchaser or authority having jurisdiction.

5.5 Additional General Certification Requirements. The certification organization shall include, as part of the product listing, the required user information and any other information or test results for the respective certified ensemble element or recognized component identified in Chapters 1 through 8.

Chapter 6 Labeling and Information (NFPA 1971)

6.1 Product Label Requirements for Both Ensembles.

6.1.1* Each element of both protective ensembles shall have at least one product label permanently and conspicuously located inside each element when the element is properly assembled with all layers and components in place.

6.1.1.1 Recognized components shall have identifiable markings either on the product itself, or on the smallest unit packaging.

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

6.1.3* The certification organization's label, symbol, or identifying mark shall be permanently attached to the product label or shall be part of the product label. All letters shall be at least 2.5 mm (3⁄32 in.) high. The label, symbol, or identifying mark shall be at least 6 mm (1⁄4 in.) in height and shall be placed in a conspicuous location.

6.1.3.1 Where the product is labeled as a recognized component, the certification organization's label, symbol, or identifying mark shall be distinct from the certification organization's label, symbol, or identifying mark used on ensemble elements.

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

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

6.1.6 The compliance statements specified in Section 6.2, Additional Product Label Requirements for Structural Firefighting Ensemble Elements Only, for structural firefighting protective ensemble elements and in Section 6.3, Additional Product Label Requirements for Proximity Firefighting Ensemble Elements Only, for proximity firefighting protective ensemble elements shall be printed legibly on the product label.

6.1.7 The information contained in Table 6.1.7 shall be printed on each product label or printed directly on the product, or product packaging, where permissible, with all letters at least 1.5 mm (1⁄16 in.) in height.

6.1.7.1 Principal materials shall include the individual layers or components as identified for the respective element as follows:

(1) For garments, at least the outer shell, moisture barrier, and thermal barrier
(2)* For helmets, at least the shell
(3)* For gloves, at least the outer shell, moisture barrier, thermal barrier, and glove interface component (wristlet)
(4)* For footwear, at least the outer shell, moisture barrier, and thermal barrier
(5) For hoods, the outer shell, particulate-blocking layer, and any lining material

6.1.7.2 Where the thermal liner, moisture barrier, and outer shell of a garment are separable, each separable layer shall also have a label containing the information required in item (4) through item (8) of Table 6.1.7.

Table 6.1.7 Information Required to Be Present on Product Labeling

Labeling Item	Ensemble Elements	Components
(1) Manufacturer's name, identification, or designation	X	X
(2) Manufacturer's address	X	
(3) Country of manufacturer	X	X
(4) Manufacturer's element identification number, lot number, or serial number	X	X
(5) Month and year of manufacturer, not coded	X	X
(6) Model name, number, or design	X	X
(7) Size or size range	X	
(8) Principal materials(s) of construction	X	X
(9) Cleaning precautions	X	

6.1.7.3 The identification of textile-based principal materials shall indicate the fiber composition of the fabric, list any coatings or films present, and specify the type and purpose of any finishes that are also present.

6.1.7.3.1 Where available, trade names of materials shall be used.

6.1.7.4 Where leather is used as a principal material, the type of leather shall be listed.

6.1.7.5* Manufacturers shall be permitted to include the following statement as part of their product label where the required evidence is provided as specified in 6.5.11 for indicating PFAS levels in the respective protective element:

THIS *[type of protective element]* UPON CERTIFICATION HAS A PFAS (TOTAL FLUORINE) CONCENTRATION OF NO MORE THAN 100 PPM.

6.1.7.6* For helmet labels only, a label limited to the information required in item (1), item (4), and item (5) of Table 6.1.7 and the words **"NFPA 1970 (1971), 2025 ED"** shall be placed securely against the inner surface of the helmet.

6.1.8* Nonvisual/machine-readable tags providing a means for electronic dissemination or tracking of information shall be permitted in addition to the labels required in Section 6.1, Product Label Requirements for Both Ensembles.

6.1.8.1 Nonvisual/machine-readable tags shall be permitted to include all or a portion of the information required in Section 6.1, Product Label Requirements for Both Ensembles.

6.1.8.2 Nonvisual/machine-readable tags shall meet the applicable requirements in Chapter 8.

6.2 Additional Product Label Requirements for Structural Firefighting Ensemble Elements Only.

6.2.1 The following compliance statement shall be printed on the product label for each structural firefighting protective ensemble element, unless the requirements in 6.2.1.1 prevail. The term for the element type — garment, helmet, glove, footwear, hood — shall be inserted in the compliance statement text where indicated. All product label letters and figures shall be at least 2.5 mm (3⁄32 in.) in height.

THIS STRUCTURAL FIREFIGHTING PROTECTIVE (insert element term here) MEETS THE (insert element term here) REQUIREMENTS OF NFPA 1970 (1971), 2025 EDITION.

DO NOT REMOVE THIS LABEL.

6.2.1.1 Where the garment is also certified as compliant with the optional requirements for protection against liquid and particulate contaminants, the garment element shall have the following compliance statement on the product label in place of the compliance statement specified in 6.2.1. All product label letters and figures shall be at least 2.5 mm (3⁄32 in.) in height.

LIQUID AND PARTICULATE PROTECTIVE GARMENT

THIS GARMENT IS NOT INTENDED AS PART OF A HAZARDOUS MATERIALS PROTECTIVE ENSEMBLE.

THIS STRUCTURAL FIREFIGHTING PROTECTIVE (insert term COAT OR PANT here) MEETS THE (insert term COAT OR PANT here) REQUIREMENTS OF NFPA 1970 (1971), 2025 EDITION, AND THE OPTIONAL REQUIREMENTS FOR LIQUID AND PARTICULATE CONTAMINANT PROTECTION. THIS (insert term COAT OR PANT here) MUST BE WORN WITH A (insert term COAT OR PANT here) THAT IS ALSO CERTIFIED AS MEETING THE OPTIONAL REQUIREMENTS FOR LIQUID AND PARTICULATE CONTAMINANT PROTECTION.

DO NOT REMOVE THIS LABEL.

6.2.2 Where other protective item(s) or detachable components must be used with structural firefighting protective ensemble elements for an element to be compliant with this standard, at least the following statement and information shall also be printed on the product label. All letters shall be at least 2.5 mm (3⁄32 in.) high. The term for the element type — garment, helmet, glove, footwear, hood — shall be inserted in the statement text where indicated. Following this statement, the additional protective items or detachable components shall be listed by type, identification, and how to assemble.

FOR COMPLIANCE WITH THE STRUCTURAL FIREFIGHTING (insert element term here) REQUIREMENTS OF NFPA 1970 (1971), THE FOLLOWING PROTECTIVE ITEMS MUST BE WORN IN CONJUNCTION WITH THIS [insert element term here]:

(List additional items or detachable components here.)

DO NOT REMOVE THIS LABEL.

6.2.3 For helmets only, the helmet manufacturer shall place a unique manufacturer's part number, the symbol of the certification organization, and the words **"NFPA 1970 (1971), 2025 ED."** permanently on each replaceable performance-critical part of the goggle lens or faceshield.

6.2.4 For hoods only, where the hood is designed to interface with a specific SCBA facepiece(s), the hood manufacturer shall add an item to the items specified in 6.1.7.

6.2.4.1 The hood manufacturer shall designate the specific SCBA facepiece(s), model(s) and size(s) in the new item of 6.1.7.

6.2.4.2 Where the hood is designed to be used with a specific SCBA facepiece(s), the hood manufacturer shall add to the hood product label the following statement:

FOR COMPLIANCE WITH THE STRUCTURAL FIREFIGHTING REQUIREMENTS OF NFPA 1970 (1971), THIS HOOD CAN ONLY BE USED WITH THE FOLLOWING NOTED SCBA FACEPIECE(S) [insert SCBA facepieces(s), model(s), and size(s) here].

6.2.5 For garments only, the garment manufacturer shall place a manufacturer's identification number, lot number or serial number, the size or size range, the symbol of the certification organization, and the words **"NFPA 1970 (1971), 2025 ED."** on the drag rescue device (DRD).

6.3 Additional Product Label Requirements for Proximity Firefighting Ensemble Elements Only.

6.3.1 The following compliance statement shall be printed on the product label for each proximity firefighting protective ensemble element. The term for the element type — garment, helmet, glove, footwear — shall be inserted in the compliance statement text where indicated. All product label letters and figures shall be at least 2.5 mm (3⁄32 in.) in height.

THIS PROXIMITY FIREFIGHTING PROTECTIVE [insert element term here] MEETS THE [insert element term here] REQUIREMENTS OF NFPA 1970 (1971), 2025 EDITION.

DO NOT REMOVE THIS LABEL.

6.3.1.1 Where the garment is also certified as compliant with the optional requirements for protection against liquid and particulate contaminants, the garment element shall have the following compliance statement on the product label in place of the compliance statement specified in 6.3.1. All product label letters and figures shall be at least 2.5 mm (3⁄32 in.) in height.

LIQUID AND PARTICULATE CONTAMINANT PROTECTIVE GARMENT

THIS GARMENT IS NOT INTENDED AS PART OF A HAZARDOUS MATERIALS PROTECTIVE ENSEMBLE.

THIS PROXIMITY FIREFIGHTING PROTECTIVE [insert term COAT OR PANT here] MEETS THE [insert term COAT OR PANT here] REQUIREMENTS OF NFPA 1970 (1971), 2025 EDITION, AND THE OPTIONAL REQUIREMENTS FOR LIQUID AND PARTICULATE CONTAMINANT PROTECTION. THIS (insert term COAT OR PANT here) MUST BE WORN WITH A (insert term COAT OR PANT here) THAT IS ALSO CERTIFIED AS MEETING THE OPTIONAL REQUIREMENTS FOR LIQUID AND PARTICULATE CONTAMINANT PROTECTION.

DO NOT REMOVE THIS LABEL.

6.3.2 Where other protective item(s) or detachable components must be used with proximity firefighting protective ensemble elements for an element to be compliant with this standard, at least the following statement and information shall also be printed on the product label. All letters shall be at least 2.5 mm (3⁄32 in.) high. The term for the element type — garment, helmet, glove, footwear — shall be inserted in the statement text where indicated. Following this statement, the additional protective items or detachable components shall be listed by item/component identification or part number, and where applicable, how to assemble.

FOR COMPLIANCE WITH THE PROXIMITY FIREFIGHTING (insert element term here) REQUIREMENTS OF NFPA 1970 (1971), THE FOLLOWING PROTECTIVE ITEMS MUST BE WORN IN CONJUNCTION WITH THIS [insert element term here]:

[List additional items or detachable components here.]

DO NOT REMOVE THIS LABEL.

6.3.2.1 For proximity firefighting helmets, the list of additional items or detachable components shall include, as a minimum, the shroud, cover (except where the helmet cover is part of the shroud), and faceshield.

6.3.3 For helmets only, the helmet manufacturer shall place a unique manufacturer's part number, the symbol of the certification organization, and the words **"NFPA 1970 (1971), 2025 ED."** permanently on each replaceable performance-critical part of the faceshield.

6.3.4* For the helmet shroud and cover (except where the helmet cover is part of the shroud), the manufacturer shall place a label on the shroud and cover (except where the helmet cover is part of the shroud) with a unique manufacturer's part number or identification and the following statement. The term for the item, shroud or cover, shall be inserted in the statement text where indicated.

FOR COMPLIANCE WITH THE PROXIMITY FIREFIGHTING REQUIREMENTS OF NFPA 1970 (1971)-2025, THIS [insert item term here] CAN ONLY BE USED WITH THE FOLLOWING NOTED HELMET(S) AND ADDITIONAL ITEM(S): [insert helmet manufacturer's name and specific helmet model; and item name (shroud or cover) and shroud or cover part number, or identification where applicable].

6.3.5 For garments only, the garment manufacturer shall place a manufacturer's identification number, lot number or serial number, the size or size range, the symbol of the certification organization, and the words "**NFPA 1970 (1971), 2025 ED.**" on the DRD.

6.4 Additional Product Label Requirements for Structural and Proximity Firefighting Protective Ensembles and Ensemble Elements Containing Electrical Circuitry.

6.4.1* Nonincendive Equipment and Systems. The following additional compliance statement shall be printed on the product label for each structural and proximity firefighting protective ensemble and ensemble element containing electrical circuitry that complies with 7.20.2. The term for the element type — garment, helmet, glove, footwear, hood — shall be inserted in the compliance statement text where indicated. All product label letters and figures shall be at least 2.5 mm (3⁄32 in.) in height.

THIS (insert STRUCTURAL or PROXIMITY) FIREFIGHTING PROTECTIVE (insert element term here) CONTAINS ELECTRICAL CIRCUITRY MEETING THE REQUIREMENTS OF UL 121201, 2017, FOR CLASS I & II, DIVISION 2, GROUPS C, D, F, G, AND CLASS III, (insert temperature class).

DO NOT REMOVE THIS LABEL.

6.4.2 Intrinsically Safe Apparatus and Systems. The following additional compliance statement shall be printed on the product label for each structural and proximity firefighting protective ensemble and ensemble element containing electrical circuitry that complies with Section 7.19. The term for the element type — garment, helmet, glove, footwear, hood — shall be inserted in the compliance statement text where indicated. All product label letters and figures shall be at least 2.5 mm (3⁄32 in.) in height.

THIS (insert STRUCTURAL or PROXIMITY) FIREFIGHTING PROTECTIVE (insert element term here) CONTAINS ELECTRICAL CIRCUITRY MEETING THE REQUIREMENTS OF UL 913, SIXTH EDITION, FOR CLASS I & II, DIVISION 1, GROUPS C, D, E, F, G, AND CLASS III, (insert temperature class).

DO NOT REMOVE THIS LABEL.

6.5 User Information Requirements for Both Ensembles.

6.5.1 The manufacturer shall provide at least the user information that is specified in 6.5.4 with each structural and proximity firefighting element. This information shall be permitted to be delivered from the manufacturer in various formats, including, but not limited to, printed materials or instructions to access the information electronically/digitally.

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

6.5.3 The required user information, or packaging containing the user information, shall be attached to the element so that a deliberate action is necessary to remove it. The manufacturer shall provide notice that the user information is to be removed only by the end user.

6.5.4* The manufacturer shall provide at least the following instructions and information with each element:

(1) Pre-use information, as follows:
  (a) Safety considerations
  (b) Limitations of use
  (c) Marking recommendations and restrictions
  (d) A statement that most performance properties of the element cannot be tested by the user in the field
  (e) Warranty information
  (f) Instructions for users to refer to and comply with NFPA 1851 requirements that do not contradict any subject user information or instructions provided by the manufacturer
(2) Preparation information for use, as follows:
  (a) Sizing/adjustment
  (b) Recommended storage practices
(3) Inspection frequency and details
(4) Donning/doffing information, as follows:
  (a) Donning and doffing procedures
  (b) Sizing and adjustment procedures
  (c) Interface issues
(5) Proper use consistent with NFPA 1550 and 29 CFR 1910.132, "Personal Protective Equipment: General Requirements"

(6) Maintenance and cleaning instructions, as follows:
   (a) Cleaning instructions and precautions that address preliminary exposure reduction, advanced cleaning, sanitization, and specialized cleaning in accordance with NFPA 1851; a warning for the hazards associated with wearing contaminated protective clothing; and statements advising users not to use an element that is not thoroughly cleaned and dried, and to practice good hygiene when handling and wearing protective clothing before and after structural and proximity firefighting and other emergency responses
   (b) Inspection details
   (c) Maintenance criteria and methods of repair where applicable
   (d) Decontamination procedures for both chemical and biological contamination
(7) Retirement and disposal criteria and considerations
(8) A statement that the moisture barrier has not been evaluated for all chemicals that can be encountered during firefighting operations, and that the effects of chemical exposure on the moisture barrier are to be evaluated in accordance with the inspection procedures in NFPA 1851

6.5.5 For the DRD only, the manufacturer shall provide specific information on the use, inspection, maintenance, cleaning, and retirement of the DRD. Additional instructions shall be provided on the removal and reinstallation of the DRD into the garment.

6.5.6* For gloves only, manufacturers shall provide a chart and other information such that the end user can select the appropriate size based on hand measurements or other approaches to ensure adequate fit and function of the gloves.

6.5.6.1 If hand measurements are used, this information shall include diagrams or descriptions for how the hand measurements are to be made.

6.5.7 For footwear only, the manufacturer shall establish and provide, upon request, a size conversion chart for each model or style footwear element based on toe length, arch length, and foot width as measured on a Brannock Scientific Foot Measuring Device.

6.5.8 For helmets only, the manufacturer shall provide a list of items that are installed on, attached to, or packaged with the compliant helmet that meet the requirements of 7.4.8.

6.5.9 For protective garments certified to the optional liquid and particulate contaminant protection requirements, the manufacturer shall provide the following additional instruction and information with the garment:

(1) A statement that the garment is not to be used as part of a hazardous materials protective ensemble and that liquid and particulate contaminant protection is not inclusive of all vapors nor all liquids and particulates
(2) Specific care and maintenance provisions associated with maintaining the unique performance properties of the garment if such provisions are necessary beyond normal care and maintenance instructions.
(3)* The manufacturer shall provide a list of the specific elements, including manufacturer and model or style number, used in the ensemble testing for garment certification and any specific interfacing or donning instructions applied during that testing.
(4) The manufacturer shall indicate that the full test reports for both the overall liquid integrity and inward particulate leakage tests are available to the purchaser upon request.

6.5.10 When the optional requirements for liquid and particulate contaminant protection necessitate a specific action to engage interface areas, the manufacturer shall provide details explaining those procedures.

6.5.11* If the manufacturer makes the claim permitted in 6.1.7.5, then the claim shall be based on test results when their protective elements are evaluated as specified in 9.10.2, Test for Total Fluorine.

6.5.11.1 If the manufacturer makes the claim permitted in 6.1.7.5, then the manufacturer shall make the report specified in 9.10.2.6.3 available to the authority having jurisdiction upon request. *(See also A.6.1.7.5.)*

6.5.12* Where specific requirements exist in Chapters 1 through 8 for conducting testing and reporting the results of those tests, the results shall be made available as part of the user information.

Chapter 7 Design Requirements (NFPA 1971)

7.1* Protective Garment Element Design Requirements for Both Ensembles.

7.1.1 Protective garment elements shall have at least the applicable design requirements specified in this section where inspected and evaluated by the certification organization as specified in Section 4.3, Inspection and Testing, and Section 5.3, Inspection and Testing.

7.1.1.1 For coveralls, the portion of the coverall that corresponds to the coat shall meet all garment requirements and all requirements specified for coat elements of this section.

7.1.1.2 For coveralls, the portion of the coverall that corresponds to the trouser shall meet all garment requirements and all requirements specified for trouser elements of this section.

7.1.2* Garments shall consist of a composite of an outer shell, moisture barrier, and thermal barrier.

7.1.2.1 The composite specified in 7.1.2 shall be permitted to be configured as a single layer or multiple layers.

7.1.2.2 Supplemental garments that are provided to meet the performance requirements of Chapters 4 through 9 of this standard but are not intended to be worn continuously with the wearing of the garment element shall not be permitted.

7.1.3* Garments shall have a means of securing the moisture barrier and thermal barrier to the outer shell.

7.1.4 Garment moisture barriers and thermal barriers, or materials meeting the performance requirements of these components, shall extend at least to the neckline seam of coats, at least to the waistline seam of trousers, and shall extend at least to within 75 mm (3 in.) of the bottom outer shell hems of both coats and trousers.

7.1.4.1 For coats, the moisture barriers and thermal barriers, or materials meeting the performance requirements of these components, shall extend at least to within 25 mm (1 in.) of the sleeve ends of the outer shell and shall be attached at or adjacent to the end of the coat sleeves, unless those barrier layers terminate in a garment-glove interface.

7.1.4.2 For trousers, moisture barriers and thermal barriers, or materials meeting the performance requirements of these components, shall be attached to the trouser legs, unless those barrier layers terminate in booties.

7.1.4.3 Any mechanism used to attach the liner system to the coat sleeves or trouser legs shall not be greater than 25 mm (1 in.) between the attachment points, and the mechanism and attachment points shall not be expandable.

7.1.5 Garments and their closure systems, including the coat front and the trouser fly, shall be constructed in a manner that provides continuous moisture and thermal protection.

7.1.5.1 Such closure systems shall be secured with positive locking fasteners including, but not limited to, hooks and dees or zippers.

7.1.5.2 Nonpositive fasteners, such as snaps or hook and pile tape, shall not be used as positive locking fasteners but shall be permitted to be utilized as supplementary garment closure devices.

7.1.6 All garment hardware finishes shall be free of rough spots, burrs, or sharp edges.

7.1.7 All sewing thread utilized in the construction of garments and the drag rescue devices (DRDs) shall be made of an inherently flame-resistant fiber.

7.1.8* Garment cargo pockets, where provided, shall have a means to drain water and shall have a means of fastening in the closed position.

7.1.9 Coats shall be designed to provide protection to the upper torso, neck, arms, and wrists, excluding the hands and head.

7.1.9.1 Each coat element shall have a DRD installed in the upper torso portion of the element.

7.1.9.1.1 The DRD shall be accessible from the exterior of the garment.

7.1.9.1.2* The DRD shall be accessible for deployment, shall be designed to minimize the risk of accidental deployment, and shall allow for visual inspection.

7.1.9.1.3 The DRD shall be fully functional and shall not require any subsequent actions to be used, other than deploying the DRD, when the garment is donned in accordance with the manufacturer's instructions.

7.1.9.1.4 The DRD shall be designed to allow deployment and operation of the DRD while the incapacitated firefighter is wearing an SCBA. *(See A.7.1.9.1.2.)*

7.1.9.1.5 The DRD shall be designed so that when deployed, the DRD secures the firefighter by the upper torso or shoulders so that the DRD pulls directly on the body and shall not pull only the garment.

7.1.9.2* Each coat sleeve shall have a protective wristlet or other interface component permanently attached to the coat sleeve.

7.1.9.2.1 The wristlet or other garment sleeve interface component shall be designed so that it will not permit a gap in thermal protection.

7.1.9.2.2 The wristlet or other garment sleeve interface component shall meet the requirements specified in Section 7.16, Protective Wristlet Interface Component Design Requirements for Both Ensembles.

7.1.9.3 Coats shall have a composite collar at least 75 mm (3 in.) in height at any point when measured from the top of the collar down.

7.1.9.3.1 The collar shall incorporate a closure system.

7.1.9.3.2 The collar and closure system shall consist of an outer shell, a moisture barrier, and a thermal barrier, or of a composite that meets all applicable performance requirements specified in Section 8.1, Protective Garment Performance Requirements for Both Ensembles.

7.1.9.3.3 Where a hood is permanently attached to the coat, a collar shall not be required.

7.1.9.3.4 Where a hood is permanently attached to the coat, it shall meet the requirement of 7.1.9.3.1 and at least the bottom 75 mm (3 in.) of the hood shall meet the requirement of 7.1.9.3.2.

7.1.9.4 Coat hardware shall not penetrate through the outer shell, moisture barrier, and thermal barrier to contact the wearer's body when the coat is worn with the closures fastened, unless the hardware is completely covered by external closure flaps.

7.1.10 Trousers shall be designed to provide protection to the lower torso and legs, excluding the ankles and feet.

7.1.10.1 Trousers shall be permitted to include integrated booties to protect the wearer's feet in conjunction with outer footwear.

7.1.10.2 Where trousers incorporate booties, the booties shall be designed as an extension of the trouser leg and shall cover the entire foot and ankle.

7.1.10.3 Trouser hardware shall not penetrate through the outer shell, moisture barrier, and thermal barrier to come into contact with the wearer's body when the trouser is worn with the closures fastened, unless the hardware is located on or above the waistline or hardware is completely covered by external closure flaps.

7.1.11* In order to label a coat, trouser, or coverall as compliant with Chapters 4 through 9 of this standard, the manufacturer shall provide coats, trousers, or coveralls in the size ranges specified in Table 7.1.11.

7.1.11.1 The sizing increments for the ranges specified in Table 7.1.11 for men's and women's chest sizes shall be in increments no greater than 50 mm (2 in.), sleeve lengths shall be in increments no greater than 25 mm (1 in.), men's and women's waist sizes shall be in increments no greater than 50 mm (2 in.), and inseam lengths shall be in increments no greater than 50 mm (2 in.).

7.1.11.2 Men’s and women’s sizing shall be accomplished by men’s and women’s individual patterns.

7.1.12* When life safety harnesses, escape belts, and ladder belts penetrate the outer shell, are incorporated as part of a garment closure system, or are temporarily or permanently attached to the garment, the harness or belt components shall meet the applicable requirements of Chapters 24 through 28 of NFPA 2500 and the optional requirements for flame-resistant life safety harnesses or optional requirements for flame-resistant belts.

7.1.13 Liners that consist of a thermal barrier sewn to a moisture barrier shall include an inspection opening that permits the examination of the lining interior, including all moisture barrier seams.

7.1.14 Garment outer shells, moisture barriers, thermal barriers, and wristlet/garment–glove interface components shall be recognized components that meet levels of restricted substances as specified in Section 8.21, Acceptable Levels of Restricted Substances in Specified Protective Element Recognized Components.

7.1.15 The shoulder areas shall consist of reinforcement composite meeting the requirements of 8.1.9.

7.1.15.1 The composite shall be at least 100 mm (4 in.) wide on the crown of each shoulder as defined in 7.1.15.3.

7.1.15.2 The composite shall extend down from the crown, as defined in 7.1.15.3, on both the front and back of the garment by at least 50 mm (2 in.).

7.1.15.3 The crown of the shoulder shall be the uppermost line of the shoulder when the garment is lying flat on an inspection surface with all closures fastened.

7.1.16 The knee areas shall consist of reinforcement composite meeting the requirements of 8.1.9.

7.1.16.1 The composite shall measure at least 150 mm × 150 mm (6 in. × 6 in.).

7.2 Additional Design Requirements for Structural Firefighting Protective Garment Elements Only.

7.2.1 Structural firefighting protective garment elements shall also have at least the applicable design requirements specified in this section in addition to the design requirements specified in Section 7.1, Protective Garment Element Design Requirements for Both Ensembles, where inspected and evaluated by the certification organization as specified in Section 4.3, Inspection and Testing, and Section 5.3, Inspection and Testing.

7.2.2* Garments shall have fluorescent and retroreflective trim permanently attached to the outer shells of garments to meet visibility requirements.

7.2.2.1 Trim shall be at least 50 mm (2 in.) wide and shall have both retroreflective and fluorescent surfaces.

7.2.2.2 The retroreflective surface of trim shall be at least 16 mm (5⁄8 in.) wide.

7.2.2.3 Trim used to meet the minimum trim pattern requirements shall have a minimum fluorescent surface of 50 mm^2/linear mm (2 in.^{2}/linear in.) of trim.

7.2.2.4 The fluorescent and retroreflective areas of trim specified in 7.2.2.2 and 7.2.2.3 shall appear to be continuous at a distance of 30.5 m (100 ft) for the length of the trim, with gaps of not more than 3 mm (1⁄8 in.).

7.2.2.5 Trim used in excess of that required by the minimum trim pattern requirements specified and illustrated in Figure 7.2.3 shall be permitted to not meet the minimum fluorescent surface of 50 mm^2/linear mm (2 in.^{2}/linear in.) of trim and shall be permitted to be obscured by components including

Table 7.1.11 Available Coat/Trouser Size Ranges

	Men		Women		Increment	
Dimension	**mm**	**in.**	**mm**	**in.**	**mm**	**in.**
Chest	865–1525	34–60	710–1270	28–50	50	2
Sleeve	820–965	32–38	710–865	28–34	25	1
Waist	760–1525	30–60	710–1270	28–50	50	2
Inseam	660–915	26–36	610–865	24–34	50	2

but not limited to pockets, storm flaps, and reinforcing patches as long as the minimum trim pattern is not obscured.

7.2.3* Coat trim configuration shall be in accordance with Figure 7.2.3. No vertical stripes of trim shall be permitted on the front of the coat.

7.2.3.1 The coat minimum trim pattern shall have one circumferential band of trim or a staggered 360-degree visibility pattern meeting or exceeding the surface area of a continuous circumferential band around the bottom of the coat. The front of the coat shall also have at least one band of horizontal trim at the chest level located within 75 mm (3 in.) above or below the sleeve-to-body underarm garment seam.

7.2.3.2 The lower edge of the circumferential band on the lower part of the coat shall be within 25 mm (1 in.) of the coat hem's highest point.

7.2.3.3 Where a staggered pattern is used in the lower circumferential trim band, the lower edge of the upper trim piece shall not be higher than the upper edge of the lower trim piece.

7.2.3.4 The back of the coat shall also have a minimum of either two vertical stripes of trim, perpendicular to the bottom band and with one strip located on both the left and right sides of the back of the coat, or a minimum of one horizontal band of trim at the chest/shoulder blade level located within 75 mm (3 in.) above or below the sleeve-to-body underarm garment seam.

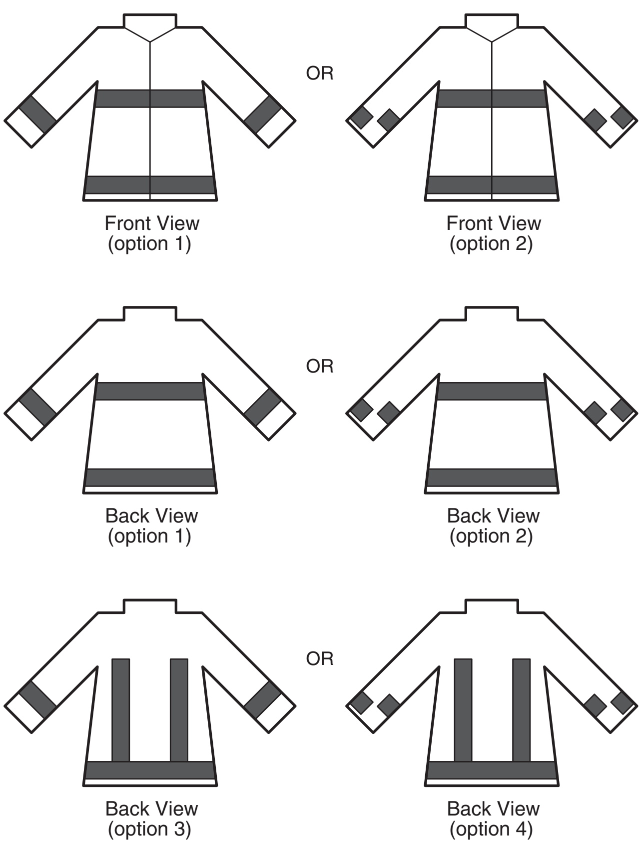


FIGURE 7.2.3 Minimum Required Structural Firefighting Coat Trim Patterns.

7.2.3.5 The minimum trim configuration for each sleeve shall be one circumferential band, or a staggered 360-degree visibility pattern meeting or exceeding the surface area of a continuous circumferential band, between the wrist and elbow level.

7.2.3.5.1 Where trim on the coat intersects a zipper or where the trim intersects the innermost seam of each sleeve, a maximum gap in the trim of 25 mm (1 in.) shall be permitted.

7.2.4* Trouser trim configuration shall be in accordance with Figure 7.2.4.

7.2.4.1 The minimum trim pattern for the trousers shall consist of two circumferential bands of trim, with one band around each leg between the bottom hem and knee areas.

7.2.4.2 Where trim on the trouser element intersects a zipper or where the trim intersects the innermost seam of each trouser leg, a maximum gap in the trim of 25 mm (1 in.) shall be permitted.

7.3 Additional Design Requirements for Proximity Firefighting Protective Garment Elements Only.

7.3.1 Proximity firefighting protective garment elements shall also have at least the applicable design requirements specified in this section in addition to the design requirements specified in Section 7.1, Protective Garment Element Design Requirements for Both Ensembles, where inspected and evaluated by the certification organization as specified in Section 4.3, Inspection and Testing.

7.3.2 Garments shall not have materials that do not meet the radiant reflective requirements specified in 8.3.2 affixed to the outer shell radiant reflective surfaces of the garments unless such materials are covered in 7.3.3.

7.3.3 Reinforcing materials that do not meet the radiant reflective requirements specified in 8.3.2 shall be permitted to be affixed only to the garment outer shell radiant reflective surfaces as reinforcement of the sleeve cuffs and trouser leg cuffs where the following requirements are met:

(1) The reinforcing materials shall meet the flame-resistant requirements specified in 8.1.3.
(2) The reinforcing materials shall meet the heat resistance requirements specified in 8.1.5.
(3) Reinforcement areas shall not cover the radiant reflective surfaces of the garment by more than 25 mm (1 in.) when measured from the edge of the cuff back along the sleeve or leg.

7.3.4 The collar lining material shall not be reflective material.

FIGURE 7.2.4 Minimum Required Structural Firefighting Trouser Trim Patterns.

7.4 Protective Helmet Element Design Requirements for Both Ensembles.

7.4.1 Protective helmet elements shall have at least the applicable design requirements specified in this section where inspected and evaluated by the certification organization as specified in Section 4.3, Inspection and Testing.

7.4.2 No openings shall penetrate the helmet shell other than those provided by the manufacturer for mounting energy absorbing systems, retention systems, and accessories.

7.4.3 The helmet retention system shall include a chin strap and a nape device. The chin strap shall have a minimum width of 16 mm (⅝ in.).

7.4.4 All sewing thread used in the construction of helmets shall be made of inherently flame-resistant fiber.

7.4.5 The helmet faceshield or the faceshield/goggle component, when deployed, shall provide at least the following field of vision:

(1) Dihedral angle of at least 85 degrees
(2) Upper dihedral angle of at least 10 degrees
(3) Lower dihedral angle of at least 40 degrees

7.4.5.1 The field of vision shall be measured from the center of the eye.

7.4.5.2 The helmet with the faceshield or the faceshield/goggle component deployed shall be positioned in accordance with the HPI as described in 9.1.13 on a facial feature headform as defined in 3.3.64. Where the crown clearance of the helmet is adjustable, the helmet shall be mounted with the least amount of clearance.

7.4.6 The helmet faceshield or the faceshield/goggle component in the stowed position as described in 9.1.16 shall provide peripheral vision clearance of at least 94 degrees to each side.

7.4.6.1 The peripheral vision clearance shall be measured from the center of the eye, with the helmet positioned in accordance with the HPI as described in 9.1.13 on a facial feature headform as defined in 3.3.64. Where the crown clearance of the helmet is adjustable, the helmet shall be mounted with the least amount of clearance.

7.4.7 Where helmets are provided with an SCBA facepiece that is attached or integrated with the helmet, the helmet with the SCBA facepiece installed shall meet all applicable design and performance requirements of Chapters 4 through 9 of this standard.

7.4.8* For helmets with items installed or attached, the helmet with the items installed/attached shall meet the affected design and performance requirements of Chapters 4 through 9 of this standard.

7.4.9 Helmet ear cover fabric material layers, textile-based suspension materials, and textile-based retention system materials shall be recognized components and meet the levels of restricted substances as specified in Section 8.21, Acceptable Levels of Restricted Substances in Specified Protective Element Recognized Components.

7.5 Additional Design Requirements for Structural Firefighting Protective Helmet Elements Only.

7.5.1 Structural firefighting protective helmet elements shall also have at least the applicable design requirements specified in this section in addition to the design requirements specified in Section 7.4, Protective Helmet Element Design Requirements for Both Ensembles, where inspected and evaluated by the certification organization as specified in Section 4.3, Inspection and Testing, and Section 5.3, Inspection and Testing.

7.5.2* Helmets shall consist of at least all of the following assembled components:

(1) Shell
(2) Energy absorbing system
(3) Retention system
(4) Fluorescent and retroreflective trim
(5) Ear covers
(6) A faceshield or goggles, or both

7.5.2.1 Where a faceshield is selected in accordance with 7.5.2(6), the faceshield component shall be attached to the helmet.

7.5.2.2 Where the goggle component is selected in accordance with 7.5.2(6), the goggles shall be permitted to be unattached, not assembled, to the helmet.

7.5.2.3 Where the manufacturer provides or intends to provide both a faceshield and goggles with the helmet, whether the faceshield is or is not provided installed or attached to the helmet, both the faceshield and the goggles shall be considered components of the helmet.

7.5.3 Helmets shall have fluorescent and retroreflective trim on the shell exterior.

7.5.3.1 A minimum of 2580 mm^2 (4 $in.^2$) of the retroreflective and fluorescent trim shall be visible above the reference plane when the helmet, with the faceshield/goggle component in the stowed position as described in 9.1.16, is viewed at the following positions:

(1) Left intersection of the coronal and reference planes at a distance of 2.4 m (8 ft)
(2) Right intersection of the coronal and reference planes at a distance of 2.4 m (8 ft)
(3) Rear intersection of the midsagittal and reference planes at a distance of 2.4 m (8 ft)

7.5.3.2 A minimum of 2580 mm^2 (4 $in.^2$) of the retroreflective and fluorescent trim shall be visible when the helmet, with the faceshield/goggle component in the stowed position as described in 9.1.16, is viewed at the intersection of the midsagittal plane and the coronal plane at a distance of 2.4 m (8 ft).

7.5.3.3 The entire surface of the trim shall be permitted to be both fluorescent and retroreflective.

7.5.4 Helmet ear covers or the portion of the helmet providing the coverage of the ears, when deployed, shall provide at least the following coverage:

(1) 95 mm (3¾ in.) measured 50 mm (2 in.) forward of the coronal plane
(2) 120 mm (4¾ in.) measured 25 mm (1 in.) forward of the coronal plane
(3) 130 mm (5⅛ in.) measured at the coronal plane
(4) 130 mm (5⅛ in.) measured at the midsagittal plane at the rear of the headform

7.5.4.1 The helmet, with the ear covers or the portion of the helmet providing the ear coverage deployed, shall be positioned according to the HPI as described in 9.1.13 on an ISO size J headform as specified in Figure 9.3.6.4.1. Where the crown clearance of the helmet is adjustable, the helmet shall be mounted with the most amount of clearance.

7.5.4.2 In this position, the ear coverage shall be measured downward from the reference plane to the lower edge of the ear coverage at the specified points to determine the coverage specified in 7.5.4.

7.5.4.3 Where the helmet incorporates a ratchet-style headband, an opening in the covering surrounding the ratchet knob shall be permitted. The opening shall not extend more than 13 mm (½ in.) in any direction around the perimeter of the adjustment device.

7.5.5 Goggle components shall meet the respective requirements for goggles and be marked “Z87+” in accordance with ANSI/ISEA Z87.1, *Occupational and Educational Personal Eye and Face Protection Devices.*

7.5.6 Faceshield components shall meet the respective requirements for faceshields and be marked either “Z87+” or “Z87+O2” in accordance with ANSI/ISEA Z87.1, *Occupational and Educational Personal Eye and Face Protection Devices.*

7.6 Additional Design Requirements for Proximity Firefighting Helmet Elements Only.

7.6.1 Proximity firefighting protective helmet elements shall also have at least the applicable design requirements specified in this section in addition to the design requirements specified in Section 7.4, Protective Helmet Element Design Requirements for Both Ensembles, where inspected and evaluated by the certification organization as specified in Section 4.3, Inspection and Testing.

7.6.2 Helmet elements shall consist of at least the following assembled components:

(1) Shell
(2) Energy absorbing system
(3) Retention system
(4) Faceshield
(5) Shroud
(6) Cover (where separate from the shroud)

7.6.3 Helmet faceshields shall be attached to the helmet.

7.6.4 Helmets shall be permitted to have an outer cover to provide the radiant reflective protection for the exterior of the helmet shell, including the upper surface of the brim, and the brim edge.

7.6.4.1 The helmet outer cover shall be permitted to be removable.

7.6.4.2 The helmet, and helmet outer cover where provided, shall be permitted to have fluorescent and retroreflective trim on the helmet exterior and on the helmet outer cover.

7.6.4.3 Identification markings or material including, but not limited to, trim, lettering, patches, name or number stencils, emblems, and paint shall be permitted *only* on the helmet outer cover, provided such materials are located above the corresponding helmet test line.

7.6.5 The shroud shall be attached to the helmet and shall be designed to cover and provide continuous radiant reflective protection for the head, face, and neck areas that do not receive primary protection from the helmet or faceshield.

7.6.5.1 Shrouds shall provide at least the following coverage:

(1) 230 mm (9⅛ in.) on each side measured downward from the reference plane at the coronal plane
(2) 330 mm (13 in.) in the back measured downward from the reference plane at the rear midsagittal plane
(3) 295 mm (11⅝ in.) in the front measured downward from the reference plane at the front midsagittal plane, including the gap of material where the face opening is located

7.6.5.1.1 The helmet, with the shroud deployed, shall be positioned according to the HPA as described in 9.1.13 on an ISO size J headform as specified in Figure 9.3.6.4.1. Where the crown clearance of the helmet is adjustable, the helmet shall be mounted with the most amount of clearance.

7.6.5.1.2 With the helmet positioned as required by 7.6.5.1.1, the shroud coverage shall be measured downward from the reference plane to the lower edge of the shroud coverage at the specified points to determine the coverage specified in 7.6.5.1.

7.6.5.2 The shroud shall be permitted to be a part of a helmet outer cover, where provided.

7.6.5.3 The shroud shall be designed to interface with a specific helmet.

7.6.5.4 The helmet shroud, when deployed, shall provide at least the following field of vision:

(1) Dihedral angle of at least 85 degrees
(2) Upper dihedral angle of at least 7 degrees
(3) Lower dihedral angle of at least 40 degrees

7.6.5.4.1 The field of vision shall be measured from the center of the eye.

7.6.5.4.2 The helmet with the shroud attached shall be positioned according to the HPI as described in 9.1.13 on a facial feature headform as defined in 3.3.64. Where the crown clearance of the helmet is adjustable, the helmet shall be mounted with the least amount of clearance.

7.6.6 No openings shall be permitted in the helmet shroud other than to meet the requirements of 7.6.5.

7.6.7 When the hood interface component is integrated with the protective garment, the shroud shall be permitted to consist of only the outer reflective layer and those other layers necessary to meet the requirements in 8.13.2 for thermal protective performance (TPP).

7.7 Protective Glove Elements Design Requirements for Both Ensembles.

7.7.1 Protective glove elements shall have at least the applicable design requirements specified in this section when inspected and evaluated by the certification organization as specified in Section 4.3, Inspection and Testing, and Section 5.3, Inspection and Testing.

7.7.2 Gloves shall consist of a composite meeting the performance requirements of Section 8.7, Protective Glove Elements Performance Requirements for Both Ensembles.

7.7.2.1 The composite shall be permitted to be configured as a continuous or joined single layer or as continuous or joined multiple layers.

7.7.2.2 Supplemental gloves that are provided to meet the performance requirements of Chapters 4 through 9 of this standard but are not intended to be worn continuously with the wearing of the gloves shall not be permitted.

7.7.2.3 Where a glove is made up of multiple layers, all layers of the glove shall be individually graded per size.

7.7.2.4 Where the coat sleeve end terminates in a garment-glove interface and the interface demonstrates liquid integrity and continuous thermal protection in accordance with Section 8.16, Protective Wristlet and Garment-Glove Interface Components Performance Requirements for Both Ensembles, gloves shall not be required to meet the requirements in 7.7.3 through 7.7.3.4.

7.7.2.5 All sewing thread utilized in the construction of gloves shall be made of an inherently flame-resistant fiber.

7.7.3 The glove shall consist of a glove body.

7.7.3.1 The glove shall extend from the tip of the fingers to at least 50 mm (2 in.) beyond the wrist crease.

7.7.3.2 The portion of the glove that extends from the tip of the fingers to 50 mm (2 in.) beyond the wrist crease shall be considered to be the glove body and shall meet the glove body requirements in Section 8.7, Protective Glove Elements Performance Requirements for Both Ensembles; Section 8.8, Additional Performance Requirements for Structural Firefighting Protective Glove Elements Only; and Section 8.9, Additional Performance Requirements for Proximity Firefighting Protective Glove Elements Only, as applicable.

7.7.3.3 The portion of the glove that extends greater than 50 mm (2 in.) beyond the wrist crease but less than or equal to 125 mm (5 in.) beyond the wrist crease, where present, shall be considered to be the glove interface component and shall meet the glove interface component requirements in Section 8.7, Protective Glove Elements Performance Requirements for Both Ensembles; Section 8.8, Additional Performance Requirements for Structural Firefighting Protective Glove Elements Only; and Section 8.9, Additional Performance Requirements for Proximity Firefighting Protective Glove Elements Only, as applicable.

7.7.3.4 The portion of the glove that extends greater than 125 mm (5 in.) beyond the wrist crease up to the end of the entire glove, where present, shall be considered to be the glove extension and shall meet the glove extension requirements in Section 8.7, Protective Glove Elements Performance Requirements for Both Ensembles; Section 8.8, Additional Performance Requirements for Structural Firefighting Protective Glove Elements Only; and Section 8.9, Additional Performance Requirements for Proximity Firefighting Protective Glove Elements Only, as applicable.

7.7.3.5* The location of the wrist crease shall be determined by the following procedures, as shown in Figure 7.7.3.5:

(1) The location of the wrist crease shall be determined by first placing the glove on a measurement board palm down and securing (i.e., locking) the fingertips down onto the board.
(2) A 0.45 kg (1 lb) weight shall be attached to the end of the glove body, glove interface component, or glove extension. The weight shall not be attached to a knitted wristlet glove interface component. The weight shall be applied evenly across the glove.
(3) The weight shall be allowed to hang freely for 60 seconds prior to taking any measurements.
(4)* The bottom of digit three shall be found by drawing a line on the back side of the glove from the finger crotches on either side of digit three. A point shall then be placed at the center of that line. Depending on the index finger length for the glove size, the distance to the wrist crease shall be determined by laying a ruler parallel with the length of the glove from the point representing the bottom of digit three to a second point using one of the following dimensions that corresponds to the index finger length. The second point shall be marked on the back of the glove.
    (a) 64 [N (normal), W (wide), and XW (extra-wide)]: 8.36 cm (3.29 in.)
    (b) 70 (N, W, and XW): 9.46 cm (3.72 in.)
    (c) 76 (N, W, and XW): 10.68 cm (4.20 in.)
    (d) 82 (N, W, and XW): 11.73 cm (4.62 in.)
(5) A straight line shall be drawn across the back of the glove perpendicular to the two points. This line shall be extended around the side edges of the glove.
(6) The glove shall be removed from the measurement board. A line shall be drawn on the palm side of the glove by connecting the lines from the side edges of the glove.
(7) The resulting straight line around the circumference of the glove shall be the location of the wrist crease.

7.7.4* For selection of the glove size for testing and when the glove manufacturer uses the default sizing system provided in this standard, the dimensions for index finger length and hand breadth shall be measured as follows:

(1) Using a straight ruler, the index finger length shall be measured to the nearest 1 mm ($\frac{1}{16}$ in.) from the tip of the index finger to the base of the finger located by the crease as shown in Figure 7.7.4(a).

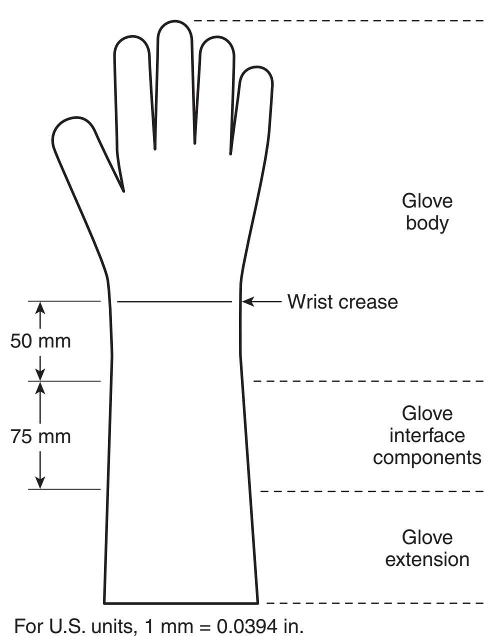


FIGURE 7.7.3.5 Location of Wrist Crease.

(2) Using a set of calipers or similar measuring device, the hand breadth shall be measured to the nearest 1 mm (1⁄16 in.) across the back of the hand knuckles from metacarpal II landmark (thumb side of index finger or digit 2) to the metacarpal V landmark (outside of little finger, or digit 5), as shown in Figure 7.7.4(b).

7.7.4.1 For testing purposes or when the default system is used for labeling the size of gloves, gloves shall be classified as the following sizes in accordance with dimensional ranges for both index finger length and hand breath as shown in Figure 7.7.4.1:

(1) 64N (normal), 64W (wide), 64XW (extra-wide)
(2) 70N (normal), 70W (wide), 70XW (extra-wide)
(3) 76N (normal), 76W (wide), 76XW (extra-wide)
(4) 82N (normal), 82W (wide), 82XW (extra-wide)

7.7.5* To be labeled as compliant with this standard, gloves shall be provided and labeled in at least the following seven sizes as determined by accommodating the respective index finger length and hand breadth ranges established in Figure 7.7.4.1:

(1) 64N (normal)
(2) 70N (normal)
(3) 70W (wide)
(4) 76N (normal)
(5) 76W (wide)
(6) 82N (normal)
(7) 82W (wide)

7.7.5.1 Alternatively, gloves shall be provided in a minimum of seven unique sizes that accommodate a range of specific hand sizes for both men and women based on achieving accommodation of the 5th to 95th percentile dimensions in both hand breadth and hand length as established in the NIOSH Firefighter Anthropometric Data Base.

7.7.5.1.1* Manufacturers shall be permitted to establish their own unique sizing system and method of designating glove sizing based on their respective glove designs.

7.7.5.1.2 Manufacturers shall be required to designate which of their unique sizes conform to the individual sizes defined in 7.7.5 as required for testing purposes.

7.7.5.1.3* Manufacturers shall provide the certification organization with the specific details for how a glove wearer can determine size.

7.7.5.1.4 Manufacturers shall label their gloves consistent with the unique size as indicated by their sizing system.

7.7.6* Glove principal textile-based fabric materials, including shells, moisture barriers, linings, and wristlets, shall be recognized components that meet levels of restricted substances as specified in Section 8.21, Acceptable Levels of Restricted Substances in Specified Protective Element Recognized Components.

7.7.6.1 A moisture barrier that does not include a textile layer shall still be a recognized component that meets levels of restricted substances as specified in Section 8.21, Acceptable Levels of Restricted Substances in Specified Protective Element Recognized Components.

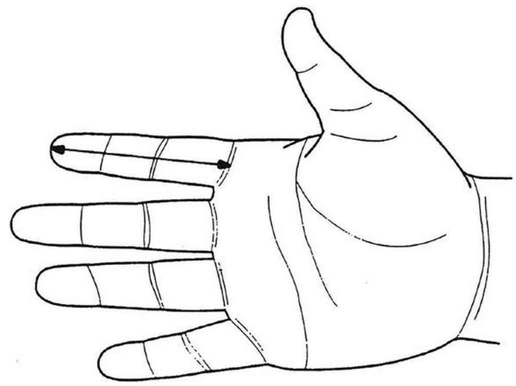


FIGURE 7.7.4(a) Measurement Location for Index Finger Length.

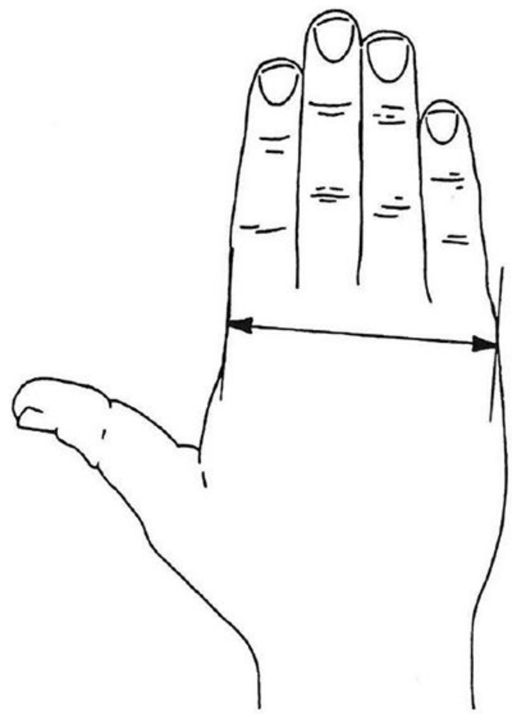
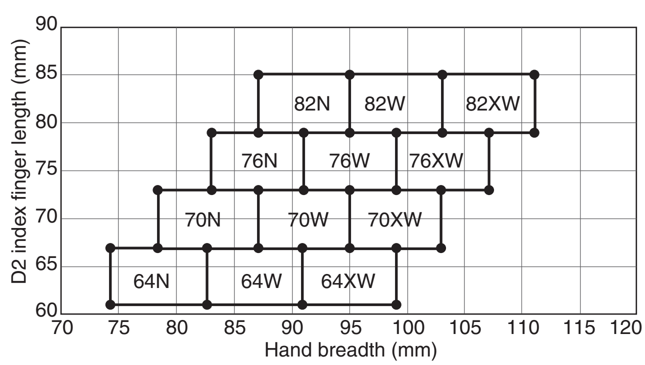


FIGURE 7.7.4(b) Measurement Location for Hand Breadth.



For U.S. units, 1 mm = 0.394 in.

FIGURE 7.7.4.1 NFPA 1971 Size Definitions.

7.8 Additional Design Requirements for Structural Firefighting Protective Glove Elements Only. (Reserved)

7.9 Additional Design Requirements for Proximity Firefighting Protective Glove Elements Only.

7.9.1 Proximity firefighting protective glove elements shall also have at least the applicable design requirements specified in this section in addition to the design requirements specified in Section 7.7, Protective Glove Elements Design Requirements for Both Ensembles, where inspected and evaluated by the certification organization as specified in Section 4.3, Inspection and Testing, and Section 5.3, Inspection and Testing.

7.9.2 Gloves shall not be permitted to have any hardware.

7.9.3 The outer shell of the back and portions of the sides of the glove body including the back of the digits shall be a radiant reflective material.

7.9.3.1 Glove fingers, thumb, and the back shall have radiant reflective protection of 210 degrees, +20°/–0°. The radiant reflective material shall provide coverage from 0 degrees to 105 degrees, +10°/–0°, and then from 255 degrees, +10°/–0°, to 360 degrees as specified in Figure 7.9.3.1.

7.9.3.2 The radiant reflective material shall provide coverage for the finger/thumb tip of at least 195 degrees, +10°/–0°, as specified in Figure 7.9.3.1.

7.9.3.3 The portion of the finger, thumb, and palm surfaces that are not covered by the radiant reflective protection shall be the gripping surface of the glove.

7.9.4 The outer shell of the glove interface component and glove extension, where provided, shall be a radiant reflective material, with the exception of a knitted wristlet as the interface component.

7.10 Protective Footwear Elements Design Requirements for Both Ensembles.

7.10.1 Protective footwear elements shall have at least the applicable design requirements specified in this section where inspected and evaluated by the certification organization as specified in Section 4.3, Inspection and Testing, and Section 5.3, Inspection and Testing.

7.10.2 Footwear shall consist of at least the following assembled components: a sole with a heel, an upper with lining, a puncture-resistant device, an insole, a ladder shank or whole sole equivalent, and an impact- and compression-resistant toe cap.

7.10.2.1 Where booties are incorporated as a component of the pant and are specified by the manufacturer as removable for laundering or replacement only, the booties component shall meet the performance requirements of 8.1.12, 8.1.13, 8.1.14, 8.1.15, 8.1.16, and 8.1.17.

7.10.2.2 Where booties are incorporated as a component of the footwear, the combination of the bootie component incorporated in the footwear shall meet the performance requirements of Section 8.10, Protective Footwear Elements Performance Requirements for Both Ensembles, with the exception of 8.10.4 and 8.10.5.

7.10.2.3 Where booties are used, the outer footwear shall not be required to have a liner in the upper.

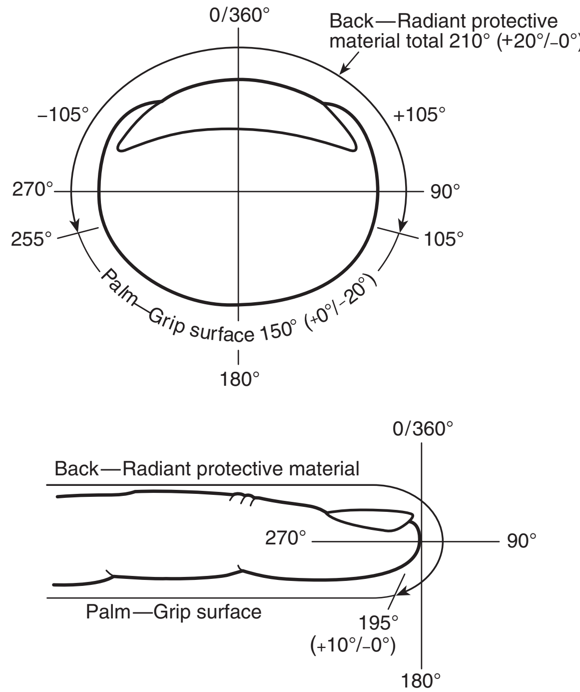


FIGURE 7.9.3.1 Glove Radiant Reflective Protection Areas.

7.10.2.4 Supplemental footwear that is provided to meet the performance requirements of Chapters 4 through 9 of this standard but is not intended to be worn continuously with the wearing of the footwear element shall not be permitted.

7.10.3 Footwear height shall be a minimum of 250 mm (9.84 in.).

7.10.3.1 The footwear height shall be determined by measuring inside the footwear from the center of the insole at the heel up to a perpendicular reference line extending across the footwear at the lowest point of the top line, excluding the tongue and gusset as specified in 9.1.22.

7.10.3.2 Removable insoles shall not be removed prior to measurement.

7.10.3.3 Moisture protection shall be continuous circumferentially to within 50 mm (2 in.) of the footwear top line at all locations except the area inside of and within 13 mm (½ in.) around pull-up holes that fully penetrate the footwear from outside to inside. The height of thermal, physical, and moisture protection at all locations of the boot shall be no less than 250 mm (9.84 in.) when measured as described in 7.10.3.1. The technique specified in 9.1.22 shall be used for making these measurements, particularly when it is not obvious where the moisture protection location ends in the top of the footwear.

7.10.3.4 Thermal and physical protection shall be continuous circumferentially to within 50 mm (2 in.) of the footwear top line at all locations except the gusset and the area inside of and within 13 mm (½ in.) around pull-up holes that fully penetrate the footwear from outside to inside. The height of thermal and physical protection at all locations of the boot except the gusset shall be no less than 250 mm (9.84 in.) when measured as described in 7.10.3.1.

7.10.4 The footwear heel breast shall not be less than 13 mm (½ in.) nor more than 25 mm (1 in.).

7.10.4.1 The heel breasting angle shall not be less than 90 degrees nor more than 135 degrees.

7.10.4.2 The heel edges shall not extend more than 13 mm (½ in.) laterally from the upper at any point.

7.10.4.3 The width of the footwear heel shall be equal to or greater than the width of the sole at the intersection of the heel breast and the sole bottom, excluding any calendar roll where present.

7.10.5 The puncture-resistant device shall cover the maximum area of the insole as specified in Section 3.3 of CSA Z195, *Protective Footwear*.

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

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

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

7.10.7 All sewing thread utilized in the construction of footwear shall be made of an inherently flame-resistant fiber.

7.10.8 In order to label or otherwise represent footwear as compliant with the requirements of Chapters 4 through 9 of this standard, the manufacturer shall have footwear available in all of the following sizes:

(1) Men's 5–16, including half sizes and a minimum of three widths
(2) Women's 5–10, including half sizes and a minimum of three widths

7.10.8.1 Manufacturers shall be required to establish and provide upon request a size conversion chart for each model or style of protective footwear based on toe length, arch length, and foot width as measured on the Brannock Scientific Foot Measuring Device.

7.10.8.2 Full and half sizes in each of the three required widths shall be accomplished by individual and unique men's and women's lasts to provide proper fit. Dual sizing of the same pair of boots to cover men's and women's boot styles shall not be acceptable.

7.10.9 Footwear shall meet the performance requirements as specified in ASTM F2413, *Standard Specification for Performance Requirements for Protective (Safety) Toe Cap Footwear*, for impact, compression, and puncture-resistance, with the exception that flex resistance to cracking shall be evaluated at 1,000,000 cycles.

7.10.10* Footwear upper principal textile-based fabric material layers, including any exterior layer(s), barrier layers(s), and lining(s), shall be recognized components that meet levels of restricted substances as specified in Section 8.21, Acceptable Levels of Restricted Substances in Specified Protective Element Recognized Components.

7.10.10.1 If the barrier layers do not include a textile layer, they shall still be recognized components that meet levels of restricted substances as specified in Section 8.21, Acceptable Levels of Restricted Substances in Specified Protective Element Recognized Components.

7.11 Additional Design Requirements for Structural Firefighting Protective Footwear Only. (Reserved)

7.12 Additional Design Requirements for Proximity Firefighting Protective Footwear Only. (Reserved)

7.13 Protective Hood Interface Component Design Requirements for Both Ensembles.

7.13.1 Hood interface components shall have at least the applicable design requirements specified in this section where inspected and evaluated by the certification organization as specified in Section 4.3, Inspection and Testing, and Section 5.3, Inspection and Testing.

7.13.2 Hoods shall be permitted to be integrated with the protective coat.

7.13.3 The hood shall be designed to cover and provide the limited protection as specified within this section to the head, face, and neck areas, but not including the face opening specified in 7.13.6.

7.13.3.1 Where the hood is integrated with the protective coat, the hood shall not be required to meet the design requirement specified in 7.13.5.

7.13.4 All sewing thread used in the construction of hoods shall be made of an inherently flame-resistant fiber.

7.13.5* The hood shall be donned properly, in accordance with the manufacturer's instructions for wearing, on the ISO size J headform specified in Figure 9.3.6.4.1.

7.13.5.1 A single size or multiple sizes of the protective hoods shall be permitted.

7.13.5.2 In this position, the hood shall provide full coverage above the reference plane on each side measured downward from the reference plane at the coronal plane of 225 mm (9 in.), provide a minimum coverage in the back measured downward from the reference plane at the rear midsagittal plane of 330 mm (13 in.), and provide a minimum coverage in the front measured downward from the reference plane at the front midsagittal plane, including the face opening, of 305 mm (12 in.).

7.13.5.3* Hoods shall be provided in sizes that accommodate the range of head sizes for both men and women as shown in Table 7.13.5.3.

7.13.6 Hoods shall be designed with a face opening.

7.13.6.1 Other than where the hood face opening is designed to interface with a specific SCBA facepiece, or where the hood face opening is designed to be adjustable, the hood face open-

Table 7.13.5.3 Sizing Requirements for Hoods

Measurement location	Men's sizing (mm)	Women's sizing (mm)
Bitragion arc length, sitting	343–384	327–366
Head arc length, sitting	328–386	306–371
Head circumference, sitting	553–601	538–582

ing shall be able to be stretched to a circumference of at least 800 mm (31 in.).

7.13.6.2 Where the hood face opening is designed to interface with a specific SCBA facepiece, the hood face opening shall overlap the outer edge of the specific SCBA facepiece-to-face seal perimeter by not less than 13 mm (½ in.). Using the test equipment and approach specified in 9.8.10.4.2 and 9.8.10.4.5 shall be permitted.

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

7.13.7 Hood fabric materials, including the outer layer, inner layer (where different), and particulate-blocking layers, as applicable, shall be recognized components that meet levels of restricted substances as specified in Section 8.21, Acceptable Levels of Restricted Substances in Specified Protective Element Recognized Components.

7.14 Additional Design Requirements for Structural Firefighting Protective Hood Interface Components Only.

7.14.1 The hood interface component shall include a particulate-blocking material specifically for meeting the requirements of 8.14.1 that includes all areas of the hood except as specified in 7.14.2 and 7.14.3.

7.14.2 The particulate-blocking hood material shall be extended at least to within 19 mm (¾ in.) of any hem of the hood bib.

7.14.3 Binding, including the elastic and stitching around the hood face opening, shall be permitted to exclude particulate-blocking material specifically for meeting the requirements of 8.14.1 for a distance of 19 mm (¾ in.) from the leading edge of the hood face opening. The distance shall be measured in eight separate locations, with the hood lying on a flat surface and the face opening facing upward, and measured from the innermost row of stitching to the face opening leading edge.

7.15 Additional Design Requirements for Proximity Firefighting Protective Hood Interface Components Only. (Reserved)

7.16 Protective Wristlets Interface Component Design Requirements for Both Ensembles.

7.16.1 Wristlet interface components shall have at least the applicable design requirements specified in this section where inspected and evaluated by the certification organization as specified in Section 4.3, Inspection and Testing.

7.16.2* Wristlets shall be designed to cover and provide limited protection to the wrist areas.

7.16.3 Wristlets shall be permanently attached to the protective coat sleeve in a manner that will not permit a gap in the thermal protection.

7.16.4 All sewing thread utilized in the construction of wristlets shall be made of an inherently flame-resistant fiber.

7.17 Additional Design Requirements for Structural Firefighting Protective Wristlet Interface Components Only. (Reserved)

7.18 Additional Design Requirements for Proximity Firefighting Protective Wristlet Interface Components Only. (Reserved)

7.19 Optional Design Requirements for Protection from Liquid and Particulate Contaminants.

7.19.1 Liquid and Particulate Contaminants Protective Ensemble Design Requirements for Both Ensembles. (Reserved)

7.19.2 Additional Liquid and Particulate Contaminant Protection Design Requirements for Structural Firefighting Protective Ensembles Only. (Reserved)

7.19.3 Additional Liquid and Particulate Contaminant Protection Design Requirements for Proximity Firefighting Protective Ensembles Only. (Reserved)

7.19.4 Liquid and Particulate Contaminant Protective Garment Element Design Requirements for Both Ensembles.

7.19.4.1 Liquid and particulate contaminant protective garments shall have at least the applicable design requirements specified in this subsection in addition to the design requirements specified in Section 7.1, Protective Garment Element Design Requirements for Both Ensembles, and Section 7.2, Additional Design Requirements for Structural Firefighting Protective Garment Elements Only, or as in Section 7.3, Additional Design Requirements for Proximity Firefighting Protective Garment Elements Only, where inspected and evaluated by the certification organization as specified in Section 4.3, Inspection and Testing, and Section 5.3, Inspection and Testing.

7.19.4.1.1* For the requirement in 7.19.4.1, a garment design shall be considered unique based on the following factors:

(1) Type and orientation of front closure system(s) on coats and trousers
(2) Type of coat collar, collar closure, and interface with hood
(3) Type of coat sleeve end and wristlet interface component for creating an interface with protective gloves
(4) Type of trouser leg construction for creating an interface with protective footwear
(5) Type of coat and trouser interface and overlap
(6) Type of interface materials

7.19.4.1.2 Liquid and particulate contaminant protective garments subject to the requirements in 7.19.4.1 and 7.19.4.1.1 shall include either a specific set of coats and trousers, or consist of a coverall.

7.19.4.2 Liquid and particulate contaminant protective garments shall be designed and configured to protect at least the wearer's upper and lower torso, arms, and legs, but excluding the hands, feet, and head.

7.19.4.2.1 Liquid and particulate contaminant protective garments shall be permitted to include integrated hoods to protect the wearer's head in conjunction with the SCBA specified by the ensemble manufacturer.

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

7.19.4.4* The manufacturer shall be permitted to specify undergarments or other related garments worn as part of the ensemble when the identified items are required to be worn with the ensemble as indicated on the product label for particulate and liquid protection as specified in 6.2.1.1 and 6.2.2. The undergarments shall also be used in the evaluation of the garment for overall liquid integrity and particulate inward leakage, and must be worn for the garment to function for providing the wearer protection from liquid and particulate exposure. The use of undergarments shall also be included in the user information required in Chapter 6.

7.19.4.4.1 The undergarments or related garments shall be certified to Chapters 10 through 14.

7.19.4.4.2 The undergarments or related garments shall collectively cover the torso, arms, and legs of the wearer, and extend at least to the wearer's wrists on the arms and down to the ankles on the legs.

7.19.4.4.3 The additional undergarments or other related garments shall be permitted to contribute to the performance of other ensemble requirements in other parts of this standard only if integrated with the garment such that the overall garment cannot be worn without the respective undergarment or related garment.

7.19.5 Additional Liquid and Particulate Contaminant Protection Design Requirements for Structural Firefighting Protective Garment Elements Only. (Reserved)

7.19.6 Additional Liquid and Particulate Contaminant Protection Design Requirements for Proximity Firefighting Protective Garment Elements Only. (Reserved)

7.19.7 Liquid and Particulate Contaminant Protective Helmet Elements Design Requirements for Both Ensembles. (Reserved)

7.19.8 Additional Liquid and Particulate Contaminant Protection Design Requirements for Structural Firefighting Protective Helmet Elements Only. (Reserved)

7.19.9 Additional Liquid and Particulate Contaminant Protection Design Requirements for Proximity Firefighting Protective Helmet Elements Only. (Reserved)

7.19.10 Liquid and Particulate Contaminant Protective Glove Elements Design Requirements for Both Ensembles. (Reserved)

7.19.11 Additional Liquid and Particulate Contaminant Protection Design Requirements for Structural Firefighting Protective Glove Elements Only. (Reserved)

7.19.12 Additional Liquid and Particulate Contaminant Protection Design Requirements for Proximity Firefighting Protective Glove Elements Only. (Reserved)

7.19.13 Liquid and Particulate Contaminant Protective Footwear Elements Design Requirements for Both Ensembles. (Reserved)

7.19.14 Additional Liquid and Particulate Contaminant Protection Design Requirements for Structural Firefighting Protective Footwear Elements Only. (Reserved)

7.19.15 Additional Liquid and Particulate Contaminant Protection Design Requirements for Proximity Firefighting Protective Footwear Elements Only. (Reserved)

7.19.16 Liquid and Particulate Contaminant Protective Hood Interface Component Design Requirements for Both Ensembles. (Reserved)

7.19.17 Liquid and Particulate Contaminant Protective Hood Interface Component Design Requirements for Structural Firefighting Ensembles. (Reserved)

7.19.18 Liquid and Particulate Contaminant Protective Shroud Interface Component Design Requirements for Proximity Firefighting Ensembles. (Reserved)

7.20 Design Requirements for Electrical Circuitry.

7.20.1 General. Structural and proximity firefighting protective ensembles and ensemble elements involving electrical circuitry shall only use circuitry that meets the requirements of this standard for one of the following types of explosion protection:

(1) Nonincendive equipment, stand-alone type (i.e., individual pieces of equipment separately certified for Class I and II, Division 2 and Class III applications, without any external electrical interconnection means, and intended for stand-alone use)
(2) Nonincendive equipment, electrically interconnected type (i.e., individual pieces of equipment separately certified for Class I and II, Division 2 and Class III applications, with external electrical interconnection means involving plugs and jacks, and intended for electrical interconnection to other separately certified nonincendive equipment, electrically interconnected types)
(3) Nonincendive system (i.e., multiple pieces of nonincendive equipment certified together for Class I and II, Division 2 and Class III applications, with electrical interconnection means, and intended for dedicated system use)
(4) Intrinsically safe apparatus, stand-alone type (i.e., individual pieces of apparatus separately certified for Class I and II, Division 1 and Class III applications, without any external electrical interconnection means, and intended for stand-alone use)
(5) Intrinsically safe system (i.e., multiple pieces of intrinsically safe apparatus certified together for Class I and II, Division 1 and Class III applications, with electrical interconnection means, and intended for dedicated system use)

7.20.1.1* Passive electrical circuitry that relies on a supplemental device to energize it shall be exempt from explosion protection if the requirement in 7.20.1.2 is met.

7.20.1.2 The instructions supplied with ensembles and ensemble elements involving passive electrical circuitry shall indicate that the supplemental device used to energize the circuitry shall not be used or stored in a hazardous location.

7.20.2 Nonincendive Equipment and Systems.

7.20.2.1* General. Electrical circuitry contained within structural and proximity firefighting protective ensembles and ensemble elements shall, at a minimum, be suitable for use in Class I, Division 2, Groups C and D; Class II, Division 2, Groups F and G; and Class III, Divisions 1 and 2 hazardous (classified) locations, with a temperature class within the range of T3 through T6 inclusive, in accordance with UL 121201, *Nonincendive Electrical Equipment for Use in Class I and II, Division 2 and Class III, Divisions 1 and 2 Hazardous (Classified) Locations.*

7.20.2.2 Interconnection of Nonincendive Equipment, Electrically Interconnected Types.

7.20.2.2.1 Interconnection of electrical circuits that are separately certified as nonincendive equipment, electrically interconnected types, shall occur by means of a plug and jack that comply with the device connector requirements specified in Section 6.10 of NFPA 1802.

7.20.2.2.2 The electrical parameters for interconnection shall comply with Table 7.20.2.2.2.

7.20.2.2.3 The instructions supplied with the ensembles and ensemble elements shall identify the circuits as nonincendive equipment, electrically interconnected types, and indicate the ability to interconnect the circuitry with any other circuitry also identified as nonincendive equipment, electrically interconnected types, in accordance with this standard.

7.20.2.3 Interconnection of Nonincendive Systems.

7.20.2.3.1 Electrical circuits that are certified as part of a nonincendive system shall only be interconnected with other electrical circuits also certified as part of the same nonincendive system.

Table 7.20.2.2.2 Electrical Parameters for Interconnection of Separately Certified Nonincendive Equipment, Electrically Interconnected Types

Device Connector as Source	Required Relationship	Device Connector as Sink
Uo ≤ 8 V	Uo ≤ Ui	Ui ≥ 10 V
Io ≤ 500 mA	Io ≤ Ii	Ii ≥ 1 A
Co ≥ 69 µF	Co ≥ Ci + Ccable*	Ci ≤ 68 µF
Lo ≥ 320 µH	Lo ≥ Li +Lcable*	Li ≤ 315 µH

*Assumption for cable capacitance (Ccable) and cable inductance (Lcable): 200 pF/m and 1 µH/m.

7.20.2.3.2 The instructions supplied with the ensembles and ensemble elements shall identify the circuits as part of a nonincendive system and indicate the other circuits that comprise the nonincendive system in accordance with this standard.

7.20.3 Intrinsically Safe Apparatus and Systems.

7.20.3.1* General. Electrical circuitry contained within structural and proximity firefighting protective ensembles and ensemble elements shall be permitted to be certified at a minimum for use in Class I, Division 1, Groups C and D; Class II, Division 1, Groups E, F, and G; and Class III, Divisions 1 and 2 hazardous locations, with a temperature class within the range of T3 through T6 inclusive, in accordance with UL 913, *Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, and III, Division 1 Hazardous (Classified) Locations.*

7.20.3.2 Interconnection of Intrinsically Safe Systems.

7.20.3.2.1 Electrical circuits that are certified as part of an intrinsically safe system shall only be interconnected with other electrical circuits certified as part of the same intrinsically safe system.

7.20.3.2.2 The instructions supplied with the ensembles and ensemble elements shall identify the circuits as part of an intrinsically safe system and indicate the other circuits that comprise the intrinsically safe system in accordance with this standard.

Chapter 8 Performance Requirements (NFPA 1971)

8.1 Protective Garment Elements Performance Requirements for Both Ensembles.

8.1.1* Protective garment elements composite consisting of outer shell, moisture barrier, and thermal barrier shall be tested for thermal insulation as specified in Section 9.2.16, Thermal Protective Performance (TPP) Test, and shall have an average TPP of not less than 35.0.

8.1.2 Garments shall be tested for overall liquid penetration resistance as specified in Section 9.5.1, Whole Garment and Ensemble Liquid Penetration Test, and shall allow no liquid penetration except as permitted in 9.5.1.8.2.

8.1.3 Garment outer shells, moisture barriers, thermal barriers, collar linings, winter liners where provided, drag rescue devices (DRDs), trim, lettering, and other materials used in garment construction, including, but not limited to, padding, reinforcement, interfacing, binding, hanger loops, emblems, and patches, shall be individually tested for resistance to flame as specified in Section 9.2.1, Flame Resistance Test 1, and shall not have a char length of more than 100 mm (4 in.) average, shall not have an afterflame of more than 2.0 seconds average, and shall not melt.

8.1.3.1 Labels and nonvisual/machine-readable tags shall meet the performance requirements specified in 8.1.3 only where placed on the exterior of the garment.

8.1.3.2 Zippers and seam-sealing materials shall meet the performance requirements specified in 8.1.3 only where located on the exterior of the garment or located where they will directly contact the wearer's body.

8.1.3.3 Elastic and hook and pile fasteners shall meet the performance requirements specified in 8.1.3 only where located where they will directly contact the wearer's body.

8.1.3.4 Small specimens such as hanger loops and emblems or patches that are not large enough to meet the specimen size requirements in 9.2.1.2.1 shall be tested for resistance to flame as specified in Section 9.2.1, Flame Resistance Test 1, and shall not be totally consumed, shall not have an afterflame of more than 2.0 seconds average, and shall not melt.

8.1.3.5 Life safety harnesses, escape belts, and ladder belts shall meet the performance requirements specified in 8.1.3 only when they penetrate the outer shell, are incorporated as part of a garment closure system, or are attached to the garment.

8.1.4 Garment outer shells, moisture barriers, thermal barriers, winter liners where provided, and collar linings shall be individually tested for resistance to heat as specified in Section 9.2.4, Heat and Thermal Shrinkage Resistance Test, and shall not shrink more than 10.0 percent in any direction.

8.1.5 Garment outer shells, moisture barriers, thermal barriers, collar linings, winter liners where provided, DRDs, trim, lettering, and other materials used in garment construction, including, but not limited to, padding, reinforcement, labels, nonvisual/machine-readable tags, interfacing, binding, hanger loops, emblems, or patches, but excluding elastic and hook and pile fasteners where these items are placed so that they will not directly contact the wearer's body, shall be individually tested for resistance to heat as specified in Section 9.2.4, Heat and Thermal Shrinkage Resistance Test, and shall not melt, separate, or ignite.

8.1.6 Garment moisture barrier seams shall be individually tested for resistance to heat as specified in Section 9.2.4, Heat and Thermal Shrinkage Resistance Test, and shall not drip or ignite.

8.1.7 Garment outer shells and collar linings shall be individually tested for resistance to heat as specified in Section 9.2.4, Heat and Thermal Shrinkage Resistance Test, and shall not char.

8.1.8 All garment hardware, including zippers but excluding hook and pile fasteners, where placed so that they will not directly contact the wearer's body, shall be individually tested for resistance to heat as specified in Section 9.2.4, Heat and Thermal Shrinkage Resistance Test, and shall not ignite and shall remain functional.

8.1.9 The garment composite from the shoulder areas and the knee areas shall be tested for resistance to heat transfer as specified in Section 9.2.10, Conductive and Compressive Heat Resistance (CCHR) Test, and shall demonstrate passing performance.

8.1.10 All sewing thread utilized in the construction of garments and DRDs shall be tested for resistance to melting as specified in Section 9.2.5, Thread Melting Test, and shall not melt at or below 260°C (500°F).

8.1.11 Garment outer shells and collar linings shall be individually tested for resistance to tearing as specified in Section 9.3.1, Tear Resistance Test, and shall have a tear strength of not less than 100 N (22 lbf).

8.1.12 Garment moisture barriers, thermal barriers, and winter liners, where provided, shall be tested for resistance to tearing as specified in Section 9.3.1, Tear Resistance Test, and shall have a tear strength of not less than 22 N (5 lbf).

8.1.13 All garment seam assemblies shall be tested for strength as specified in Section 9.3.4, Seam-Breaking Strength Test.

8.1.13.1 Woven garment seam assemblies and specimens of seam assemblies that contain at least one woven material shall demonstrate a sewn seam strength equal to or greater than 667 N (150 lbf) force for Major A seams, 334 N (75 lbf) force for Major B seams, and 180 N (40 lbf) force for Minor seams when tested using the method specified in 9.3.4.3.2.1.

8.1.13.2 Seam breaking strength shall be considered acceptable where the fabric strength is less than the required seam strength specified in 8.1.13.1, providing the fabric fails without failure of the seam below the applicable forces specified in 8.1.13.1.

8.1.13.3 All knit or stretch woven garment seam assemblies shall demonstrate a sewn seam strength equal to or greater than 180 N (40 lbf) when tested using the method specified in 9.3.4.3.2.2.

8.1.13.4 All combination woven and knit or stretch knit seam specimens shall meet the requirements specified in 8.1.13.1.

8.1.14 Garment moisture barriers shall be tested for resistance to water penetration as specified in Section 9.4.2, Water Penetration Resistance Test, and shall have a minimum water penetration resistance of 172 kPa (25 psi).

8.1.15* Garment moisture barrier materials and seams shall be tested for resistance to liquid penetration as specified in Section 9.4.3, Liquid Penetration Resistance Test, and shall show no penetration of the test liquids for at least 1 hour.

8.1.16 Garment moisture barriers and moisture barrier seams shall be tested for liquid barrier performance and meet the Level 3 barrier requirements of ANSI/AAMI PB70, *Liquid barrier performance and classification of protective apparel and drapes intended for use in health care facilities*, as specified in Section 9.11, Liquid Barrier Performance Test.

8.1.16.1 In lieu of testing according to 8.1.16, garment moisture barriers and moisture barrier seams shall be permitted to be tested for resistance to liquid-borne or blood-borne pathogens according to 9.4.5 Viral Penetration Resistance, and shall allow no penetration of the Phi X-174 bacteriophage above the test interpretation threshold for at least 1 hour.

8.1.17 Garment moisture barriers, thermal barriers, winter liners where provided, and collar linings shall be individually tested for resistance to shrinkage as specified in Section 9.9.1, Cleaning Shrinkage Resistance Test, and shall not shrink more than 5 percent in any direction.

8.1.18 Garment outer shells and collar linings shall be individually tested for resistance to water absorption as specified in Section 9.4.1, Water Absorption Resistance Test, and shall not have more than 15 percent water absorption.

8.1.19 All garment metal hardware and specimens of all garment hardware that include metal parts shall be individually tested for resistance to corrosion as specified in Section 9.4.6, Corrosion Resistance Test, and shall have metals that are inherently resistant to corrosion including but not limited to stainless steel, brass, copper, aluminum, and zinc show no more than light surface-type corrosion or oxidation, shall have ferrous metals show no corrosion of the base metal, and shall have all hardware remain functional.

8.1.20 Labels shall be tested for durability and legibility as specified in Section 9.8.12, Label Durability and Legibility Test 1, shall remain in place, and shall be legible.

8.1.20.1 Nonvisual/machine-readable tags shall be tested for durability as specified in Section 9.8.12, Label Durability and Legibility Test 1, and shall remain functional, including the ability to scan and read the tag according to the manufacturer's instructions.

8.1.21 DRD materials, seams, splices, and joints shall be tested for material strength as specified in Section 9.3.20, Drag Rescue Device (DRD) Materials Strength Test, and shall have a minimum tensile strength of 7 kN (1573 lbf).

8.1.22 Garments with the DRD installed shall be tested for functionality as specified in Section 9.8.11, Drag Rescue Device (DRD) Function Test, and shall allow for the manikin to be dragged for a minimum of 2.5 m (98 in.), the DRD shall be deployed within 10 seconds, the SCBA shall not move higher on the torso from the donned position, and the SCBA shall not separate from the manikin.

8.1.23 Garment zippers shall be tested for crosswise breaking strength of chain; crosswise breaking strength of separating unit; holding strength of stops, retainers, and separating units; operating force; and slider lock strength requirements of A-A-55634C, *Commercial Item Description, Zippers (Fasteners, Slide, Interlocking)*.

8.1.24 Fastener tape shall be tested for breaking strength as specified in Section 9.3.19, Hook and Loop Fastener Tape Strength Test, and shall meet or exceed the minimum breaking strength requirements as established in Table 1 of A-A 55126C, *Commercial Item Description, Fastener Tapes, Hook and Loop, Synthetic*.

8.1.25 Fastener tape shall be tested for shear strength as specified in Section 9.3.19, Hook and Loop Fastener Tape Strength Test, and shall meet or exceed the minimum shear strength requirements as established in Table 1 of A-A 55126C, *Commercial Item Description, Fastener Tapes, Hook and Loop, Synthetic*.

8.1.26 Fastener tape shall be tested for peel strength as specified in Section 9.3.19, Hook and Loop Fastener Tape Strength Test, and shall meet or exceed the minimum peel strength requirements as established in Table 1 of A-A 55126C, *Commercial Item Description, Fastener Tapes, Hook and Loop, Synthetic*.

8.1.27* Garment moisture barrier materials shall be tested for resistance to light degradation as specified in 9.4.10, Light Degradation Resistance Test, and demonstrate passing performance.

8.2 Additional Performance Requirements for Structural Firefighting Protective Garment Elements Only.

8.2.1 Structural firefighting protective garment elements shall also meet the performance requirements specified in this section in addition to the performance requirements specified in Section 8.1, Protective Garment Elements Performance Requirements for Both Ensembles.

8.2.2* Garment composite consisting of the outer shell, moisture barrier, and thermal barrier shall be tested for evaporative heat transfer as specified in Section 9.7.1, Total Heat Loss (THL) Test, and shall have a THL of not less than 205 W/m^2.

8.2.2.1* Garment composites consisting of the outer shell, moisture barrier, and thermal barrier shall be tested for evaporative resistance a specified in Section 9.7.2, Evaporative Resistance Test 1,and shall have an evaporative resistance value of less than or equal to 45 Pa·m^2/W.

8.2.2.2 Certain garment composites shall be permitted to be excluded from direct testing for evaporative resistance and instead calculated when testing is conducted by a sequence of tests as specified in 9.7.2.1.2.

8.2.3 Garment trim shall be tested for retroreflectivity and fluorescence as specified in Section 9.8.1, Trim Retroreflectivity and Fluorescence Test, and shall have a coefficient of retroreflection (R_a) of not less than 100 cd/lux/m^2 (100 cd/fc/ft^2), and shall have the color be fluorescent yellow-green, fluorescent orange-red, or fluorescent red.

8.2.4 Garment outer shells shall be individually tested for resistance to shrinkage as specified in Section 9.9.1, Cleaning Shrinkage Resistance Test, and shall not shrink more than 5 percent in any direction.

8.2.5 Garment outer shells and collar linings shall be individually tested for strength after washing as specified in Section 9.3.2, Breaking Strength Test, and shall have a breaking strength of not less than 623 N (140 lbf).

8.2.6 Garment element sleeves that include enhancements exterior to the outer shell shall be considered enhanced composites. Enhancements shall include items such as visibility markings and other materials used in construction, including, but not limited to, padding, reinforcements, emblems, patches, and logos, but excluding reinforcement materials that do not extend more than 25 mm (1 in.) when measured from the edge of the cuff along the sleeve. The enhanced composite shall be tested for transmitted and stored thermal energy as specified in Section 9.2.15, Transmitted and Stored Thermal Energy Test, and shall have an average predicted time to second-degree burn of 130 seconds or greater.

8.2.7 Garment outer shells shall be evaluated for flame resistance following fuel exposure and cleaning as specified in Section 9.9.4, Flame Resistance Following Fuel Exposure and Cleaning Test, with the following results reported in the user information:

(1) Indices of repellency, penetration, and absorption following exposure to diesel fuel
(2) Indices of repellency, penetration, and absorption following exposure to diesel fuel and after being subjected to laundering conditioning
(3) Flame resistance following exposure to diesel fuel
(4) Flame resistance following exposure to diesel fuel and the application of one cleaning cycle

8.2.8 Where the garment manufacturer or component supplier is required to report the contaminant removal efficiency for semivolatile organic compounds and heavy metals in the user information, outer shells, moisture barriers, and thermal barriers shall be evaluated for ease of cleaning as specified in 9.9.3, Contamination Removal Efficiency Tests.

8.3 Additional Performance Requirements for Proximity Firefighting Protective Garment Elements Only.

8.3.1 Proximity firefighting protective garment elements shall also meet the performance requirements specified in this section, in addition to the performance requirements specified in Section 8.1, Protective Garment Elements Design Requirements for Both Ensembles.

8.3.2 Garment outer shells shall be tested for radiant reflective capability as specified in Section 9.2.14, Radiant Protective Performance Test, and shall have an intersect time of not less than 20 seconds.

8.3.3 Garment outer shells shall be tested for resistance to delamination as specified in Section 9.4.7, Coating/Laminate Wet Flex Test, and shall show no signs of cracking on the face or delamination.

8.3.4 Garment outer shells shall be tested for adhesion durability as specified in Section 9.4.8, Coating/Laminate Adhesion After Wet Flex, and shall show no evidence of separation or removal of the surface coating.

8.3.5 Garment outer shells shall be tested for flex durability as specified in Section 9.4.9, Coating/Laminate Flex Resistance at Low Temperature Test, and shall show no evidence of breaking, shattering, or cracking of the coating, laminate, or fabric.

8.3.6 Garment outer shells shall be tested for blocking durability as specified in Section 9.2.6, Resistance to High-Temperature Blocking Test, and shall show no blocking.

8.4 Protective Helmet Elements Performance Requirements for Both Ensembles.

8.4.1 Protective helmet elements shall be tested for resistance to impact as specified in Section 9.3.5, Helmet Top Impact Resistance Test (Force), and shall have no sample transmit a force of more than 3780 N (850 lbf).

8.4.2 Helmets shall be tested for resistance to impact as specified in Section 9.3.6, Helmet Impact Resistance Test (Acceleration), and shall have no specimen exceed the maximum acceleration specified in Table 8.4.2. Any acceleration above 200 g_n shall not exceed a duration of 3 milliseconds, and an acceleration above 150 g_n shall not exceed a duration of 6 milliseconds. Helmets shall maintain sufficient structural integrity to withstand impacts in all five locations.

8.4.3 Helmets shall be tested for resistance to penetration as specified in Section 9.3.7, Helmet Physical Penetration Resistance Test, and shall exhibit no electrical or physical contact between the penetration test striker and the headform.

8.4.4 Helmets shall be tested for resistance to heat as specified in Section 9.2.4, Heat and Thermal Shrinkage Resistance Test. The following results shall be considered unacceptable:

(1) Parts of the complete helmet assembly that do not contact the headform before this test come in contact with the headform as a result of this test
(2) Distortion of the back of the helmet shell extending more than 40 mm (1⅝ in.) below the original position of the helmet shell
(3) Distortion of the front and sides of the helmet shell extending more than 30 mm (1³⁄₁₆ in.) below the original position of the helmet shell
(4) Separation, melting, or dripping of the retention system, energy absorption system, or ear covers
(5) Dysfunctional chin strap closure device
(6) Ignition of any part of the helmet assembly
(7) Ignition or melting of the product labels and where used, nonvisual/machine-readable tags
(8)* Any component of the helmet assembly, including, but not limited to, supplemental faceshields, extending more than 30 mm (1³⁄₁₆ in.) below the initial lowest point of the helmet shell in the front area, both before and after oven exposure
(9) Dripping of the faceshield/goggle component

8.4.5 Helmets shall be tested for resistance to flame as specified by Procedure A and Procedure C in Section 9.2.2, Flame Resistance Test 2,and shall not show any visible afterflame or glow 5.0 seconds after removal from the test flame in each test.

8.4.6 Helmet ear covers and helmet shrouds shall be tested for thermal insulation as specified in Section 9.2.16, Thermal Protective Performance (TPP) Test, and shall have an average TPP rating of at least 20.0.

8.4.7 Helmets shall be tested for retention ability as specified in Section 9.3.9, Helmet Retention System Test, without any

Table 8.4.2 Impact Acceleration

Impact Location	Maximum Acceleration	m · sec/sec	ft · sec/sec
Top	$150 \times g_n$	1471.5	4830
Front	$300 \times g_n$	2943.0	9660
Sides	$300 \times g_n$	2943.0	9660
Back	$300 \times g_n$	2943.0	9660

Note: g_n denotes gravitational acceleration, which is defined as 9.81 m · sec/sec (32.2 ft · sec/sec).

break occurring and without any resulting slip or stretch of more than 20 mm ($^{13}/_{16}$ in.).

8.4.8 Helmet suspension systems shall be tested for retention ability as specified in Section 9.3.10, Helmet Suspension System Retention Test, and shall not separate from the helmet.

8.4.9 Helmets shall be tested for shell retention ability as specified in Section 9.3.8, Helmet Shell Retention Test, and shall not have the helmet shell separate from the helmet suspension and retention systems.

8.4.10 All materials utilized in the construction of helmet chin straps, excluding elastic and hook and pile fasteners where these items are placed so that they will not directly contact the wearer's body or hood, shall be individually tested for resistance to flame as specified in Section 9.2.1, Flame Resistance Test 1, and shall not have a char length greater than 100 mm (4 in.), shall not show any visible afterflame 2.0 seconds after removal from the test flame, and shall not melt or drip.

8.4.11 All materials utilized in the construction of helmet chin straps, excluding elastic and hook and pile fasteners where these items are placed so that they will not directly contact the wearer's body or hood, shall be individually tested for resistance to heat as specified in Section 9.2.4, Heat and Thermal Shrinkage Resistance Test, and shall not shrink more than 10 percent in any direction, and shall not melt, separate, or ignite. Helmet chin strap material shall meet the thermal shrinkage requirement for the length dimension only.

8.4.12 All sewing thread used in the construction of helmets shall be tested for melting resistance as specified in Section 9.2.5, Thread Melting Test, and shall not melt below 260°C (500°F).

8.4.13 All helmet metal hardware and specimens of all helmet hardware that include metal parts shall be individually tested for resistance to corrosion as specified in Section 9.4.6, Corrosion Resistance Test, and shall have metals that are inherently resistant to corrosion including but not limited to stainless steel, brass, copper, aluminum, and zinc show no more than light surface-type corrosion or oxidation, shall have ferrous metals show no corrosion of the base metal, and shall have all hardware remain functional.

8.4.14 Labels shall be tested for durability and legibility as specified in Section 9.8.13, Label Durability and Legibility Test 2, shall remain in place, and shall be legible.

8.4.14.1 Nonvisual/machine-readable tags shall be tested for durability as specified in Section 9.8.13, Label Durability and Legibility Test 2, and shall remain functional, including the ability to scan and read the tag according to the manufacturer's instructions.

8.4.15 Faceshield/goggle components shall be tested for resistance to impact as specified in Section 9.3.11, Faceshield/Goggle Component Lens Impact Resistance Test, Tests One and Two, and shall not have any faceshield/goggle component contact an "eye" of the headform, and shall not have any parts or fragments be ejected from the component that could contact the eye of the headform.

8.4.16 Faceshield/goggle components shall be tested for flame resistance as specified in Section 9.2.2, Flame Resistance Test 2, Procedure B, and shall not show any visible afterflame 5.0 seconds after removal of the test flame.

8.5 Additional Performance Requirements for Structural Firefighting Protective Helmet Elements Only.

8.5.1 Structural firefighting protective helmet elements shall also meet the performance requirements specified in this section in addition to the performance requirements specified in Section 8.4, Protective Helmet Elements Performance Requirements for Both Ensembles.

8.5.2 All fabrics utilized in construction of faceshield/goggle components shall be tested for flame resistance as specified in Section 9.2.1, Flame Resistance Test 1, and all fabrics shall not have a char length of more than 100 mm (4 in.) average, and shall not have an afterflame of more than 5.0 seconds average after removal of the test flame.

8.5.3 Faceshield/goggle component lenses shall be tested for resistance to scratching as specified in Section 9.3.12, Faceshield/Goggle Component Lens Scratch Resistance Test, and shall not exhibit a delta haze of greater than 25 percent.

8.5.4 Faceshield/goggle component lenses shall be tested for transmittance of light as specified in 9.8.2, Faceshield/Goggle Component Lens Luminous (Visible) Transmittance Test, and shall have clear lenses transmit a minimum of 85 percent of the incident visible radiation, and shall have colored lenses transmit a minimum of 43 percent of the incident visible radiation.

8.5.5 Where provided, the faceshield/goggle component attachment hardware shall be tested for flame resistance as specified in Section 9.2.2, Flame Resistance Test 2, Procedure D, and shall not show any visible afterflame 5.0 seconds after removal of the test flame.

8.5.6 Helmets shall be tested for resistance to electricity as specified in both Procedure A and Procedure B of Section 9.6.1, Electrical Insulation Test 1, and shall not have leakage current exceeding 3.0 mA in each test.

8.5.7 All materials utilized in the construction of helmet ear covers, excluding elastic and hook and pile fasteners where these items are placed so that they will not directly contact the wearer's body or hood, shall be individually tested for resistance to flame as specified in Section 9.2.1, Flame Resistance Test 1, shall not have a char length greater than 100 mm (4 in.), shall not show any visible afterflame 2.0 seconds after removal from the test flame, and shall not melt or drip.

8.5.8 All materials utilized in the construction of helmet ear covers, excluding elastic and hook and pile fasteners where these items are placed so that they will not directly contact the wearer's body or hood, shall be individually tested for resistance to heat as specified in Section 9.2.4, Heat and Thermal Shrinkage Resistance Test, and shall not shrink more than 10 percent in any direction, and shall not melt, separate, or ignite.

8.5.9 Helmet visibility markings shall be tested for retroreflectivity and fluorescence as specified in Section 9.8.1, Retroreflectivity and Fluorescence Test, and shall have a coefficient of retroreflection (*Ra*) of not less than 100 cd/lux/m^2 (100 cd/fc/ft^2), and shall have the color be fluorescent yellow-green, fluorescent orange-red, or fluorescent red.

8.5.10 Helmet ear covers, sweatbands, chin straps, nape device coverings, if provided, and any other textile-based soft goods, excluding suspension soft goods, that come in contact with the wearer's head shall be evaluated for ease of removal and reinstallation as specified in Section 9.9.2, Helmet Soft Goods Ease of Removal and Reinstallation Test, and have a test time of 20 minutes or less.

8.5.11 Where the helmet manufacturer or component supplier is required to report the contaminant removal efficiency for semivolatile organic compounds and heavy metals in the user information, helmet ear cover materials, textile-based suspension system materials, and textile-based retention system materials that come in contact with the wearer's head or neck without a protective hood shall be evaluated for ease of cleaning as specified in 9.9.3, Contamination Removal Efficiency Tests.

8.6 Additional Performance Requirements for Proximity Firefighting Helmet Elements Only.

8.6.1 Proximity firefighting protective helmet elements shall also meet the performance requirements specified in this section in addition to the performance requirements specified in Section 8.4, Protective Helmet Elements Performance Requirements for Both Ensembles.

8.6.2 Helmets shall be tested for radiant heat resistance as specified in Section 9.2.13, Radiant Heat Resistance Test 3, and shall not have a temperature rise of more than 25°C (45°F).

8.6.3 Helmet shrouds shall be tested for radiant reflective capability as specified in Section 9.2.14, Radiant Protective Performance Test, and shall have an intersect time of not less than 20 seconds.

8.6.4 Helmet shrouds with a laminate base fabric shall be tested for resistance to delamination as specified in Section 9.4.7, Coating/Laminate Wet Flex Test, and shall show no signs of cracking on the face or delamination.

8.6.5 Helmet shrouds shall be tested for adhesion durability as specified in Section 9.4.8, Coating/Laminate Adhesion After Wet Flex, and shall show no evidence of separation or removal of the surface coating.

8.6.6 Helmet shrouds shall be tested for flex durability as specified in Section 9.4.9, Coating/Laminate Flex Resistance at Low Temperature Test, and shall show no evidence of breaking, shattering, or cracking of the coating, laminate, or fabric.

8.6.7 Helmet shrouds shall be tested for blocking durability as specified in Section 9.2.6, Resistance to High-Temperature Blocking Test, and shall show no blocking.

8.6.8 All materials utilized in the construction of proximity helmet covers and shrouds, excluding elastic and hook and pile fasteners where these items are placed so that they will not directly contact the wearer's body or hood, shall be individually tested for resistance to heat as specified in Section 9.2.4, Heat and Thermal Shrinkage Resistance Test, and shall not shrink more than 10 percent in any direction, and shall not melt, separate, or ignite.

8.6.9 Helmet shroud outer shell material shall be individually tested for resistance to tearing as specified in Section 9.3.1, Tear Resistance Test, and shall have a tear strength of not less than 100 N (22 lbf).

8.6.10 Helmet faceshield component lenses shall be tested for transmittance of light as specified in 9.8.2, Faceshield/Goggle Component Lens Luminous (Visible) Transmittance Test, and shall transmit not less than 30 percent of the incident visible radiation.

8.6.11 Helmet faceshields shall be tested for radiant reflective capability as specified in Section 9.2.14, Radiant Protective Performance Test, and shall have an intersect time of not less than 30 seconds.

8.6.12 Helmet outer covers, where provided, shall be tested for radiant reflective capability as specified in Section 9.2.14, Radiant Protective Performance Test, and shall have an intersect time of not less than 20 seconds.

8.6.13 Helmet outer covers, where provided, shall be tested for resistance to delamination as specified in Section 9.4.7, Coating/Laminate Wet Flex Test, and shall show no signs of cracking on the face or delamination.

8.6.14 Helmet outer covers, where provided, shall be tested for adhesion durability as specified in Section 9.4.8, Coating/Laminate Adhesion After Wet Flex Test, and shall show no evidence of separation or removal of the surface coating.

8.6.15 Helmet outer covers, where provided, shall be tested for flex durability as specified in Section 9.4.9, Coating/Laminate Flex Resistance at Low Temperature Test, and shall show no evidence of breaking, shattering, or cracking of the coating, laminate, or fabric.

8.6.16 Helmet outer covers, where provided, shall be tested for blocking durability as specified in Section 9.2.6, Resistance to High-Temperature Blocking Test, and shall show no blocking.

8.6.17 Helmet outer covers, where provided, shall be tested for resistance to tearing as specified in Section 9.3.1, Tear Resistance Test, and shall have a tear strength of not less than 22 N (5 lbf).

8.6.18 All materials utilized in the construction of proximity helmet covers and shrouds, excluding elastic and hook and pile fasteners where these items are placed so that they will not directly contact the wearer's body or hood, shall be individually tested for resistance to flame as specified in Section 9.2.1, Flame Resistance Test 1, and shall not have a char length greater than 100 mm (4 in.), shall not show any visible afterflame 2.0 seconds after removal from the test flame, and shall not melt or drip.

8.6.19 Helmet faceshield component lenses shall be tested for resistance to scratching as specified in Section 9.3.12, Faceshield/Goggle Component Lens Scratch Resistance Test, and shall not exhibit a delta haze of greater than 5 percent.

8.6.20 Proximity faceshields shall be tested for adhesion of reflective coating as specified in Section 9.3.13, Proximity Faceshield Reflective Coating Adhesion Test, and shall show evidence of removal not to exceed 2B classification (i.e., 15 percent to 35 percent removal).

8.7 Protective Glove Elements Performance Requirements for Both Ensembles.

8.7.1 The glove body composite shall be tested for thermal insulation as specified in Section 9.2.16, Thermal Protective Performance (TPP) Test, and have an average TPP rating of at least 35.0.

8.7.2 The glove interface component composite shall be tested for thermal insulation as specified in Section 9.2.16, Thermal Protective Performance (TPP) Test, and shall have an average TPP rating of at least 20.0.

8.7.3 Gloves shall be tested for resistance to heat as specified in Section 9.2.4, Heat and Thermal Shrinkage Resistance Test, and shall not melt, separate, or ignite; shall not shrink more than 8 percent in length or width; shall be donnable; and shall be flexible.

8.7.3.1 Hook and pile fasteners on gloves shall be excluded from these requirements where these items are placed such that they will not directly contact the wearer's body.

8.7.3.2 Where hook and pile fasteners are placed on the gloves such that they will directly contact the wearer's body, they shall not melt, separate, or ignite when tested as part of the whole glove.

8.7.4 The glove lining materials of the glove body shall be individually tested for resistance to heat as specified in Section 9.2.4, Heat and Thermal Shrinkage Resistance Test, and shall not melt, separate, or ignite.

8.7.5 Portions of the glove body composite representative of the palm of the glove shall be tested for conductive heat resistance as specified in Section 9.2.7, Conductive Heat Resistance Test 1, and shall have a second-degree burn time of not less than 10.0 seconds and shall have a pain time of not less than 6.0 seconds.

8.7.6 The glove body composite, including, but not limited to, trim, external labels, external nonvisual/machine-readable tags, and external tags, but excluding hardware, and excluding hook and pile fasteners that do not directly contact the wearer's body, shall be tested for resistance to flame as specified in 9.2.17, Flame Resistance Test 3, and shall not have an average char length of more than 100 mm (4 in.), shall not have an average afterflame of more than 2.0 seconds, shall not melt or drip, and shall not have the amount of consumed materials exceed 5 percent.

8.7.7 The glove interface component composite, including, but not limited to, trim, external labels, external nonvisual/machine-readable tags, and external tags, but excluding hardware and hook and pile fasteners that do not directly contact the wearer's body, shall be tested for resistance to flame as specified in 9.2.17, Flame Resistance Test 3, and shall not have an average char length of more than 100 mm (4 in.), shall not have an average afterflame of more than 2.0 seconds, shall not melt or drip, and shall not have the amount of consumed materials exceed 5 percent.

8.7.8 The glove extension composite, including, but not limited to, trim, external labels, external nonvisual/machine-readable tags, and external tags, but excluding hardware and hook and pile fasteners that do not directly contact the wearer's body, shall be tested for resistance to flame as specified in 9.2.17, Flame Resistance Test 3, and shall not have an average char length of more than 100 mm (4 in.), shall not have an average afterflame of more than 2.0 seconds, shall not melt or drip, and shall not have the amount of consumed materials exceed 5 percent.

8.7.9* All sewing thread utilized in the construction of gloves shall be tested for melting resistance as specified in Section 9.2.5, Thread Melting Test, and shall not melt at or below 260°C (500°F).

8.7.10 The glove body seams shall be tested for resistance to liquid-borne or blood-borne pathogens as specified in Section 9.4.5, Viral Penetration Resistance Test, and shall allow no penetration of the Phi-X-174 bacteriophage above the test interpretation threshold for at least 1 hour.

8.7.11* Glove body seams shall be tested for resistance to liquid penetration as specified in Section 9.4.3, Liquid Penetration Resistance Test, and shall allow no penetration of test liquids for at least 1 hour.

8.7.12 The glove body composite shall be tested for resistance to cut as specified in Section 9.3.15, Glove and Footwear Cut Resistance Test, and shall have a distance of blade travel of more than 20 mm (0.8 in.).

8.7.13 The glove interface component shall be tested for resistance to cut as specified in Section 9.3.15, Glove and Footwear Cut Resistance Test, and shall have a distance of blade travel of more than 20 mm (0.8 in.).

8.7.14 The glove body composite shall be tested for resistance to puncture as specified in Section 9.3.14, Glove and Footwear Puncture Resistance Test, and shall not be punctured under an average applied force of 40 N (8.8 lbf).

8.7.15* Gloves shall be tested for hand function as specified in Section 9.8.4, Glove Hand Function Test, and shall have an average percent of bare-handed control not exceeding 220 percent.

8.7.16 Knit glove wristlet material(s) shall be tested for material strength as specified in Section 9.3.3, Burst Strength Test, and shall have a burst strength of not less than 225 N (51 lbf).

8.7.17 Glove body to glove interface component major seams shall be tested for seam strength as specified in Section 9.3.4, Seam-Breaking Strength Test, and shall have a burst strength of not less than 182 N (41 lbf).

8.7.18* Gloves shall be tested for resistance to leakage as specified in Section 9.5.2, Whole Glove Liquid Integrity Test 1, and shall show no leakage.

8.7.19* Gloves shall be tested for ease of donning as specified in Section 9.8.3, Glove Donning Test, and shall have the dry hand donning time not exceed 10 seconds, shall have the wet hand donning time not exceed 30 seconds, shall have no detachment of the inner liner, shall have no detachment of the moisture barrier, and shall allow full insertion of all digits.

8.7.20 Gloves shall be tested for retention of the glove liner as specified in Section 9.3.16, Liner Retention Test, and shall have no detachment of the inner liner or moisture barrier.

8.7.21 Labels shall be tested for durability and legibility as specified in Section 9.8.12, Label Durability and Legibility Test 1, shall remain in place, and shall be legible.

8.7.21.1 Nonvisual/machine-readable tags shall be tested for durability as specified in Section 9.8.12, Label Durability and Legibility Test 1, shall remain functional, including the ability to scan and read the tag according to the manufacturer's instructions.

8.7.22 Gloves shall be tested for grip as specified in Section 9.8.5, Glove Grip Test, and shall not have a drop of force of more than 30 percent in any 0.2-second interval.

8.7.23 Gloves shall be tested using the torque test as specified in Section 9.8.6, Glove Torque Test, and shall have an average percent of bare-handed control not less than 80 percent.

8.7.24 Gloves shall be tested for hand function as specified in Section 9.8.7, Glove Tool Test, and shall have an average percent of bare-handed control not exceeding 175 percent.

8.7.25 The glove body composite at the back of the glove shall be tested for radiant heat resistance as specified in Section 9.2.15, Transmitted and Stored Thermal Energy Test, and shall have a second-degree burn time of not less than 130 seconds.

8.8 Additional Performance Requirements for Structural Firefighting Protective Glove Elements Only.

8.8.1 Structural firefighting protective glove elements shall also meet the performance requirements specified in this section in addition to the performance requirements specified in Section 8.7, Protective Glove Elements Performance Requirements for Both Ensembles.

8.8.2 All glove metal hardware and all glove hardware that include metal parts shall be individually tested for resistance to corrosion as specified in Section 9.4.6, Corrosion Resistance Test, and shall have metals that are inherently resistant to corrosion including but not limited to stainless steel, brass, copper, aluminum, and zinc show no more than light surface-type corrosion or oxidation, shall have ferrous metals show no corrosion of the base metal, and shall have all hardware remain functional.

8.9 Additional Performance Requirements for Proximity Firefighting Protective Glove Elements Only.

8.9.1 Proximity firefighting protective glove elements shall also meet the performance requirements specified in this section in addition to the performance requirements specified in Section 8.7, Protective Glove Elements Performance Requirements for Both Ensembles.

8.9.2 The radiant reflective protective areas as required in Section 7.9, Additional Design Requirements for Proximity Firefighting Protective Glove Elements Only, of the glove body, glove interface component, and glove extension shall be tested for radiant reflective capability as specified in Section 9.2.14, Radiant Protective Performance Test, and shall have an intersect time of not less than 20 seconds.

8.9.3 The radiant reflective protective areas as required in Section 7.9, Additional Design Requirements for Proximity Firefighting Protective Glove Elements Only, of the glove body, glove interface component, and glove extension shall be tested for resistance to delamination as specified in Section 9.4.7, Coating/Laminate Wet Flex Test, and shall show no signs of cracking on the face or delamination.

8.9.4 The radiant reflective protective areas as required in Section 7.9, Additional Design Requirements for Proximity Firefighting Protective Glove Elements Only, of the glove body, glove interface component, and glove extension shall be tested for adhesion durability as specified in Section 9.4.8, Coating/Laminate Adhesion After Wet Flex Test, and shall show no evidence of separation or removal of the surface coating.

8.9.5 The radiant reflective protective areas as required in Section 7.9, Additional Design Requirements for Proximity Firefighting Protective Glove Elements Only, of the glove body, glove interface component, and glove extension shall be tested for flex durability as specified in Section 9.4.9, Coating/Laminate Flex Resistance at Low Temperature Test, and shall show no evidence of breaking, shattering, or cracking of the coating, laminate, or fabric.

8.9.6 The radiant reflective protective areas as required in Section 7.9, Additional Design Requirements for Proximity Firefighting Protective Glove Elements Only, of the glove body, glove interface component, and glove extension shall be tested for blocking durability as specified in Section 9.2.6, Resistance to High-Temperature Blocking Test, and shall show no blocking.

8.10 Protective Footwear Elements Performance Requirements for Both Ensembles.

8.10.1 Protective footwear elements shall be tested for thermal insulation as specified in Section 9.2.8, Conductive Heat Resistance Test 2, and the temperature of the insole surface in contact with the foot shall not exceed 44°C (111°F).

8.10.2 Footwear, with components in place, shall be tested for resistance to flame as specified in Section 9.2.3, Flame Resistance Test 4, shall not have an afterflame of more than 5.0 seconds, shall not melt or drip, and shall not exhibit any burn-through.

8.10.2.1* Components that do not contribute to the required footwear protection that demonstrate melt, drip, or burn-through (but not afterflame) shall not be considered in the evaluation of the footwear performance.

8.10.3 All sewing thread utilized in the construction of footwear shall be tested for melt resistance as specified in Section 9.2.5, Thread Melting Test, and shall not melt below 260°C (500°F).

8.10.4 The footwear upper material composite and footwear seams shall be tested for resistance to liquid penetration as specified in Section 9.4.3, Liquid Penetration Resistance Test, and shall allow no penetration of the test liquids for at least 1 hour.

8.10.5 The footwear upper material composite and footwear seams shall be tested for resistance to liquid-borne or blood-borne pathogens as specified in Section 9.4.5, Viral Penetration Resistance Test, and shall allow no penetration of the Phi-X-174 bacteriophage above the test interpretation threshold for at least 1 hour.

8.10.6 Footwear shall be tested for resistance to puncture as specified in Section 9.3.14, Glove and Footwear Puncture Resistance Test, and shall not puncture the footwear upper under an average applied force of 60 N (13 lbf).

8.10.7 Footwear uppers shall be tested for resistance to cut as specified in Section 9.3.15, Glove and Footwear Cut Resistance Test, and shall have a cut distance resistance of more than 20 mm (0.8 in.).

8.10.8 Footwear shall be tested for slip resistance as specified in Section 9.8.9, Footwear Slip Resistance Test, and shall have a coefficient of friction of 0.40 or greater.

8.10.9 Footwear soles and heels shall be tested for resistance to abrasion as specified in Section 9.3.17, Footwear Sole Abrasion Resistance Test, and the relative volume loss shall not be greater than 250 mm^3 (0.015 $in.^3$).

8.10.10* Footwear shall be tested for resistance to electricity as specified in Section 9.6.2, Electrical Insulation Test 2, and shall have no current leakage in excess of 3.0 mA.

8.10.11 Footwear ladder shanks or whole sole equivalents shall be tested for resistance to bending as specified in Section 9.8.8, Footwear Ladder Shank Bend Resistance Test, and shall not deflect more than 6 mm (¼ in.).

8.10.12 Footwear stud posts and eyelets shall be tested for attachment strength as specified in Section 9.3.18, Footwear Eyelet and Stud Post Attachment Test, and shall have a minimum detachment strength of 294 N (66 lbf).

8.10.13 All footwear metal hardware and specimens of all footwear hardware that include metal parts, including but not limited to toe cap, ladder shank, and components, shall be individually tested for resistance to corrosion as specified in Section 9.4.6, Corrosion Resistance Test, and shall have metals that are inherently resistant to corrosion, including but not limited to stainless steel, brass, copper, aluminum, and zinc, show no more than light surface-type corrosion or oxidation, shall have ferrous metals show no corrosion of the base metal, and shall have all hardware remain functional.

8.10.14 Labels shall be tested for durability and legibility as specified in Section 9.8.12, Label Durability and Legibility Test 1, shall remain in place, and shall be legible.

8.10.14.1 Nonvisual/machine-readable tags shall be tested for durability as specified in Section 9.8.12, Label Durability and Legibility Test 1, and shall remain functional, including the ability to scan and read the tag according to the manufacturer's instructions.

8.10.15 Footwear shall be tested for resistance to heat as specified in Section 9.2.4, Heat and Thermal Shrinkage Resistance Test, and shall not have any part of the footwear melt, separate, or ignite; shall show no water penetration; and shall have all components remain functional.

8.11 Additional Performance Requirements for Structural Firefighting Protective Footwear Elements Only.

8.11.1 Structural firefighting protective footwear elements shall also meet the performance requirements specified in this section in addition to the performance requirements specified in Section 8.10, Protective Footwear Elements Performance Requirements for Both Ensembles.

8.11.2 Footwear shall be tested for thermal insulation as specified in Section 9.2.11, Radiant Heat Resistance Test 1, and the temperature of the upper surface in contact with the skin shall not exceed 44°C (111°F).

8.11.3 Footwear shall be tested for thermal insulation as specified in Section 9.2.7, Conductive Heat Resistance Test 1, and the temperature of the upper lining surface in contact with skin shall have a second-degree burn time of not less than 10.0 seconds, and shall have a pain time of not less than 6.0 seconds.

8.12 Additional Performance Requirements for Proximity Firefighting Protective Footwear Elements Only.

8.12.1 Proximity firefighting protective footwear elements shall also meet the performance requirements specified in this section in addition to the performance requirements specified in Section 8.10, Protective Footwear Elements Performance Requirements for Both Ensembles.

8.12.2 Footwear shall be tested for thermal insulation as specified in Section 9.2.9, Conductive Heat Resistance Test 3, and the temperature of the upper lining surface in contact with skin shall not reach 44°C (111°F) in 10 minutes or less.

8.12.3 Footwear shall be tested for thermal insulation as specified in Section 9.2.12, Radiant Heat Resistance Test 2, and the temperature of the upper lining surface in contact with the skin shall not exceed 44°C (111°F).

8.13 Protective Hood Interface Component Performance Requirements for Both Ensembles.

8.13.1 Firefighting protective hood face openings that are not designed for interface with a specific SCBA facepiece shall be tested for shape retention as specified in Section 9.8.10, Hood Opening Size Retention Test, shall slide freely over the top half of the hood measuring device while in the relaxed state, and shall not show any gaps when placed on the lower half of the hood measuring device.

8.13.1.1 Where hood face openings are designed to interface with a specific SCBA facepiece, specimens of such hood face openings shall be tested for shape retention as specified in Section 9.8.10, Hood Opening Size Retention Test, and shall overlap the outer edge of the specific SCBA facepiece-to-face seal perimeter by not less than 13 mm (½ in.).

8.13.2 Hoods shall be tested for thermal insulation as specified in Section 9.2.16, Thermal Protective Performance (TPP) Test, and shall have an average TPP rating of not less than 20.0.

8.13.3 Hood material(s), excluding hook and pile fasteners, nonvisual/machine-readable tags, and elastic when not placed in direct contact with the body, shall be individually tested for resistance to flame as specified in Section 9.2.1, Flame Resistance Test 1, shall not have a char length of more than 100 mm (4 in.) average, shall not have an afterflame of more than 2.0 seconds average, and shall not melt and drip.

8.13.3.1 Hood labels, lettering, and emblems shall be individually tested for resistance to flame as specified in Section 9.2.1, Flame Resistance Test 1, shall not have an afterflame of more than 2.0 seconds average, shall not melt and drip, and shall not be totally consumed.

8.13.4 Hoods, excluding labels, hook and pile fasteners, nonvisual/machine-readable tags, and elastic, shall be individually tested for resistance to heat as specified in Section 9.2.4, Heat and Thermal Shrinkage Resistance Test, shall slide freely over the top half of the hood measuring device while in the relaxed state, shall not show any gaps when placed on the lower half of the hood measuring device, and shall not shrink more than 10 percent.

8.13.5 Hoods shall be individually tested for resistance to heat as specified in Section 9.2.4, Heat and Thermal Shrinkage Resistance Test, and shall not melt, separate, or ignite.

8.13.5.1 Components attached to hoods, including labels, lettering, and emblems but excluding hook and pile fasteners, nonvisual/machine-readable tags, and elastic when these items are placed where they will not directly contact the wearer's body, shall be individually tested for resistance to heat as specified in Section 9.2.4, Heat and Thermal Shrinkage Resistance Test, and shall not melt, separate, or ignite.

8.13.6 Hoods with elastic or manually adjustable face openings shall be individually tested for resistance to shrinkage as specified in Section 9.9.1, Cleaning Shrinkage Resistance Test, shall slide freely over the top half of the hood measuring device while in the relaxed state, shall not show any gaps when placed on the lower half of the hood measuring device, and shall not have the measurements made from the top of the hood to the marks at the back and both sides of the hood exhibit shrinkage of more than 5 percent.

8.13.6.1 Hoods designed to interface with a specific SCBA facepiece shall be individually tested for resistance to shrinkage as specified in Section 9.9.1, Cleaning Shrinkage Resistance Test, and the overlap of the outer edge of the hood and the specific SCBA facepiece shall not shrink more than 5 percent. The measurements from the top of the hood to the marks at the back and both sides of the hood shall not exhibit shrinkage of more than 5 percent.

8.13.7 All sewing thread used in the construction of hoods shall be tested for melting resistance as specified in Section 9.2.5, Thread Melting Test, and shall not melt below 260°C (500°F).

8.13.8 The outermost hood material shall be tested for material strength as specified in Section 9.3.3, Burst Strength Test, and shall have a burst strength of not less than 225 N (51 lbf). All additional hood material layers shall be tested for material strength as specified in Section 9.3.3, Burst Strength Test, and shall have a burst strength of not less than 225 N (51 lbf).

8.13.9 Hood seams shall be tested for seam strength as specified in Section 9.3.4, Seam-Breaking Strength Test, and shall have a burst strength of not less than 181 N (41 lbf).

8.13.10 Labels shall be tested for durability and legibility as specified in Section 9.8.12, Label Durability and Legibility Test 1, shall remain attached to the hood, and shall be legible.

8.13.10.1 Nonvisual/machine-readable tags shall be tested for durability as specified in Section 9.8.12, Label Durability and Legibility Test 1, and shall remain functional, including the ability to scan and read the tag according to the manufacturer's instructions.

8.14 Additional Performance Requirements for Structural Firefighting Protective Hood Interface Components Only.

8.14.1 Hood composite materials and seams including a particulate blocking layer shall be tested for particulate blocking as specified in Section 9.4.4, Particulate Blocking Test, and shall have a particulate filtration efficiency of 90 percent or greater for each particle size from 0.1 μm to 1.0 μm.

8.14.2 Hood composites including a particulate blocking layer shall be tested for evaporative heat transfer as specified in Section 9.7.1, Total Heat Loss (THL) Test, and shall have a THL of not less than 325 W/m^2.

8.14.3 Where the manufacturer is required to report the results in the user information, hood composite materials including a particulate blocking layer shall be tested for transmitted and stored thermal energy as specified in Section 9.2.15, Transmitted and Stored Thermal Energy Test.

8.14.4 Where the hood manufacturer is required to report the contaminant removal efficiency for semivolatile organic compounds and heavy metals in the user information, hood composites shall be evaluated for ease of cleaning as specified in 9.9.3, Contamination Removal Efficiency Tests.

8.15 Additional Performance Requirements for Proximity Firefighting Protective Hood Interface Components Only. (Reserved)

8.16 Protective Wristlet and Garment-Glove Interface Component Performance Requirements for Both Ensembles.

8.16.1 Protective wristlet interface components shall be tested for thermal insulation as specified in Section 9.2.16, Thermal Protective Performance (TPP) Test, and shall have an average TPP rating of not less than 20.0.

8.16.1.1 Where the coat sleeve end terminates in a garment-glove interface, the interface composite shall be tested for thermal insulation as specified in Section 9.2.16, Thermal Protective Performance (TPP) Test, and shall have an average TPP rating of not less than 35.0.

8.16.2 Wristlet material(s) shall be individually tested for resistance to flame as specified in Section 9.2.1, Flame Resistance Test 1, and shall not have a char length of more than 100 mm (4 in.) average, shall not have an afterflame of more than 2.0 seconds average, and shall not melt or drip.

8.16.3 Wristlet material(s) shall be individually tested for resistance to heat as specified in Section 9.2.4, Heat and Thermal Shrinkage Resistance Test, and shall not shrink more than 10 percent in any direction.

8.16.4 Wristlet material(s) shall be individually tested for resistance to heat as specified in Section 9.2.4, Heat and Thermal Shrinkage Resistance Test, and shall not melt, separate, or ignite.

8.16.5 Wristlet material(s) shall be individually tested for resistance to shrinkage as specified in Section 9.9.1, Cleaning Shrinkage Resistance Test, and shall not shrink more than 5 percent in any direction.

8.16.6 All sewing thread utilized in the construction of wristlets shall be tested for melting resistance as specified in Section 9.2.5, Thread Melting Test, and shall not melt at or below 260°C (500°F).

8.16.7 Knit wristlet material(s) shall be tested for material strength as specified in Section 9.3.3, Burst Strength Test, and shall have a burst strength of not less than 225 N (51 lbf).

8.16.8 Knit wristlet seams shall be tested for seam strength as specified in Section 9.3.4, Seam-Breaking Strength Test, and shall have a breaking strength of not less than 181 N (41 lbf).

8.16.9 Where the coat sleeve end terminates in a garment-glove interface, the interface area shall be tested in accordance with Section 9.5.1, Whole Garment and Ensemble Liquid Penetration Test, and shall allow no liquid penetration.

8.17 Additional Performance Requirements for Structural Firefighting Protective Wristlet Interface Components Only. (Reserved)

8.18 Additional Performance Requirements for Proximity Firefighting Protective Wristlet Interface Components Only. (Reserved)

8.19 Reserved.

8.20 Optional Performance Requirements for Protection from Liquid and Particulate Contaminants.

8.20.1 Liquid and Particulate Contaminant Protective Ensemble Performance Requirements for Both Ensembles. (Reserved)

8.20.2 Additional Liquid and Particulate Contaminant Protection Performance Requirements for Structural Firefighting Protective Ensembles Only. (Reserved)

8.20.3 Additional Liquid and Particulate Contaminant Protection Performance Requirements for Proximity Firefighting Protective Ensembles Only. (Reserved)

8.20.4 Liquid and Particulate Contaminant Protective Garment Element Performance Requirements for Both Ensembles.

8.20.4.1 Liquid and particulate contaminant garments shall meet the performance requirements of 8.20.4 in addition to meeting the performance requirements as specified in Section 8.1, Protective Garment Elements Performance Requirements for Both Ensembles, and Section 8.2, Additional Performance Requirements for Structural Firefighting Protective Garment Elements Only, or in Section 8.3, Additional Performance Requirements for Proximity Firefighting Protective Garment Elements Only.

8.20.4.2 The protective garment shall be tested for overall particulate inward leakage with other ensemble elements as specified in Section 9.5.3, Particle Inward Leakage Test, and shall allow no visual particulate inward leakage on the test subject black indicator garment.

8.20.4.3 The protective garments shall be tested as specified in Section 9.5.1, Whole Garment and Ensemble Liquid Penetration Test, and shall show no liquid penetration.

8.20.5 Additional Liquid and Particulate Contaminant Protection Performance Requirements for Structural Firefighting Protective Garment Elements Only. (Reserved)

8.20.6 Additional Liquid and Particulate Contaminant Protection Performance Requirements for Proximity Firefighting Protective Garment Elements Only. (Reserved)

8.20.7 Protective Helmet Element Liquid and Particulate Contaminant Protection Performance Requirements for Both Ensembles. (Reserved)

8.20.8 Additional Liquid and Particulate Contaminant Protection Performance Requirements for Structural Firefighting Protective Helmet Elements Only. (Reserved)

8.20.9 Additional Liquid and Particulate Contaminant Protection Performance Requirements for Proximity Firefighting Protective Helmet Elements Only. (Reserved)

8.20.10 Protective Glove Elements Liquid and Particulate Contaminant Protection Performance Requirements for Both Ensembles. (Reserved)

8.20.11 Additional Liquid and Particulate Contaminant Protection Performance Requirements for Structural Firefighting Protective Glove Elements Only. (Reserved)

8.20.12 Additional Liquid and Particulate Contaminant Protection Performance Requirements for Proximity Firefighting Protective Glove Elements Only. (Reserved)

8.20.13 Protective Footwear Elements Liquid and Particulate Contaminant Protection Performance Requirements for Both Ensembles. (Reserved)

8.20.14 Additional Liquid and Particulate Contaminant Protection Performance Requirements for Structural Firefighting Protective Footwear Elements Only. (Reserved)

8.20.15 Additional Liquid and Particulate Contaminant Protection Performance Requirements for Proximity Firefighting Protective Footwear Elements Only. (Reserved)

8.20.16 Protective Hood Interface Component Liquid and Particulate Contaminant Protection Performance Requirements for Both Ensembles. (Reserved)

8.20.17 Additional Liquid and Particulate Contaminant Protection Performance Requirements for Structural Firefighting Protective Hood Interface Components Only. (Reserved)

8.20.18 Additional Liquid and Particulate Contaminant Protection Performance Requirements for Proximity Firefighting Protective Hood Interface Components Only. (Reserved)

8.21* Acceptable Levels of Restricted Substances in Specified Protective Element Recognized Components. Components that are required to be certified for individual protective elements shall meet the acceptable restricted substances as established in Table 8.21(a) when tested as specified in 9.10.1, Test Method for Acceptable Levels of Specific Restricted Substances, subject to the following applications or exceptions:

(1) Testing for acetophenone and 2-Phenyl-2-propanol shall only be applied to polymers that contain ethylene vinyl acetate.
(2) Testing for acidic or alkaline substances (pH) shall be excluded for materials and components that are plastics, rubber, or polymers.
(3) Testing for azo-amines and aryl amine salts shall be excluded for materials and components that are plastics, rubber, or polymers.
(4) Testing for bisphenols shall only be applied to materials and components that are plastics, rubber, or polymers, including elastomers.
(5) Testing for chlorobenzenes and chlorotoluenes shall only be applied to materials and components that include synthetic fibers, natural and synthetic fiber blends, or artificial leather.
(6) A maximum level of 30 mg/kg of 1,2-Dichlorobenzene shall be permitted when C.I. Pigment Violet 23 (CAS No. 6358-30-1), Yellow 93 (CAS No. 5580-57-4), Orange 61 (CAS No. 40716-47), and Red 214 (CAS No. 82643-43-4) solution-dyed fibers are used.
(7) Testing for chlorinated paraffins shall be excluded for materials that include natural or synthetic fibers.
(8) Testing for chlorophenols shall be only applied to materials and components that include natural fibers, synthetic fibers, or natural and synthetic fiber blends.
(9) Testing for dyes shall only be applied to materials and components that include synthetic fibers or natural and synthetic fiber blends.
(10) Testing for formaldehyde shall be excluded for materials and components that are plastics or polymers.

(11) Testing for heavy metal Chromium VI shall be only applied to materials and components that consist of natural fibers or synthetic fibers.
(12) Testing for total heavy metal content that includes arsenic, cadmium, lead, and mercury shall be excluded for materials and components that include synthetic fibers.
(13) Testing for monomers shall be only applied to materials and components that include artificial leather or are plastics, rubber, and polymers.
(14) Testing for nitrosamines shall be only applied to materials and components that are rubber.
(15) Testing for ortho-phenylphenol shall be excluded for materials and components that are plastics, rubber, or polymers.
(16) Testing for phthalates shall be excluded for materials and components that include natural fibers, synthetic fibers, and natural and synthetic fiber blends.
(17) Testing for polycyclic aromatic hydrocarbons shall be excluded for materials and components that include natural fibers, synthetic fibers, and natural and synthetic fiber blends.
(18) Testing for quinoline shall be applied to materials and components that include synthetic fibers or natural and synthetic fiber blends.
(19) Testing for solvent residuals shall be applied to materials and components that include synthetic coated fabrics or artificial leather or that are polyurethane-based plastics or polymers.
(20) A maximum level of 1000 mg/kg for Dimethylacetamide (DMAC), Dimethylformamide (DMF), and N-Methyl-2-pyrrolidone (NMP) shall be permitted for materials made of acrylic, elastane, polyurethane, polyimide, aramids, and coated textiles.
(21) A maximum level of 3.0 weight percent for Dimethylacetamide (DMAC), Dimethylformamide (DMF), and N-Methyl-2-pyrrolidone (NMP) shall be permitted for material products that must undergo further industrial production stages, such as fibers that are spun with the aid of DMAC, DMF, or NMP.
(22) Testing for UV stabilizers shall be applied to materials and components that include plastics, rubber, or polymers.
(23) Testing for volatile organic compounds shall be applied to materials and components that include artificial leather or are polyurethane-based plastics or polymers.
(24) Perfluorinated and polyfluorinated alkyl substances shall be tested in relevant materials and components for both total PFAS and individual PFAS chemicals.

Table 8.21(a) Acceptable Levels of Restricted Substances in Specified Protective Element Recognized Components

Chemical Class or Group	Restricted Substance(s)	Maximum Level
Acetophenone and 2-Phenyl-2-propanol	Acetophenone and 2-Phenyl-2-propanol	10 mg/kg
Acidity and alkaline substances	Measured by reporting pH	Acceptable range 4.0–7.5
Akyl phenols and ethoxylates	Sum of 4-tert butylphenol, nonylphenol, octylphenol, heptaphenol, and pentylphenol	10.0 mg/kg
	Sum of 4-tert butylphenol, nonylphenol, octylphenol, heptaphenol, pentylphenol, nonylphenolethoxylates, and octylphenol-ethoxylates	100.0 mg/kg
Azo-amines and aryl amine salts	Each individual substance in Table 8.21(b)	20 mg/kg
Bisphenols	Bisphenol A, Bisphenol B, and Bisphenol S, each	1000 mg/kg
Chlorinated benzenes and toluenes	Sum of all chemicals in Table 8.21(c), except Chlorobenzene	1.0 mg/kg
	Chlorobenzene	30 mg/kg[a]
Chlorinated paraffins	Short-chain chlorinated paraffins (SCCPs) (C10–C13)	1000 mg/kg
Chlorinated phenols	Pentachlorophenol	0.5 mg/kg
	Tetrachlorophenols	0.5 mg/kg
	Trichlorophenols	2.0 mg/kg
	Dichlorophenols	3.0 mg/kg
	Monochlorophenols	3.0 mg/kg
Dyes	Each individual substance in Table 8.21(d)	50 mg/kg
	Navy blue	Not present
Flame retardants	Each individual substance in Table 8.21(e)	10 mg/kg
	Sum of all chemicals in Table 8.21(e)	50 mg/kg
Formaldehyde	Free and partially releasable	75 mg/kg
Heavy metals, extractable	Antimony	30.0 mg/kg
	Arsenic	1.0 mg/kg
	Barium	1000 mg/kg
	Cadmium	0.1 mg/kg
	Chromium	2.0 mg/kg
	Chromium VI	0.5 mg/kg
	Cobalt	4.0 mg/kg
	Copper	50.0 mg/kg
	Lead	1.0 mg/kg
	Mercury	0.02 mg/kg
	Nickel	4.0 mg/kg
	Selenium	100 mg/kg
Heavy metals, total content	Arsenic	100 mg/kg
	Cadmium	40.0 mg/kg
	Lead	90.0 mg/kg
	Mercury	0.5 mg/kg
Monomers	Styrene	0.005 kg/m^3
	Vinyl chloride	0.002 kg/m^3
Nitrosamines	Each individual substance in Table 8.21(f)	0.5 mg/kg
	Sum of N-nitrosatable substances	5 mg/kg
Organotin compounds	Tributyltin (TBT)	1.0 mg/kg
	Triphenyltin (TPhT)	1.0 mg/kg
	Each individual substance in Table 8.21(g)	2.0 mg/kg
Ortho-phenylphenol	Ortho-phenylphenol	25 mg/kg

(continues)

Table 8.21(a) ***Continued***

Chemical Class or Group	Restricted Substance(s)	Maximum Level
Perfluorinated and polyfluorinated alkyl substances (PFC/PFAS)	Total fluorine content [includes non-PFAS]	Report
	Sum of C9-C14 PFCA-related substances	260 µg/kg
	Sum of PFOS, PFOSA, PFOSF, N-Me-FOSA, N-Et-FOSA, N-Me-FOSE, NEt-FOSE	1 µg/m^2
	Each and sum of PFHpA, PFNA, PFDA, PFUdA, PFDoA, PFTrDA, PFTeDA and further perfluorinated carboxylic acids in Table 8.21(j)	25 µg/kg
	Sum of perfluorinated sulfonic acids in Table 8.21(j)	250 µg/kg
	Each partially fluorinated carboxylic/sulfonic acids in Table 8.21(j)	250 µg/kg
	Sum of partially fluorinated linear alcohols in Table 8.21(j)	250 µg/kg
	Sum of esters of fluorinated alcohols with acrylic acid in Table 8.21(j)	250 µg/kg
	Sum of PFOA and salts	25 µg/kg
	Sum of PFOA-related substances	250 µg/kg
Phthalates	Sum of substances listed in Table 8.21(h)	500 mg/kg
Polycyclic aromatic hydrocarbons (PAH)	Benzo(a)pyrene	1.0 mg/kg
	Benzo(e)pyrene	1.0 mg/kg
	Benzo(a)anthracene	1.0 mg/kg
	Chrysene	1.0 mg/kg
	Benzo(b)fluoroanthrene	1.0 mg/kg
	Benzo(j)fluoroanthrene	1.0 mg/kg
	Benzo(k)fluoroanthrene	1.0 mg/kg
	Dibenzo(a,h)anthracene	1.0 mg/kg
	Sum of substances listed in Table 8.21(i)	10.0 mg/kg
Quinoline	Quinoline	50.0 mg/kg
Solvent residues	Dimethylacetamide (DMAC)	500 mg/kg 1000 mg/kg[b]
	Dimethylformamide (DMF)	500 mg/kg 1000 mg/kg[b] 3.0%[c]
	Formamide	1000 mg/kg
	N-Methyl-2-Pyrrolidone (NMP)	500 mg/kg 1000 mg/kg[b] 3.0%[c]
UV absorbers or stabilizers	2-Benzotriazol-2-yl-4,6-di-tert-butylphenol (UV 320)	1000 mg/kg
	2,4-Di-tert-butyl-6-(5-chlorobenzotriazol-2-yl) phenol (UV 327)	1000 mg/kg
	2-(2H-Benzotriazol-2-yl)-4,6-di-tert-penthylphenol (UV 328)	1000 mg/kg
	2-(2H-Benzotriazol-2-yl)-4-(tert-butyl)-6-(sec-butyl)phenol (UV 350)	1000 mg/kg
Volatile organic compounds (VOCs)	Benzene	5 mg/kg
	Each VOC listed in Table 8.21(k)	10 mg/kg

[a]A maximum level of 30 mg/kg of 1,2-Dichlorobenzene applies when C.I. Pigment Violet 23 (CAS No. 6358-30-1), Yellow 93 (CAS No. 5580-57-4), Orange 61 (CAS No. 40716-47), and Red 214 (CAS No. 82643-43-4) solution-dyed fibers are used *[see 8.21 (6)]*.
[b]A maximum level of 1000 mg/kg applies to materials made of acrylic, elastane, polyurethane, polyimide, aramids, and coated textiles *[see 8.21(20)]*.
[c]A maximum level of 3.0 weight percent applies to material products that must undergo further industrial production stages, such as fibers that are spun with the aid of DMAC, DMF, or NMP *[see 8.21(21)]*.

Table 8.21(b) List of Restricted Azo-amines and Aryl Amine Salts

Azo-amine or Aryl Amine Salt Chemical	CAS Number
4-Aminobiphenyl	92-67-1
Benzidine	92-87-5
4-Chloro-o-toluidine	95-69-2
2-Naphthylamine	91-59-8
o-Aminoazotoluene	97-56-3
2-Amino-4-nitrotoluene	99-55-8
p-Chloraniline	106-47-8
2,4-Diaminoanisole	615-05-4
4,4'-Diaminodiphenylmethane	101-77-9
3,3'-Dichlorobenzidine	91-94-1
3,3'-Dimethoxybenzidine	119-90-4
3,3'-Dimethylbenzidine	119-93-7
3,3'-dimethyl-4,4'-diaminodiphenylmethane	838-88-0
p-Cresidine	120-71-8
4,4'-Methylen-bis(2-chloraniline)	101-14-4
4,4'-Oxydianiline	101-80-4
4,4'-Thiodianiline	139-65-1
o-Toluidine	95-53-4
2,4-Toluenediamine	95-80-7
2,4,5-Trimethylaniline	137-17-7
2,4 Xylidine	95-68-1
2,6 Xylidine	87-62-7
2-Methoxyaniline (= o-Anisidine)	90-04-0
p-Aminoazobenzene	60-09-3
4-Chloro-o-toluidinium chloride	3165-93-3
2-Naphthylammoniumacetate	553-00-4
4-Methoxy-m-phenylene diammonium sulphate	39156-41-7
2,4,5-Trimethylaniline hydrochloride	21436-97-5

Table 8.21(c) List of Restricted Chlorinated Benzenes and Toluenes

Chlorinated Benzene or Toluene Chemical	CAS Number
2-Chlorotoluene	95-49-8
3-Chlorotoluene	108-41-8
4-Chlorotoluene	106-43-4
2,3-Dichlorotoluene	32768-54-0
2,4-Dichlorotoluene	95-73-8
2,5-Dichlorotoluene	19398-61-9
2,6-Dichlorotoluene	118-69-4
3,4-Dichlorotoluene	95-75-0
3,5-Dichlorotoluene	25186-47-4
2,3,5-Trichlorotoluene	56961-86-5
2,3,6-Trichlorotoluene	2077-46-5
2,4,5-Trichlorotoluene	6639-30-1
3,4,5-Trichlorotoluene	21472-86-6
2,4,6-Trichlorotoluene	23479-65-7
2,3,4,5-Tetrachlorotoluene	76057-12-0
2,3,4,6-Tetrachlorotoluene	875-40-1
2,3,5,6-Tetrachlorotoluene	1006-31-1
2,3,4,5,6-Pentachlorotoluene	877-11-2
1,2-Dichlorobenzene	95-50-1
1,3-Dichlorobenzene	541-73-1
Dichlorobenzenes	25321-22-6
1,4-Dichlorobenzene	106-46-7
1,2,3-Trichlorobenzene	87-61-6
1,2,4-Trichlorobenzene	120-82-1
1,3,5-Trichlorobenzene	108-70-3
Trichlorobenzenes	12002-48-1
1,2,3,4-Tetrachlorobenzene	634-66-2
1,2,3,5-Tetrachlorobenzene	634-90-2
1,2,4,5-Tetrachlorobenzene	95-94-3
Pentachlorobenzene	608-93-5
Hexachlorobenzene	118-74-1
p-Chlorobenzotrichloride	5216-25-1
Benzotrichloride	98-07-7
Benzyl chloride	100-44-7

Table 8.21(d) List of Restricted Dyes

Dye Chemical	CAS Number
C.I. Acid Red 26	3761-53-3
C.I. Acid Red 114	6459-94-5
C.I. Basic Blue 26	2580-56-5
C.I. Basic Green 4	569-4-2, 10309-95-2, and 2437-29-8
C.I. Basic Red 9	569-61-9
C.I. Basic Violet 3	548-62-9
C.I. Basic Violet 14	632-99-5
C.I. Basic Yellow 2	2465-27-2 and 492-80-9
C.I. Direct Black 38	1937-37-7
C.I. Direct Blue 6	2602-46-2
C.I. Direct Blue 15	2429-74-5
C.I. Direct Brown 95	16071-86-6
C.I. Direct Red 28	573-58-0
C.I. Disperse Blue 1	2475-45-8
C.I. Disperse Blue 3	2475-46-9
C.I. Disperse Blue 7	3179-90-6
C.I. Disperse Blue 26	3860-63-7
C.I. Disperse Blue 35	12222-75-2
C.I. Disperse Blue 102	12222-97-8
C.I. Disperse Blue 106	12223-01-7
C.I. Disperse Blue 124	61951-51-7
C.I. Disperse Brown 1	23355-64-8
C.I. Disperse Orange 1	2581-69-3
C.I. Disperse Orange 3	730-40-5
C.I. Disperse Orange 11	82-28-0
C.I. Disperse Orange 37/59/76	12223-33-5, 13301-61-6, and 51811-42-8
C.I. Disperse Orange 149	85136-74-9
C.I. Disperse Red 1	2872-52-8
C.I. Disperse Red 11	2872-48-2
C.I. Disperse Red 17	3179-89-3
C.I. Disperse Red 60	12223-37-9 and 17418-58-5
C.I. Disperse Yellow 1	119-15-3
C.I. Disperse Yellow 3	2832-40-8
C.I. Disperse Yellow 9	6373-73-5
C.I. Disperse Yellow 23	6250-23-3
C.I. Disperse Yellow 49	54824-37-2
C.I. Pigment Red 104 (lead chromate molybdate sulphate red)	12656-85-8
C.I. Pigment Yellow 34 (lead sulfochromate yellow)	1344-37-2
C.I. Solvent Blue 4	6786-83-0
C.I. Solvent Yellow 1 (4-Aminoazobenzene)	60-09-2
C.I. Solvent Yellow 3 (2-Aminoazobenzene)	97-56-3
4,4'-bis(dimethylamino)-4''-(methylamino)trityl alcohol	561-41-1

Table 8.21(e) List of Restricted Flame Retardant Substances

Flame Retardant Chemical	CAS Number
Decabromodiphenyl ethane (DBDPE)	84852-53-9
Pentabromodiphenyl ether (PentaBDE)	32534-81-9
Octabromodiphenyl ether (OctaBDE)	32536-52-0
Decabromodiphenyl ether (DecaBDE)	1163-19-5
All other polybrominated diphenyl ethers (PBDEs)	Various
Tetrabromobisphenol A (TBBP A)	79-94-7
Polybromobiphenyls (PBB)	59536-65-1
Hexabromocyclododecane (HBCDD)	3194-55-6
2,2-bis(bromomethyl)-1,3-propanediol (BBMP)	3296-90-0
Tris(1,3-dichloro-isopropyl) phosphate (TDCPP)	13674-87-8
Trixylyl phosphate (TXP)	25155-23-1
Tris(2,3,-dibromopropyl) phosphate (TRIS)	126-72-7
Tris(1-aziridinyl)phosphine oxide) (TEPA)	545-55-1
Tris(2-chloroethyl)phosphate (TCEP)	115-96-8
Bis(2,3-dibromopropyl) phosphate (BIS)	5412-25-9

Table 8.21(f) List of Restricted Nitrosamines

Nitrosamine Chemical	CAS Number
N-nitrosodimethylamine (NDMA)	62-75-9
N-nitrosodiethylamine (NDEA)	55-18-5
N-nitrosodipropylamine (NDPA)	621-64-7
N-nitrosodibutylamine (NDBA)	924-16-3
N-nitrosopiperidine (NPIP)	100-75-4
N-nitrosopyrrolidine (NPYR)	930-55-2
N-nitrosomorpholine (NMOR)	59-89-2
N-nitroso N-methyl N-phenylamine (NMPhA)	614-00-6
N-nitroso N-ethyl N-phenylamine (NEPhA)	612-64-6

Table 8.21(g) List of Restricted Organotin Substances

Organotin Chemical	CAS Number
Dibutyltin (DBT)	Various
Dimethyltin (DMT)	Various
Dicotyltin (DOT)	Various
Diphenyltin (DPhT)	Various
Dipropyltin (DPT)	Various
Monobutyltin (MBT)	Various
Monooctyltin (MOT)	Various
Monomethyltin (MMT)	Various
Monophenyltin (MPhT)	Various
Tetrabutyltin (TeBT)	Various
Tetraethyltin (TeET)	Various
Tetraoctyltin (TeOT)	Various
Tricylohexyltin (TCyHT)	Various
Trimethyltin (TMT)	Various
Trioctyltin (TOT)	Various
Triproyltin (TPT)	Various

Table 8.21(h) List of Restricted Phthalate Substances

Phthalate Chemical	CAS Number
Butylbenzylphthalate (BBP)	85-68-7
Dibutylphthalate (DBP)	84-74-2
Diethylphthalate (DEP)	84-66-2
Dimethylphthalate (DMP)	131-11-3
Di-(2-ethylhexyl)-phthalate (DEHP)	117-81-7
Di-(2-methoxyethyle)-phthalate (DMEP)	117-82-8
Di-C6-8 branched alkylphthalates (DIHP)	71888-89-6
Di-C7-11 branched and linear alkylphthalates (DHNUP)	68515-42-4
Di-cyclohexyl phthalate (DCHP)	84-61-7
Di-hexylphthalates, branched and linear (DHxP)	68515-50-4
Di-iso-butylphthalate (DIBP)	84-69-5
Di-iso-hexyl phthalate (DIHxP)	71850-09-4
Di-iso-octyl phthalate (DIOP)	27554-26-3
Di-iso-nonylphthalate (DINP)	28553-12-0, 68515-48-0
Di-iso-decylphthalate (DIDP)	26761-40-0, 68515-49-1
Di-n-propyl phthalate (DPrP)	131-16-8
Di-n-hexylphthalate (DHP)	84-75-3
Di-n-octylphthalate (DNOP)	117-84-0
Di-n-nonylphthalate (DNP)	84-76-4
Di-n-pentyl phthalate (DPP)), also iso- or mixed	131-18-0, 605-50-5, 776297-69-9, and 84777-06-0
1,2-Benzenedicarboxylic acid, di-C6-10-alkyl esters	68515-51-5
1,2-Benzenedicarboxylic acid, mixed decyl and hexyl and octyl diesters	68648-93-1

Table 8.21(i) List of Restricted Polycyclic Aromatic Hydrocarbon (PAH) Substances

PAH Chemical	CAS Number
Acenaphtene	83-32-9
Acenaphthylene	208-96-8
Anthracene	120-12-7
Benzo[a]anthracene	56-55-3
Benzo[a]pyrene	50-32-8
Benzo[b]fluoranthene	205-99-2
Benzo[e]pyrene	192-97-2
Benzo[g,h,i]perylene	191-24-2
Benzo[j]fluoranthene	205-82-3
Benzo(k)fluoranthene	207-08-9
Chrysene	218-01-9
Cyclopenta[c,d]pyrene	27208-37-3
Dibenzo[a,h]anthracene	53-70-3
Dibenzo[a,e]pyrene	192-65-4
Dibenzo[a,h]pyrene	189-64-0
Dibenzo[a,i]pyrene	189-55-9
Dibenzo[a,l]pyrene	191-30-0
Fluoranthene	206-44-0
Fluorene	86-73-7
Indeno(1,2,3-cd)pyrene	193-39-5
1-Methylpyrene	2381-21-7
Naphthalene	91-20-3
Phenanthrene	85-01-8
Pyrene	129-00-0

Table 8.21(j) List of Perfluorinated and Polyfluorinated Compounds (PFCs)

PFC Chemical	CAS Number	Acronym
C9-C14 PFCA-related substances		
Perfluorooctane sulfonic acid and sulfonates	1763-23-1, et. al.	PFOS
Perfluorooctane sulfonamide	754-91-6	PFOSA
Perfluorooctane sulfonfluoride	307-35-7	PFOSF/POSF
N-Methyl perfluorooctane sulfonamide	31506-32-8	N-Me-FOSA
N-Ethyl perfluorooctane sulfonamide	4151-50-2	N-Et-FOSA
N-Methyl perfluorooctane sulfonamide ethanol	24448-09-7	N-Me-FOSE
N-Ethyl perfluorooctane sulfonamide ethanol	1691-99-2	N-Et-FOSE
Perfluoroheptanoic acid and salts	375-85-9, et al.	PFHpA
Perfluorooctanoic acid and salts	335-67-1, et al.	PFOA
Perfluorononanoic acid and salts	375-95-1, et al.	PFNA
Perfluorodecanoic acid and salts	335-76-2, et al.	PFDA
Henicosafluoroundecanoic acid and salts	2058-94-8, et al.	PFUdA
Tricosafluorododecanoic acid and salts	307-55-1, et al.	PFDoA
Pentacosafluorotridecanoic acid and salts	72629-94-8, et al.	PFTrDA
Heptacosafluorotetradecanoic acid and salts	376-06-7, et al.	PFTeDA
Further perfluorinated carboxylic acids		
Perfluorobutanoic acid and salts	375-22-4, et al.	PFBA
Perfluoropentanoic acid and salts	2706-90-3, et al.	PFPeA
Perfluorohexanoic acid and salts	307-24-4, et al.	PFHxA
Perfluoro(3,7-dimethyloctanoic acid) and salts	172155-07-6, et al.	PF-3,7-DMOA
Perfluorinated carboxylic and sulfonic acids under observation		
2,3,3,3-tetrafluoro-2-(heptafluoro propoxy) propionic acid, its various salts and its acyl halides	various	
Perfluorinated sulfonic acids		
Perfluorobutane sulfonic acid and salts	375-73-5, 59933-66-3, et al.	PFBS
Perfluorohexane sulfonic acid and salts	355-46-4, et al.	PFHxS
Perfluoroheptane sulfonic acid and salts	375-92-8, et al.	PFHpS
Henicosafluorodecane sulfonic acid and salts	335-77-3, et al.	PFDS
Partially fluorinated carboxylic/sulfonic acids		
7H-Perfluoro heptanoic acid and salts	1546-95-8, et al.	7HPFHpA
2H,2H,3H,3H-Perfluoroundecanoic acid and salts	34598-33-9, et al.	4HPFUnA
1H,1H,2H,2H-Perfluorooctane sulfonic acid and salts	27619-97-2, et al.	6:2 FTS
PFOA-related substances		
1H,1H,2H,2H-Perfluordecyl acrylate	27905-45-9	8:2 FTA
1H,1H,2H,2H-Perfluoro-1-decanol	678-39-7	8:2 FTOH
1H,1H,2H,2H-Perfluorodecanesulphonic acid and its salts	39108-34-4, et al.	8:2 FTS
Partially fluorinated linear alcohols		
1H,1H,2H,2H-Perfluoro-1-decanol	678-39-7	8:2 FTOH
1H,1H,2H,2H-Perfluoro-1-dodecanol	865-86-1	10:2 FTOH
Esters of fluorinated alcohols with acrylic acid		
1H,1H,2H,2H-Perfluorooctyl acrylate	17527-29-6	6:2 FTA
1H,1H,2H,2H-Perfluorodecyl acrylate	27905-45-9	8:2 FTA
1H,1H,2H,2H-Perfluorododecyl acrylate	17741-60-5	10:2 FTA

Table 8.21(k) List of Restricted Volatile Organic Compounds

Volatile Organic Compound	CAS Number
Carbon disulfide	71-43-2
Carbon tetrachloride	75-15-0
Chloroform	67-66-3
Cyclohexanone	108-94-1
1,2-Dichloroethane	107-06-2
1,2-Dichlorethylene	75-35-4
Ethylbenzene	100-41-4
Pentachloroethane	76-01-7
1,1,1,2-Tetrachloroethane	630-20-6
1,1,2,2-Tetrachloroethane	73-34-5
Tetrachloroethylene	127-18-4
Toluene	108-88-3
1,1,1-Trichloroethane	71-55-6
1,1,2-Trichloroethane	79-00-5
Trichloroethylene	79-01-6
Xylenes (meta-, ortho-, para-)	1330-20-7, 108-38-3, 95-47-6, and 106-24-3

Chapter 9 Test Methods (NFPA 1971)

9.1* Sample Preparation Procedures.

9.1.1 Application.

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

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

9.1.2 Top-Loading Washing and Drying Procedure.

9.1.2.1 Unless otherwise specified, specimens shall be subjected to five cycles of washing and drying in accordance with the procedure specified in Machine Cycle 1, Wash Temperature V, and Drying Procedure Ai of AATCC LP1, *Home Laundering: Machine Washing*. A 1.82 kg ± 0.1 kg (4.0 lb ± 0.2 lb) load shall be used. A laundry bag shall not be used.

9.1.2.2 Gloves shall be tumble dried for 60 minutes and removed immediately at the end of the drying cycle. At the conclusion of the final drying cycle, the gloves shall be direct dried on a forced-air non-tumble-drying mechanism operated at 10°C ± 5°C (18°F ± 9°F) above current room temperature for at least 8 hours and until dry.

9.1.3 Room Temperature Conditioning Procedure for Garments, Trim, Helmets, Gloves, Footwear, and Faceshield/Goggle Components.

9.1.3.1 Garment, glove, trim, and footwear samples shall be conditioned at a temperature of 21°C ± 3°C (70°F ± 5°F) and a relative humidity of 65 percent ± 5 percent until equilibrium is reached, as determined in accordance with ASTM D1776/D1776M, *Standard Practice for Conditioning and Testing Textiles*, or for at least 24 hours. Specimens shall be tested within 5 minutes after removal from conditioning.

9.1.3.2 Helmet and faceshield/goggle component samples shall be conditioned at a temperature of 21°C ± 3°C (70°F ± 5°F) and a relative humidity of 25 percent to 50 percent for at least 4 hours. Specimens shall be tested within 5 minutes after removal from conditioning.

9.1.4 Low Temperature Environmental Conditioning Procedure for Helmets and Faceshield/Goggle Components. Samples shall be conditioned by exposing them to a temperature of −32°C ± 1°C (−25°F ± 2°F) for at least 4 hours. The impact/penetration test shall be completed within 15 seconds ± 5 seconds after removal from the cold temperature environment, or the specimens shall be reconditioned before testing.

9.1.5 Convective Heat Conditioning Procedure for Helmets, Faceshield/Goggle Components, Gloves, Footwear, Moisture Barriers, Moisture Barrier Seams, Labels, Particulate Blocking Layer(s), Trim, and Outer Shells. Samples shall be conditioned by exposing them to the procedures specified in 9.2.4.4 and 9.2.4.5.2 through 9.2.4.5.3, with the following modifications:

(1) The oven temperature shall be stabilized at 140°C, +6/−0°C (285°F, +10°/−0°F), and the test exposure time shall be 10 minutes, +15/−0 seconds for the following:
    (a) Helmets
    (b) Footwear
    (c) Moisture barriers
    (d) Moisture barrier seams
    (e) Labels
    (f) Particulate blocking layers
    (g) Trim
    (h) Outer shells for conditioning in accordance with 9.1.21
(2) The oven temperature shall be stabilized at 177°C, +6/−0°C (350°F, +10°/−0°F), for gloves only; the exposure time shall be 10 minutes, +15/−0 seconds; and the procedures specified in 9.2.4.13.4 shall be followed.
(3) The exposure time shall begin when the test thermocouple reading has stabilized at the required exposure temperature.
(4) The requirements of 9.2.4.5.4 and 9.2.4.5.6 shall be disregarded.
(5) Helmet specimens shall be placed on a room temperature nonconductive headform conforming to the dimensions in Figure 9.2.4.12.3 before being placed in the oven. After oven exposure, the required testing shall be performed within 15 seconds ± 5 seconds, or the specimen shall be discarded and a new specimen shall be conditioned and tested as specified in this subsection. Only one helmet shall be conditioned at a time.
(6) For gloves, footwear, trim, labels, moisture barriers, and moisture barrier seam specimens, the required conditioning shall be performed no sooner than 24 hours after removal from conditioning. Samples shall be suspended in the oven such that there is a distance of at least 150 mm (6 in.) between items.
(7) For faceshield/goggle components, the components shall be attached to the helmet and conditioned by placing them on a room temperature, solid, nonmetallic headform conforming to the dimensions in Figure 9.2.4.12.3 and exposing them to a temperature of 108°C, +2/−0°C (225°F, +3/−0°F), for 20 minutes, +15/−0 seconds. Goggles shall be permitted to be placed directly on the headform without being attached to the helmet. The impact test shall be completed within 15 seconds ± 5 seconds, after removal from the environmental chamber, or the faceshield/goggle components shall be reconditioned and retested.
(8) The oven temperature shall be stabilized at 177°C, +6/−0°C (350°F, +10/−0°F), for glove moisture barriers, and the exposure time shall be 10 minutes, +15/−0 seconds. The glove moisture barrier sample pouch shall be filled to capacity with nominal 4 mm (5⁄32 in.) sized perforated soda-lime or borosilicate glass beads. The beads shall be room temperature. The opening of the pouch shall be folded over and clamped together, and the specimen shall be suspended by the clamp in the oven so that the entire specimen is not less than 50 mm (2 in.) from any oven surface and not less than 150 mm (6 in.) from any other specimen, and so that airflow is parallel to the plane of the material. Not more than three samples shall be placed in the test oven at one time. The samples shall be suspended such that each sample is the same distance from the airflow source, so that no sample is blocking the airflow to other samples.

9.1.6 Radiant and Convective Heat Environmental Conditioning Procedure for Helmets.

9.1.6.1 Sample helmets shall be conditioned by exposing the area to be impacted/penetrated to a radiant heat source. The top, sides, front, and back test areas to be impacted/penetrated shall be as specified in Figure 9.1.6.1.

9.1.6.2 The area to be impacted/penetrated shall be exposed to an irradiance of 1.0 W/cm^2 ± 0.1 W/cm^2, for a length of time determined by exposure of a radiant heat transducer. The heat source shall be removed and the helmet shall be tested. The helmet shall be impacted/penetrated in 15 seconds ± 5 seconds, after removal from the conditioning environment, or the helmet shall be cooled to room temperature and reconditioned before testing.

9.1.6.3 The radiometer shall be a Schmidt-Boelter or Gardon-type radiant heat flux transducer with a diameter of 25 mm, a minimum viewing angle of 150 degrees, a minimum spectral response flat within 3 percent over a range of at least 1.0 to 10.0 μm, and an overall accuracy of at least ±5 percent of the reading.

9.1.6.4 The radiant panel shall have an effective radiating surface of 150 mm ± 6 mm (6 in. ± 0.25 in.) square. The spectral radiant emittance curve of the radiant panel shall be that of a black body at a temperature of 1000°K ± 200°K (1340°F ± 360°F).

9.1.6.5 The radiant heat transducer shown in Figure 9.1.6.5 shall be constructed from sheet copper, ASTM B152/B152M, *Specification for Copper Sheet, Strip Plate, and Rolled Bar,* Type 110 ETP, half hard, 0.64 mm ± 0.05 mm (0.025 in. ± 0.002 in.), thick and 50 mm ± 0.5 mm (2 in. ± 1⁄64 in.) square. A constantan wire 0.81 mm ± 0.05 mm (0.032 in. ± 0.002 in.) in diameter and an iron wire of the same diameter shall be silver soldered 15 mm ± 1 mm (0.6 in. ± 0.39 in.) from the edges of the copper sheet on the same side, as shown in Figure 9.1.6.5. The side of the copper sheet opposite that with the wires attached shall be painted flat black. The resulting transducer is a Type J thermocouple that shall be used in conjunction with appropriate instrumentation to monitor the heat exposure to which the helmet is to be subjected.

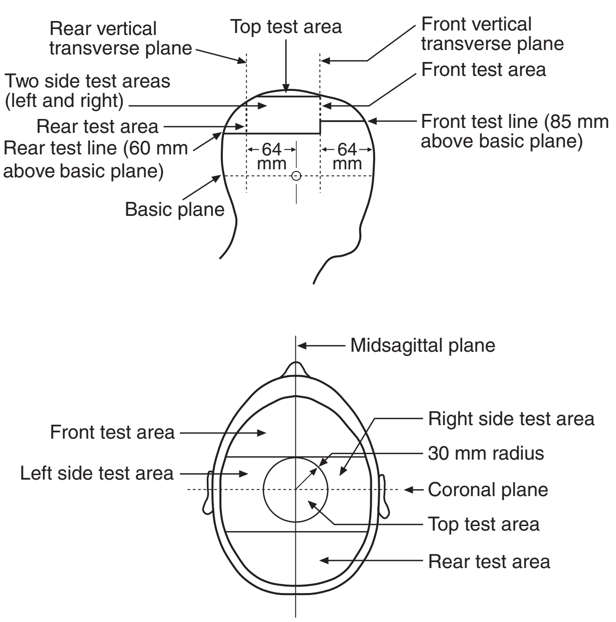
9.1.6.6 Sample helmets shall be mounted in the position to be conditioned. The point of impact or penetration on the helmet shell shall be determined in accordance with the specific test to be performed. The helmet shall be removed temporarily, and a radiometer shall be located at that point perpendicular to and facing away from the helmet surface.

9.1.6.7 The radiant panel shall be introduced in front of the radiometer with its effective radiating surface parallel to the plane tangent to the helmet surface at the center of the impact/penetration site on the helmet. The radiant panel shall be adjusted to obtain a stable uniform irradiance of 1.0 W/cm^2 ± 0.1 W/cm^2 over a minimum 75 mm (3 in.) diameter circle located on the above plane and centered at the center of impact or penetration. Stability shall be achieved when the irradiance changes by less than 10 percent during a 3-minute period.

9.1.6.8* The radiometer shall be replaced with the radiant heat transducer. The center of the transducer shall be positioned with its center coincident with the center of the impact/penetration site on the helmet and parallel to the plane tangent to the helmet surface at that point. The flat black surface of the transducer shall face the radiant panel. The time required for the transducer to reach a temperature of 260°C (500°F) shall be recorded. That time shall be 2.5 minutes ± 15.0 seconds. A closed, insulated chamber shall be required to achieve this exposure time.

9.1.6.9 The chamber and helmet shall be stabilized at 25°C ± 5°C (77°F ± 9°F). The helmet shall be positioned in the chamber in the same position specified in 9.1.6.6. The helmet shall be subjected to the exposure conditions specified in 9.1.6.2 for the time recorded in 9.1.6.8. The exposure time shall be not less than the time recorded in 9.1.6.8, nor more than 5 seconds longer than that time.

9.1.7 Wet Conditioning Procedure for Helmets and Faceshield/Goggle Components. Samples shall be conditioned by immersing them in water at a temperature of 20°C to 28°C (68°F to 82°F) for at least 4 hours but not more than 24 hours. The specimen shall be allowed to drain and be tested within 10 minutes after removal from water.



For U.S. units, 1 mm = 0.0394 in.

FIGURE 9.1.6.1 Helmet Test Areas and Landmarks.

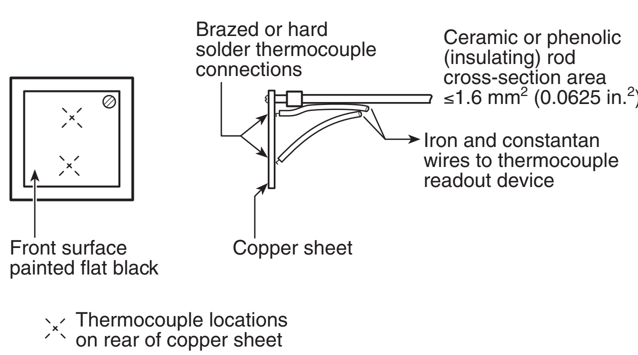


FIGURE 9.1.6.5 Radiant Heat Transducer.

9.1.8 Wet Conditioning Procedure for Glove Composites.

9.1.8.1 Samples shall be conditioned by complete immersion in water at a temperature of 21°C ± 3°C (70°F ± 5°F) for 2 minutes.

9.1.8.2 Samples shall be removed from water, hung in a vertical position with glove pouch opening facing down for 5 minutes, and laid horizontal with AATCC textile blotting paper both under and over the specimen under a pressure of 0.035 kg/cm^2 ± 0.003 kg/cm^2 (0.50 psi ± 0.05 psi), for a period of 20 minutes in accordance with paragraph 7.2 of AATCC TM70, *Test Method for Water Repellency: Tumble Jar Dynamic Absorption Test*.

9.1.9* Wet Conditioning Procedure 2 for Glove Composites.

9.1.9.1 Samples shall be conditioned by being subjected to a water spray that evenly deposits a mist of water on the thermal barrier layer of the composite using the apparatus and procedures described in 9.1.9.2 through 9.1.9.7.

9.1.9.2 A means of spraying water at a rate of 4.4 g ± 1.0 g (0.16 oz ± 0.04 oz) over a 20 second period or at an average rate of 0.22 g/s ± 0.5 g/s (0.008 oz/s ± 0.02 oz/s) uniformly over a 150 mm × 150 mm (6 in. × 6 in.) sample while measuring the weight of the sample shall be employed.

9.1.9.2.1 The nozzle shall be positioned directly over the sample.

9.1.9.2.2 The nozzle for applying the water spray shall be designed not to drip on the sample before the onset or after the completion of the designated water spray period.

9.1.9.2.3 The spraying shall be conducted in a closed chamber or area that limits disturbance of the mist deposition of the sample from air currents.

9.1.9.2.4 The sample shall be positioned on a balance that is capable of measuring the sample weight to the nearest 0.1 g (0.004 oz). The balance pan shall have a minimum pan dimension of 150 mm × 150 mm (6 in. × 6 in.).

9.1.9.2.5 The uniformity of the water spray shall be determined (calibration) by measuring the mass of water deposited into nine cups that measure 50 mm × 50 mm (2 in. × 2 in.) square that are positioned where water collects on the sample, as shown in Figure 9.1.9.2.5. Uniformity of the spray pattern shall be determined by measuring the weight of each dry cup prior to the calibration and then measuring the weight of the cup following the application of the spray for a period of 20 seconds where the coefficient of variance of the weight gained by the nine cups is no more than 20 percent.

9.1.9.3 Samples for conditioning shall be the innermost layer of the glove composite that are cut to 150 mm × 150 mm (6 in. × 6 in.).

9.1.9.4 The dry weight of the glove composite innermost layer sample to be wetted shall be measured on a spray chamber balance to the nearest 0.1 g (0.004 oz).

9.1.9.5 Separate sets of samples shall have a mass of 2.0 g /± 0.1 g (0.070 oz /± 0.004 oz), 2.5 g ± 0.1 g (0.09 oz ± 0.004 oz), and 3.0 g /± 0.1 g (0.11 oz /± 0.004 oz) of water sprayed on the innermost layer of the glove composite as confirmed by the measurement of its weight on the balance.

FIGURE 9.1.9.2.5 Glove Composite Wetting Method.

9.1.9.6 Following the application of the water spray, the innermost layer of the glove shall be handled by the edges and assembled in a composite sample representative of the glove's construction for the area of the glove to be evaluated.

9.1.9.7 Samples subjected to this conditioning shall be evaluated within 5 minutes following the wetting.

9.1.10 Wet Conditioning Procedure for Whole Gloves.

9.1.10.1 Test subjects shall be selected so that their hand dimensions are as close as possible to the middle of the range for hand length and hand circumference as specified in Figure 7.7.4.1 for size 70W (wide) and size 76W (wide) gloves.

9.1.10.2 The test subject shall don the test specimen gloves.

9.1.10.3 The test subject shall immerse the donned specimens straight down into two containers of water at a temperature of 21°C ± 3°C (70°F ± 5°F), to a height of 25 mm, +12.5/−0 mm (1 in., +0.5/−0 in.) above (away from the fingers) the end of the glove, including glove interface components or extensions, for 2 minutes, +12/−0 seconds.

9.1.10.4 The gloves shall then be removed and hung vertically by digit 5 with the glove opening facing down for 2 minutes ± 12 seconds.

9.1.10.5 The glove specimens shall then be tested within 1 minute.

9.1.11 Flexing Procedure for Gloves.

9.1.11.1 Glove samples shall be selected to fit the individual test subject.

9.1.11.2 The test subject shall don the glove sample.

9.1.11.3 Glove specimens shall be flexed by making a tight fist 10 times during a 30-second period.

9.1.12 Front-Loading Washing and Drying Procedure.

9.1.12.1 A front-loading washer/extractor shall be used. The capacity shall be between 16 kg (35 lb) and 24.9 kg (55 lb).

9.1.12.2 The wash load shall be 55 to 65 percent of an adjusted washer capacity where the volume-to-weight ratio equals 5.7 lb/ft^3. The capacity can be calculated as follows:

[9.1.12.2]

$$5.7\left(\frac{lb}{ft^3}\right) X \ Washer \ Volume \ \left(ft^3\right) = Washer \ Capacity \ \left(lb\right)$$

9.1.12.2.1 If ballast is needed to reach capacity, similar material or outer shell material consisting of 212 g/m^2 (7.5 oz/yd^2) woven 93 percent meta-aramid, 5 percent para-aramid, and 2 percent antistatic fiber shall be used.

9.1.12.3 The wash cycle procedure and water levels specified in Table 9.1.12.3(a) and Table 9.1.12.3(b) shall be followed. In addition, the *g* force shall not exceed 125 *g* throughout the wash cycle.

9.1.12.4 Samples shall be dried using a tumble dryer with a stack temperature of 38°C to 49°C (100°F to 120°F) when measured on an empty load 20 minutes into the drying cycle.

9.1.12.5 Samples shall be tumbled for 60 minutes and shall be removed immediately at the end of the drying cycle. At the conclusion of the final drying cycle, the garment samples shall be allowed to air dry for at least 48 hours prior to conducting the test and the use of a forced-air dryer operated at ambient temperature, −0°+ 5°C (−0°+ 10°F) shall be permitted.

Table 9.1.12.3(a) Front-Loading Wash Cycle

Operation	Time (min)	Temperature ±3°C	Temperature ±5°F	Water Level
Suds using AATCC detergent #1993 without optical brighteners, 1.0 g/gal ±1% water	10	49	120	Low*
Drain	1	—	—	—
Carryover	5	49	120	Low*
Drain	1	—	—	—
Rinse	2	38	100	High*
Drain	1	—	—	—
Rinse	2	38	100	High*
Drain	1	—	—	—
Rinse	2	38	100	High*
Drain	1	—	—	—
Extract	5	—	—	—

*See Table 9.1.2.3(b) for high and low water levels.

Table 9.1.12.3(b) Water Level for Front-Loading Wash Cycle Procedure

Low Water Level ±1 cm (3⁄18 in.)		High Water Level ±1 cm (3⁄18 in.)	
cm	in.	cm	in.
12.7	5.0	25.4	10.0

9.1.12.5.1 At the conclusion of the final drying cycle, glove or glove pouch samples shall be dried on a forced-air, non-tumble-drying mechanism operated at 10ºC ± 5°C (18°F ± 9°F) above current room temperature until dry but not less than 8 hours.

9.1.12.6 Garments, garment materials, wristlets, hoods, gloves, and glove pouches shall be washed and dried for a total of five cycles unless otherwise specified.

9.1.12.7 Where washing complete garments all closures shall be fastened in its "as-worn" orientation. Garments with separable liners shall not have the liners separated.

9.1.13 Helmet Positioning.

9.1.13.1 The helmet shall be seated firmly on the applicable test headform in accordance with the helmet positioning index (HPI).

9.1.13.2* The HPI shall be the vertical distance, as specified by the helmet manufacturer, from the lowest point of the front lateral midpoint of the helmet shell aligned with the midsagittal plane to the basic plane of an ISO size J headform conforming to the nominal dimensions in Figure 9.3.6.4.1, with the helmet firmly positioned on the headform.

9.1.13.3 When positioning the helmet for testing on headforms other than the ISO size J, the basic plane used for the HPI positioning shall be located 130 mm (5 in.) below and parallel to the crown of the headform and shall be marked on the headform.

9.1.13.4 The same HPI shall be used for all performance requirements where helmet positioning is used for each unique model or style of a helmet. If the HPI is adjusted for one test, then all other tests shall be repeated using the adjusted HPI.

9.1.13.5 The manufacturer shall provide the certification organization used as the basis for how they established the HPI for each unique model or style of helmet being certified. This information shall be documented in the certification test report for the respective helmet.

9.1.13.6 The HPI shall be reported with the test results for each test where helmet positioning is applied.

9.1.14 Pouch Construction for Glove Composite Samples One.

9.1.14.1 The pouch shall be 200 mm × 200 mm (8 in. × 8 in.). A smaller pouch size shall be permitted provided that the resulting test specimens are of sufficient size for the test. However, for the tests specified in Sections 9.2.7, Conductive Heat Resistance Test 1, and 9.2.16, Thermal Protective Performance (TPP) Test, the pouch size shall not be reduced.

9.1.14.2 The pouch shall be made of two glove composite swatches.

9.1.14.3 The two glove composites shall be of the same materials and construction.

9.1.14.4 The two glove composite swatches shall be constructed to simulate the actual layers of the glove body, glove interface component, or glove extension as appropriate, arranged in proper order.

9.1.14.5 Each of the two glove composite swatches shall be stitched on all four sides using the same thread as used in the glove construction.

9.1.14.6 The two glove composite swatches shall then be sewn together, inner liner to inner liner, on three sides using the same thread as used in the glove construction.

9.1.14.7 The two glove composite swatches and resulting pouch shall be permitted to not be stitched or to have reduced stitching if a laundering or wetting conditioning is not required to be performed on the composite samples.

9.1.15 Pouch Construction for Glove Composite Samples Two.

9.1.15.1 The pouch shall be 200 mm × 200 mm (8 in. × 8 in.). A smaller pouch size shall be permitted provided that the resulting test specimens are of sufficient size for the test.

9.1.15.2 The pouch shall be made of two composite swatches.

9.1.15.3 The two composite swatches shall each consist of a composite constructed to simulate a glove body composite using the following layers and construction in order:

(1) Layer 1: 3.0 to 3.5 oz/yd^2 cow split leather
(2) Layer 2: Glove moisture barrier
(3) Layer 3: 7 to 10 oz/yd^2 modacrylic knit

9.1.15.4 Where the thermal liner and barrier are combined, the modacrylic knits shall be permitted to be omitted from the composite.

9.1.15.5 Where the moisture barrier material seam is being tested, the moisture barrier layer shall contain a straight seam. The seam shall run within 25 mm (1 in.) of the center and shall extend across the entire width of the specimen.

9.1.15.6 Each of the two glove composite swatches shall be stitched on all four sides using the same thread as used in the glove construction.

9.1.15.7 The two glove composite swatches shall then be sewn together, inner liner to inner liner, on three sides using the same thread as used in the glove construction.

9.1.15.8 Where a glove is made of materials other than leather and modacrylic, the composite swatches shall be permitted to be constructed of materials that are used in the actual glove.

9.1.16 Faceshield/Goggle Component Stowed Position.

9.1.16.1 The stowed position of the faceshield/goggle component shall be determined by the manufacturer.

9.1.16.1.1 The stowed position shall not be beyond the point of any resistance when the faceshield/goggle component is pushed up and back from the deployed position, such as coming into contact with the helmet or any helmet attachments.

9.1.16.1.2 In cases in which the faceshield/goggle component can be stowed on the front or rear of the helmet, the following positions shall be used:

(1) In the situations described in 7.4.6 and 9.2.4.12.3, the front position shall be used.
(2) In situations described in 7.5.3.1 and 7.5.3.2, the front and rear positions shall be used.

9.1.17* Glove Test Areas. The glove test areas shall be as described in this paragraph and as shown in Figure 9.1.17, with the glove test area abbreviations designated as follows:

(1) P = palm; B = back; S = side.
(2) A-P: Palm side of hand from finger crotch line to ⅓ of the way down (grasp area)
(3) B-P: Palm side of hand from ⅓ of the way down (grasp area) to the wrist crease
(4) C-P: Palm side of hand from the wrist crease to 50 mm (2 in.) past the wrist crease
(5) D-P: Palm side of thumb
(6) E-P: Palm side of tip of thumb
(7) F-P: Palm side of index finger
(8) G-P: Palm side of fingertip of index finger
(9) H-P: Palm side of nonindex fingers
(10) I-P: Palm side of fingertip of nonindex fingers
(11) A-PS: Sides of hand adjacent to area A-P
(12) B-PS: Outside of hand adjacent to section B-P
(13) C-PS: Sides of hand adjacent to area C-P
(14) D-PS: Outside of thumb adjacent to area D-P
(15) E-PS: Inside of thumb adjacent to area D-P
(16) F-PS: Outside of index finger adjacent to area F-P
(17) H-PS: Between fingers adjacent to areas F-P and H-P
(18) I-PS: Outside of and adjacent to the smallest finger
(19) A-B: Back side of hand from finger crotch line to ⅓ of the way down (knuckle area)
(20) B-B: Back side of hand from ⅓ of the way down (knuckle area) to the wrist crease
(21) C-B: Back side of hand from the wrist crease to 50 mm (2 in.) past the wrist crease
(22) D-B: Back side of thumb
(23) E-B: Back side of tip of thumb
(24) F-B: Back side of index finger
(25) G-B: Back side of fingertip of index finger
(26) H-B: Back side of nonindex fingers
(27) I-B: Back side of fingertip of nonindex fingers
(28) A-BS: Sides of hand adjacent to area A-B
(29) B-BS: Outside of hand adjacent to area B-B
(30) C-BS: Sides of hand adjacent to area C-B
(31) D-BS: Outside of thumb adjacent to area D-B
(32) E-BS: Inside of thumb adjacent to area D-B
(33) F-BS: Outside of index finger adjacent to area F-B
(34) H-BS: Between fingers adjacent to areas F-B and H-B

9.1.18 Flexural Fatigue Procedure for Outer Shells.

9.1.18.1 Samples shall be subjected to flexural fatigue in accordance with ASTM F392/F392M, *Standard Practice for Conditioning Flexible Barrier Materials for Flex Durability*, with the modifications in 9.1.18.2 through 9.1.18.5.

9.1.18.2 Samples shall be flexed within 4 hours of removal of the conditions specified in 9.1.21.2(3).

9.1.18.3 In lieu of flexing Condition A, Condition B, Condition C, Condition D, or Condition E, test samples shall be flexed for the specified number of cycles at 45 cycles/min.

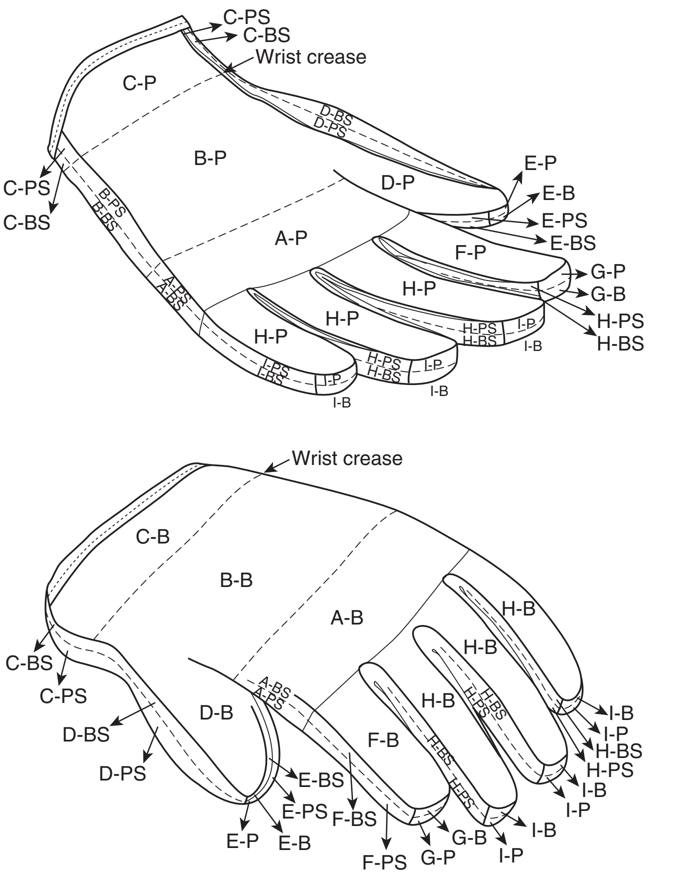


FIGURE 9.1.17 Glove Test Areas.

9.1.18.4* The mandrels shall be spaced at a distance of 204 mm ± 6 mm (8 in. ± ¼ in.) in the starting position and 50 mm (2 in.) at the closed position when measured from the back sample holding area of each mandrel.

9.1.18.5 One cycle shall consist of a full flex and twisting action.

9.1.19 Flexing Conditioning for Complete Footwear. Footwear samples shall be flexed for 100,000 cycles in accordance with Appendix B of FIA 1209, *Whole Shoe Flex*, with the following modifications:

(1) Water shall not be used.
(2) The flex speed shall be 60 cycles/min ± 2 cycles/min.
(3) Alternative flexing equipment meeting the following criteria shall be permitted to be used:
   (a) Is capable of providing the angle of flex as described in FIA 1209
   (b) Is capable of a flex speed of 60 cycles/min ± 2 cycles/min
   (c) Has a means of securing the footwear during flexing
(4) The means for securing the footwear sample in the equipment shall not cause damage to the footwear.

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

(1) A 2.3 kg (5 lb) tension weight shall be used.
(2) A 1.6 kg (3.5 lb) head weight shall be used.
(3) The abradants shall be each of the material layers in the composite.
(4) Samples shall be abraded for the specified number of cycles.
(5) Samples shall be abraded for half of the cycles against the outer layer of the composite, with the specimen facing the outer layer in its normal "as-worn" orientation.
(6) Samples shall be then abraded for the remaining cycles against the inner layer of the composite with the specimen facing the inner layer in its normal "as-worn" orientation.

9.1.21 Multienvironmental Conditioning Procedure.

9.1.21.1 Samples of outer shell measuring 381 mm × 381 mm (15 in. × 15 in.) shall be prepared by cutting and sewing or serging the edges to prevent fraying.

9.1.21.2 Outer shell samples shall be subject to the various conditions in the following order:

(1) Outer shell samples shall be laundered a total of 20 laundering cycles as specified in 9.1.2.
(2) Outer shell samples shall be subjected to convective heat conditioning procedures as specified in 9.1.5.
(3) Outer shell samples shall be conditioned for a minimum of 4 hours as specified in 9.1.3.
(4) Outer shell samples shall be subject to repeated flexing for 3000 cycles as specified in 9.1.18.
(5) Outer shell specimens for testing shall be taken so that one warp and one fill specimen is cut from the center of the conditioned samples.

9.1.21.3 Specimens of the respective composite or material shall then be removed from the fully conditioned sample and subject to the test method as specified by the respective procedures of that test method.

9.1.22* Measurement and Marking of Footwear Top Line, Internal Layer Height, and Liquid Test Level.

9.1.22.1 A representative sample shall be cut in half vertically front to back to provide a cross-section through the boot that allows the direct observation of internal layers.

9.1.22.2 The center of the heel shall be located using a square set against the bottom surface of the footwear sample and marked on the heel portion of the vertical cross-section.

9.1.22.3 A marking fixture that consists of a ring stand with a vertically adjustable clamp for holding an ink marker pen horizontally shall be used to draw a line across the lowest point at the top line of the cut footwear sample.

9.1.22.4 A height fixture shall be constructed to provide vertical alignment of the ruler used for measuring footwear sample height and shall consist of two vertical stands that support a horizontal bar that measures at least 400 mm (16 in.) in height with width to accommodate the half-cut footwear sample.

9.1.22.5 The height of the boot shall be determined by using a ruler to measure the vertical distance between the center of the heel between the top of the insole and the line representing the top line drawn on the interior of the cut footwear sample.

The height fixture shall be used to aid the vertical positioning of the ruler.

9.1.22.6 For determining the height of the moisture barrier or any other layers on the interior of the boot, a ruler shall be used to measure the vertical distance between the lowest portion of the respective layer to the line representing the top line drawn on the interior of the cut footwear sample.

9.1.22.7 For determining the height of the liquid level used in performing liquid integrity testing as part of the heat resistance test as applied to footwear, the height fixture and a ruler shall be used to place a mark 75 mm (3 in.) below the top line drawn on the interior of the cut footwear sample. The height fixture shall be used to aid the vertical positioning of the ruler.

9.1.22.8 Using the same set up as in 9.1.22.7, the interior height of the footwear sample from the top of the insole to 230 mm (9 in.) toward the topline shall be made on the interior.

9.1.22.9 The higher of the two measurements made in 9.1.22.7 and 9.1.22.8 shall be selected as the liquid test level.

9.1.22.10 The marking fixture shall be used to position the ink marker pen horizontally at the liquid test level determined in 9.1.22.9 as marked on the interior of the cut footwear sample.

9.1.22.11 The marking fixture shall then be used to transfer a circumferential line onto the exterior of each test specimen for marking the liquid test level.

9.2 Thermal Hazard Test Methods.

9.2.1 Flame Resistance Test 1. Testing shall be performed as specified in 9.2.1.2 through 9.2.1.7.

9.2.1.1 Application.

9.2.1.1.1 This test method shall apply to protective garment textiles, drag rescue devices (DRDs), hoods, wristlets, gauntlets, helmet cover materials, helmet shroud materials, helmet ear cover materials, helmet chin strap materials, helmet goggle strap materials, and trim materials.

9.2.1.1.2 Modifications to this test method for testing woven textile materials shall be as specified in 9.2.1.8.

9.2.1.1.3 Modifications to this test method for testing knit textile materials shall be as specified in 9.2.1.9.

9.2.1.1.4 Modifications to this test method for testing nonwoven textile materials shall be as specified in 9.2.1.10.

9.2.1.1.5 Modifications to this test method for testing trim materials shall be as specified in 9.2.1.11.

9.2.1.1.6 Modifications to this test method for testing hood label materials shall be as specified in 9.2.1.12.

9.2.1.1.7 Modifications to this test method for testing lettering including transfer film shall be as specified in 9.2.1.13.

9.2.1.1.8 Modifications to this test method for testing small specimens not meeting the specimen size requirements in 9.2.1.2.1 shall be tested as specified in 9.2.1.14.

9.2.1.1.9 Modifications to the test method for testing helmet chin strap materials and helmet goggle strap materials shall be as specified in 9.2.1.15.

9.2.1.1.10 Modifications to the test method for testing DRD materials shall be as specified in 9.2.1.16.

9.2.1.2 Samples.

9.2.1.2.1 Samples shall consist of a 75 mm × 305 mm (3 in. × 12 in.) rectangle with the long dimension parallel to either the warp or filling, the wale or course, or the machine or cross-machine direction of the material.

9.2.1.2.2 Each separable layer of multilayer material systems or composites shall be individually tested.

9.2.1.3 Specimens.

9.2.1.3.1 Specimens shall be tested both before and after being subjected to the procedure specified in 9.1.2.

9.2.1.3.2 All specimens to be tested shall be conditioned as specified in 9.1.3.

9.2.1.4 Apparatus. The test apparatus specified in ASTM D6413/D6413M, *Standard Test Method for Flame Resistance of Textiles (Vertical Test)*, shall be used.

9.2.1.5 Procedure.

9.2.1.5.1 Flame resistance testing shall be performed in accordance with ASTM D6413/D6413M, *Standard Test Method for Flame Resistance of Textiles (Vertical Test)*.

9.2.1.5.2 Each specimen shall be examined for evidence of melting or dripping.

9.2.1.6 Report.

9.2.1.6.1 Afterflame time and char length shall be recorded and reported for each specimen. The average afterflame time and char length for each material in each direction tested shall be calculated, reported, and recorded. The afterflame time shall be recorded and reported to the nearest 0.1 second and the char length to the nearest 1 mm ($\frac{1}{25}$ in.).

9.2.1.6.2 Observations of melting or dripping for each specimen shall be recorded and reported.

9.2.1.7 Interpretation.

9.2.1.7.1 Pass or fail performance shall be based on any observed melting or dripping, the average afterflame time, and the average char length.

9.2.1.7.2 Failure in either direction shall constitute failure of the material.

9.2.1.8 Specific Requirements for Testing Woven Textile Materials.

9.2.1.8.1 Five specimens from each of the warp and filling directions shall be tested. No two warp specimens shall contain the same warp yarns, and no two filling specimens shall contain the same filling yarns.

9.2.1.8.2 Samples for conditioning shall be at least a 1 m (39 in.) square of each material.

9.2.1.8.3 Testing shall be performed as specified in 9.2.1.2 through 9.2.1.7.

9.2.1.9 Specific Requirements for Testing Knit Textile Materials.

9.2.1.9.1 Five specimens from each of the wale and course directions shall be tested.

9.2.1.9.2 Samples for conditioning shall include material that is a minimum of 75 mm × 305 mm (3 in. × 12 in.).

9.2.1.9.3 Testing shall be performed as specified in 9.2.1.2 through 9.2.1.7.

9.2.1.10 Specific Requirements for Testing Nonwoven Textile Materials.

9.2.1.10.1 Five specimens from each of the machine and cross-machine directions shall be tested.

9.2.1.10.2 Samples for conditioning shall include material that is a minimum of 75 mm × 305 mm (3 in. × 12 in.).

9.2.1.10.3 Testing shall be performed as specified in 9.2.1.2 through 9.2.1.7.

9.2.1.11 Specific Requirements for Testing Trim Materials.

9.2.1.11.1 Five trim specimens for flammability testing shall be at least 50 mm (2 in.) wide and no more than 75 mm (3 in.) wide. Where trim material specimens are not wide enough to fit into the test frame, a narrower test frame of sufficient width to accommodate the available trim width shall be constructed. The cut edge of the trim specimen shall be oriented so that it is exposed directly to the burner flame.

9.2.1.11.2 Samples for conditioning shall include material sewn onto a 1 m (39 in.) square of ballast material no closer than 50 mm (2 in.) apart in parallel strips. The ballast material shall be as specified in AATCC TM135, *Test Method for Dimensional Changes of Fabrics after Home Laundering*. Specimens shall be removed from the ballast material prior to testing.

9.2.1.11.3 Testing shall be performed in only one direction.

9.2.1.11.4 Testing shall be performed as specified in 9.2.1.2 through 9.2.1.7.

9.2.1.12 Specific Requirements for Testing Hood Label Materials.

9.2.1.12.1 Five specimens of hood labels attached to the hood material shall be tested. The hood label specimen shall be cut from conditioned samples so that the edge of the hood label is at the bottom of the specimen.

9.2.1.12.2 Samples for conditioning shall be whole hoods, including the label as normally attached.

9.2.1.12.3 Testing shall be performed as specified in 9.2.1.2 through 9.2.1.7 with the flame applied to the edge of the label.

9.2.1.13 Specific Requirements for Testing Lettering Including Transfer Film.

9.2.1.13.1 Lettering, including transfer film, shall be applied to outer shell material meeting the requirements of Chapters 4 through 9 of this standard for testing as specified in 9.2.1.13.2. The method of applying lettering, including transfer film, shall be representative of methods used in attaching lettering during the manufacture of the protective element.

9.2.1.13.2 Lettering specimens for flammability testing shall be at least 50 mm (2 in.) and no more than 75 mm (3 in.) in width. Specimens shall be selected where lettering is most dense.

9.2.1.13.3 Samples for conditioning shall include material sewn onto a 1 m (39 in.) square of ballast material no closer than 50 mm (2 in.) apart in parallel strips. The ballast material shall be as specified in AATCC TM135, *Test Method for Dimensional Changes of Fabrics after Home Laundering*. Specimens shall be removed from the ballast material prior to testing.

9.2.1.13.4 Testing shall be performed as specified in 9.2.1.2 through 9.2.1.7.

9.2.1.13.5 A diagram or photograph showing how the transfer film is positioned on a representative test specimen shall be provided as part of the test report.

9.2.1.14 Specific Requirements for Testing Small Specimens.

9.2.1.14.1 Five specimens attached to the textile layer as used in the protective garments shall be tested. The specimens shall be attached to the textile layer such that the bottom (exposure) edge of the item coincides with the bottom (exposure) edge of the textile support layer.

9.2.1.14.2 Samples for conditioning shall be at least 1 m (39 in.) square of the textile layer on which the small specimens are attached.

9.2.1.14.3 Testing shall be performed as specified in 9.2.1.2 through 9.2.1.7. Char length shall not be measured.

9.2.1.14.4 A diagram or photograph showing how the specimen is configured for testing shall be provided as part of the test report.

9.2.1.15 Specific Requirements for Testing Helmet Chin Strap Materials and Helmet Goggle Strap Materials.

9.2.1.15.1 Five specimens of helmet chin strap materials and helmet goggle strap materials, excluding elastic or hook and pile fasteners, shall be tested. Specimens shall be at least 305 mm (12 in.) in length by the widest width of the chin strap or goggle strap used on the helmet.

9.2.1.15.2 Testing shall be performed in only one direction.

9.2.1.15.3 Samples for conditioning shall be chin strap materials or goggle strap materials.

9.2.1.15.4 The specimen holder shall be modified to permit the testing of narrow specimens.

9.2.1.15.5 Testing shall be performed as specified in 9.2.1.2 through 9.2.1.7.

9.2.1.16 Specific Requirements for Testing Drag Rescue Device (DRD) Materials.

9.2.1.16.1 Five specimens of the materials used in the construction of DRDs shall be tested.

9.2.1.16.2 DRD materials shall be at least 305 mm (12 in.) in length by the widest width of the material used in the DRD.

9.2.1.16.3 Testing shall be performed in only one direction.

9.2.1.16.4 Testing shall be performed as specified in 9.2.1.2 through 9.2.1.7.

9.2.2 Flame Resistance Test 2.

9.2.2.1 Application. This test method shall apply to protective helmets.

9.2.2.2 Samples. Helmets shall be conditioned as specified in 9.1.3.

9.2.2.3 Specimens. Three helmets shall be tested.

9.2.2.4 Apparatus.

9.2.2.4.1 A standard Bunsen burner shall be used.

9.2.2.4.2 The Bunsen burner shall be fueled by a bottled methane gas, 99 percent pure.

9.2.2.4.3 A control valve system with a delivery rate designed to furnish gas to the burner under a pressure of 0.035 kg/cm^2 ± 0.003 kg/cm^2 (1/2 psi, +0.1/−0 psi) at the burner shall be utilized.

9.2.2.4.4 The barrel of the Bunsen burner shall be 13 mm ± 3 mm (1/2 in. ± 1/8 in.) in diameter. A flame spreader shall not be used.

9.2.2.5 Procedure A.

9.2.2.5.1 The helmet shall be positioned on the ISO size J headform specified in Figure 9.3.6.4.1 according to the HPI as described in 9.1.14.

9.2.2.5.2 The flame of the Bunsen burner shall be adjusted to produce a 50 mm ± 1.5 mm (2 in. ± 1/16 in.) blue flame with an inner cone of 25 mm ± 1.5 mm (1 in. ± 1/16 in.). The temperature of the flame at the tip of the inner cone shall be measured with a K-type thermocouple and shall be 1200°C ± 100°C (2192°F ± 180°F). The tip of the inner cone of the flame shall then be applied to the helmet shell from below the helmet at an angle of 90 degrees to the basic plan, as shown in Figure 9.2.2.5.2, as follows:

(1) The flame shall be applied at the intersection of the front edge of the brim and the midsagittal plane.
(2) The flame shall be applied at the intersection of each side of the brim and the coronal plane.
(3) The flame shall be applied at one random location on the edge of the brim to be determined by test laboratory.
(4) A diagram or photograph that depicts each application area for the flame on the respective helmet shall be provided.

9.2.2.5.3 The flame shall be applied for 15 seconds, +1/−0 second. The flame shall then be removed and the duration of the afterflame and afterglow shall be measured, reported, and recorded.

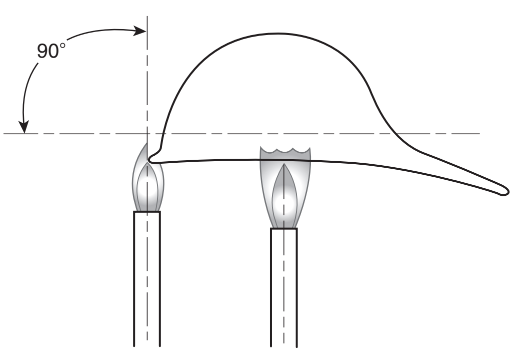


FIGURE 9.2.2.5.2 Test Procedure A.

9.2.2.6 Procedure B.

9.2.2.6.1 Specimens of faceshield/goggle components shall be attached to an appropriate test fixture so that the lower edge of the specimen is exposed. The test setup shall be as shown in Figure 9.2.2.6.1.

9.2.2.6.2 The flame of the Bunsen burner shall be adjusted to produce a 50 mm ± 1.5 mm (2 in. ± 1/16 in.) blue flame with an inner cone of 25 mm ± 1.5 mm (1 in. ± 1/16 in.). The temperature of the flame at the tip of the inner cone shall be measured with a K-type thermocouple and shall be 1200°C ± 100°C (2192°F ± 180°F). The tip of the inner cone of the flame shall then be applied to the outer edge of the specimen at the lowest exposed edge of the specimen. The burner shall be held to the test point of the specimen at an angle of 45 degrees ± 10 degrees.

9.2.2.6.3 After 15 seconds, +1/−0 second, the flame shall be removed and the duration of the afterflame shall be measured, reported, and recorded.

9.2.2.7 Procedure C.

9.2.2.7.1 The helmet shall be positioned according to the HPI as described in 9.1.13 on the ISO size J headform specified in Figure 9.3.6.4.1. The helmet shall then be placed under the radiant heat source specified in 9.1.6, while the basic plane of the headform is parallel to the radiant heat source as shown in Figure 9.2.2.7.1.

9.2.2.7.2 The flame of the Bunsen burner shall be adjusted to produce a 50 mm ± 1.5 mm (2 in. ± 1/16 in.) blue flame with an

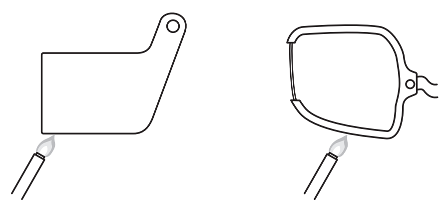


FIGURE 9.2.2.6.1 Test Procedure B.

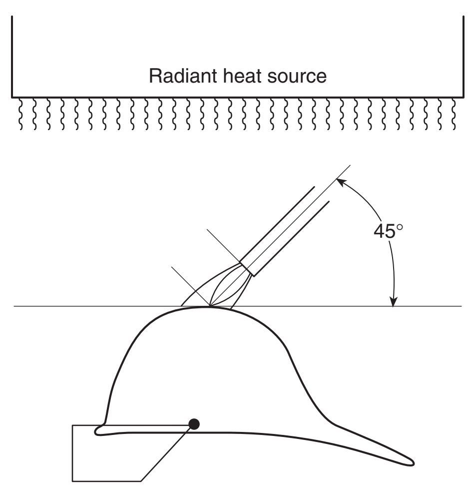


FIGURE 9.2.2.7.1 Test Procedure C.

inner cone of 25 mm ± 1.5 mm (1 in. ± 1⁄16 in.). The temperature of the flame at the tip of the inner cone shall be measured with a K-type thermocouple and shall be 1200°C ± 100°C (2192°F ± 180°F).

9.2.2.7.3 Specimen helmets shall be positioned so that the area to be tested receives a radiant heat flux of 1.0 W/cm^2 ± 0.1 W/cm^2. After 60 seconds, +5/−0 seconds, exposure to the radiant flux and without removing the radiant heat source, the tip of the inner cone of the Bunsen burner flame shall be applied against the helmet test area. The application of the flame shall create an angle of 45 degrees ± 10 degrees, with the plane tangent to the test area at the point of contact.

9.2.2.7.4 After 15 seconds, +1/−0 second, the flame shall be removed and the duration of the afterflame and afterglow shall be measured, reported, and recorded.

9.2.2.8 Procedure D.

9.2.2.8.1 Specimen helmets with faceshield/goggle component attachment hardware in place shall be positioned according to the HPI as described in 9.1.13 on the ISO size J headform specified in Figure 9.3.6.4.1.

9.2.2.8.2 The flame of the Bunsen burner shall be adjusted to produce a 50 mm ± 1.5 mm (2 in. ± 1⁄16 in.) blue flame with an inner cone of 25 mm ± 1.5 mm (1 in. ± 1⁄16 in.). The temperature of the flame at the tip of the inner cone shall be measured with a K-type thermocouple and shall be 1200°C ± 100°C (2192°F ± 180°F). The tip of the inner cone of the flame shall then be applied to each faceshield/goggle comment attachment hardware location along the helmet brim line from below the brim of the helmet at an angle of 90 degrees to the basic plane.

9.2.2.8.3 The flame shall be applied for 15 seconds, +1/−0 second. The flame shall then be removed and the duration of the afterflame and afterglow shall be measured, reported, and recorded.

9.2.2.9 Report.

9.2.2.9.1 Afterflame times shall be recorded and reported for each specimen at each flame impingement location.

9.2.2.9.2 The afterflame times shall be recorded and reported to the nearest 0.2 second.

9.2.2.9.3 A diagram or photograph showing the locations of flame application to the helmet for each procedure shall be provided.

9.2.2.10 Interpretation.

9.2.2.10.1 Pass/fail performance shall be based on the longest measured afterflame time.

9.2.3 Flame Resistance Test 4.

9.2.3.1 Application. This test method shall apply to protective footwear.

9.2.3.2 Samples.

9.2.3.2.1 Samples shall be complete items of footwear with all components closed and secured.

9.2.3.2.2 Footwear samples shall be conditioned as specified in 9.1.3.

9.2.3.3 Specimens. Three complete footwear items shall be tested.

9.2.3.4 Apparatus. The test apparatus shall consist of a fuel pan, movable shutter(s), specimen holder, n-heptane, ignition source, and timing device.

9.2.3.4.1 The fuel pan shall be 305 mm × 457 mm × 63.5 mm (12 in. × 18 in. × 2.5 in.).

9.2.3.4.2 The movable shutter(s) shall be located at a height of 255 mm ± 13 mm (10 in. ± ½ in.) above the surface of the water and n-heptane fluid as measured before ignition. The shutter(s) shall be sized such that it covers the surface area of the fuel pan and be capable of being fully retracted or fully extended within 1 second.

9.2.3.4.3 The specific holder for footwear shall provide the following mounting and positioning of the specimen:

(1) The toe shall be at an angle of 7.5 degrees ± 2.5 degrees, above the heel.
(2) The height of the lowest edge of the specimen shall be 305 mm ± 25 mm (12 in. ± 1 in.) from the surface of the water and n-heptane fluid as measured before ignition.
(3) The heel-toe axis of the specimen shall be parallel with the 457 mm (18 in.) side of the fuel pan.

9.2.3.4.4 The stopwatch or other device shall measure the burning time to the nearest 0.1 second.

9.2.3.5 Procedure.

9.2.3.5.1 The test shall be conducted in a draft-free area.

9.2.3.5.2 The fuel pan shall be level.

9.2.3.5.3 Water shall be placed in the fuel pan to a height of 13 mm (½ in.).

9.2.3.5.4 An amount of 400 mL to 500 mL (13.5 oz to 17 oz) of n-heptane shall be added to the fuel pan such that it will burn freely for 1.5 to 2.0 minutes.

9.2.3.5.5 The specimen shall be mounted in a specimen holder.

9.2.3.5.6 With the shutter retracted, the n-heptane shall be ignited using an ignition source.

9.2.3.5.6.1 Where paper or other material is used to ignite the n-heptane, it shall not be left in the fuel pan where it can disturb the flame pattern.

9.2.3.5.7 The n-heptane shall burn freely for 1 minute, ±5 seconds.

9.2.3.5.8 The shutter(s) shall be positioned above the flame.

9.2.3.5.9 The specimen shall be positioned above the shutter(s) over the approximate center of the flame area.

9.2.3.5.10 The shutter(s) shall be retracted, and specimen flame exposure shall commence not longer than 1 minute, 15 seconds from ignition.

9.2.3.5.11 The specimen shall be exposed to the flame for 12 seconds ± 0.2 second.

9.2.3.5.12 Following flame exposure, the shutter(s) shall be repositioned above the flame.

9.2.3.5.13 The afterflame time shall be measured as the time, in seconds, to the nearest 0.1 second that the specimen continues to flame after the shutter is repositioned over the flame.

9.2.3.5.14 Following the flame exposure, the specimen shall be visually examined for melting, dripping, and burn-through.

9.2.3.6 Report.

9.2.3.6.1 The afterflame time shall be recorded and reported for each specimen to the nearest 0.2 second. The average afterflame time shall be calculated and reported.

9.2.3.6.2 Observations of melting, dripping, or burn-through for each specimen shall be recorded and reported.

9.2.3.7 Interpretation. Pass or fail performance shall be based on the average afterflame time and any observed melting, dripping, or burn-through.

9.2.4 Heat and Thermal Shrinkage Resistance Test.

9.2.4.1 Application.

9.2.4.1.1 This test method shall apply to the following:

(1) Garment outer shells, moisture barriers, thermal barriers, collar linings, winter liners, trim, lettering, and other materials used in garment construction, including, but not limited to, padding, reinforcement, labels, interfacing, binding, hanger loops, emblems or patches, and elastic and hook and pile fasteners (when used where in contact with the wearer's body)
(2) Moisture barrier seams
(3) Hoods, wristlets, helmet ear cover materials, helmet shroud materials, helmet cover materials, helmet chin strap materials, innermost glove lining materials, trim, and label materials
(4) Protective helmets, protective gloves, and protective footwear

9.2.4.1.2 Modifications to this test method for testing garment outer shell, thermal barrier, winter liner, helmet ear cover, helmet shroud, helmet cover, and innermost glove lining materials shall be as specified in 9.2.4.8.

9.2.4.1.3 Modifications to this test method for testing garment moisture barrier materials and seams shall be as specified in 9.2.4.9.

9.2.4.1.4 Modifications to this test method for testing other garment, trim, and label materials shall be as specified in 9.2.4.10.

9.2.4.1.5 Modifications to this test method for testing hardware shall be as specified in 9.2.4.11.

9.2.4.1.6 Modifications to this test method for testing helmets shall be as specified in 9.2.4.12.

9.2.4.1.7 Modifications to this test method for testing gloves shall be as specified in 9.2.4.13.

9.2.4.1.8 Modifications to this test method for testing footwear shall be as specified in 9.2.4.14.

9.2.4.1.9 Modifications to this test method for testing lettering, including transfer film, shall be as specified in 9.2.4.15.

9.2.4.1.10 Modifications to this test method for testing hoods shall be as specified in 9.2.4.16.

9.2.4.1.11 Modifications to this test method for testing helmet chin strap materials shall be as specified in 9.2.4.17.

9.2.4.1.12 Modifications to this test method for testing wristlet materials shall be as specified in 9.2.4.18.

9.2.4.2 Samples. All samples shall be conditioned as specified in 9.1.3.

9.2.4.3 Specimens.

9.2.4.3.1 Only heat resistance testing shall be conducted on a minimum of three specimens for each moisture barrier seam, hardware item, glove lining material, trim material, label material, other protective garment materials, helmets, and footwear not specified in 9.2.4.3.2.

9.2.4.3.2 Both heat and thermal shrinkage resistance testing shall be conducted on a minimum of three specimens of whole gloves and for each garment outer shell, moisture barrier, thermal liner, winter liner, helmet ear cover, helmet shroud, helmet cover, and helmet chin strap materials. Each separable layer of multilayer material systems or composites shall be tested as an individual layer.

9.2.4.3.3 The unit area weight of materials specified in 9.2.4.3.2 shall be measured in accordance with the method in ASTM D3776/D3776M, *Standard Test Methods for Mass Per Unit Area (Weight) of Fabric*, within 4 hours of removal from conditioning as described in ASTM D1776 /D1776M, *Standard Practice for Conditioning and Testing Textiles.*

9.2.4.4 Apparatus. The test oven shall be as specified in ASTM F2894, *Standard Test Method for Evaluation of Materials, Protective Clothing, and Equipment for Heat Resistance Using a Hot Air Circulating Oven.*

9.2.4.5 Procedure.

9.2.4.5.1 Specimens shall be tested in accordance with ASTM F2894, *Standard Test Method for Evaluation of Materials, Protective Clothing, and Equipment for Heat Resistance Using a Hot Air Circulating Oven*, at a temperature of 260°C, +8°/−0°C (500°F, +14°/−0°F) for 5 minutes +15/−0 seconds.

9.2.4.5.2 While placing specimens in the oven for testing, the oven door shall not remain open more than 15 seconds.

9.2.4.5.3 The specimen mounted as specified in 9.2.4.5.2 shall be exposed in the test oven for 5 minutes, +0.15/−0 minute.

9.2.4.5.4 Immediately after the specified exposure, the specimen shall be removed and examined for evidence of ignition, melting, dripping, or separation.

9.2.4.5.5 Where specimens show evidence of ignition, melting, dripping, separation, or other forms of heat degradation specific to the type of element, a photograph shall be taken to document the condition of the specimen.

9.2.4.5.6 After the specified exposure, the specimen also shall be measured to determine pass or fail performance. Knit fabric shall be pulled to its original dimensions and shall be allowed to relax for 1 minute prior to measurement to determine pass or fail performance.

9.2.4.6 Report.

9.2.4.6.1 Where applicable, observations of ignition, melting, dripping, or separation shall be recorded and reported for each specimen.

9.2.4.6.2 Where applicable, the percent change in the width and length dimensions of each specimen shall be calculated. Results shall be recorded and reported as the average of all three specimens in each dimension.

9.2.4.6.3 Where applicable, the unit area weight of each specimen shall be reported.

9.2.4.6.4 Where applicable, a photograph of the heat degradation exhibited by any failing specimen shall be included as part of the test report.

9.2.4.7 Interpretation.

9.2.4.7.1 Where applicable, any evidence of ignition, melting, dripping, or separation on any specimen shall constitute failing performance.

9.2.4.7.2 Where applicable, the average percent change in both dimensions shall be used to determine pass or fail performance. Failure in any one dimension shall constitute failure for the entire sample.

9.2.4.8 Specific Requirements for Testing Garment Outer Shell, Thermal Liner, Winter Liner Materials, Helmet Ear Cover, Helmet Shrouds, Helmet Covers, and Glove Lining Materials.

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

9.2.4.8.2 Each specimen shall be 380 mm × 380 mm, ±13 mm (15 in. × 15 in., ±½ in.), and shall be cut from the fabric to be utilized in the construction of the clothing item.

9.2.4.8.3 Specimens shall be tested both before and after being subjected to the procedure specified in 9.1.2.

9.2.4.8.4 Testing shall be performed as specified in 9.2.4.2 through 9.2.4.7.

9.2.4.8.5 For protective garment outer shell and collar lining materials, any evidence of charring on any specimen of outer shell fabric shall also constitute failing performance in addition to 9.2.4.7.1.

9.2.4.8.6* For glove lining materials, all layers between the moisture barrier layer and the hand shall be individually tested. Where layers are permanently attached, the layers shall be permitted to be tested separately or attached. Where the moisture barrier layer is permanently attached to other layer(s) nearer to the hand and where the layer(s) nearer to the hand can be supplied individually for testing, only the layer(s) nearer the hand shall be tested and the moisture barrier shall not be tested. For glove lining materials, separation shall be reported if there is separation within a layer. However, separation between laminated layers shall not be reported as separation.

9.2.4.9 Specific Requirements for Testing Moisture Barrier Materials and Seams.

9.2.4.9.1 Samples for conditioning shall be at least 380 mm (15 in.) square and shall consist of a composite constructed using a layer of 7.5 oz/yd^2 woven 93 percent meta-aramid, 5 percent para-aramid, 2 percent antistat fiber with a nonfluorinated finish, the moisture barrier, and a layer of 7.8 oz/yd^2 ± 0.3 oz/yd^2 thermal barrier consisting of a woven plain weave face cloth quilted to two layers of aramid nonwoven. Where the sample includes the seam, the moisture barrier layer shall be constructed with a straight center seam that extends across the entire 380 mm (15 in.) width of the specimen. The three-layer composite shall be stitched around the entire periphery.

9.2.4.9.1.1 Where the layer intended to be the moisture barrier is configured of a composite that includes outer shell, moisture barrier, or thermal barrier combinations, the samples to be conditioned shall be constructed using those materials.

9.2.4.9.1.2 Where samples are prepared for evaluating the moisture barrier material only, marks shall be placed on the moisture barrier at 250 mm (10 in.) intervals on the moisture barrier layer for the post-oven exposure assessment of moisture barrier shrinkage.

9.2.4.9.1.3 Where samples are prepared for evaluating the moisture barrier material seams, the moisture barrier layer shall be prepared such that the seams bisect the sample into two halves. The sample with all layers shall be placed in the oven with the seam in a vertical orientation.

9.2.4.9.2 Samples shall become the test specimen and be tested both before and after conditioning as specified in 9.1.2.

9.2.4.9.3 Following the oven heat exposure, the moisture barrier layer shall be removed from the three-layer composite samples and examined for its condition.

9.2.4.9.3.1 Thermal shrinkage shall not be evaluated for moisture barrier seam samples.

9.2.4.9.4 For moisture barrier seam seal materials, observations shall be limited to seam material ignition and dripping.

9.2.4.9.5 Testing shall be performed as specified in 9.2.4.2 through 9.2.4.7. Thermal shrinkage shall not be measured.

9.2.4.10 Specific Requirements for Testing Other Garment, Clothing, Trim, and Label Materials.

9.2.4.10.1 Samples for conditioning shall include specimens attached to the textile layer as used in the protective garments positioned no closer than 50 mm (2 in.) apart in parallel strips. The textile material shall be at least 1 m (1 yd) square of the textile layer on which the specimens are attached. Specimens shall be removed from the textile material prior to testing, with the exception of label materials, which shall remain attached to the textile layer.

9.2.4.10.2 Specimen length shall be 150 mm (6 in.), other than for textiles utilized in the clothing item in lengths less than 150 mm (6 in.), where length shall be the same as utilized in the clothing item. Specimen width shall be 150 mm (6 in.), other than for textiles utilized in the clothing item in widths less than 150 mm (6 in.), where widths shall be the same as utilized in the clothing item.

9.2.4.10.3 Specimens shall be tested both before and after being subjected to the procedure specified in 9.1.2.

9.2.4.10.4 Testing shall be performed as specified in 9.2.4.2 through 9.2.4.7. Thermal shrinkage shall not be measured.

9.2.4.11 Specific Requirements for Testing Hardware.

9.2.4.11.1 A minimum of three complete hardware items shall be tested.

9.2.4.11.2 Observations of hardware condition following heat exposure shall be limited to ignition.

9.2.4.11.3 Hardware shall be evaluated for functionality within 10 minutes following removal from the oven.

9.2.4.11.4 Testing shall be performed as specified in 9.2.4.2 through 9.2.4.7. Thermal shrinkage shall not be measured.

9.2.4.12 Specific Requirements for Testing Helmets.

9.2.4.12.1 Samples for conditioning shall include complete helmets.

9.2.4.12.2 Three complete helmet specimens shall be tested. Helmet specimens shall include all components required in 7.5.2 or 7.6.2 as appropriate for the evaluation of structural firefighting protective helmet elements or proximity firefighting protective helmet elements, respectively.

9.2.4.12.3 Helmets with ear covers deployed and with the faceshield/goggle component in the stowed position as described in 9.1.17 shall be positioned according to the HPI as described in 9.1.13 on the nonconductive test headform specified in Figure 9.2.4.12.3. The chinstrap shall be secured under the chin of the headform.

9.2.4.12.4 The shell shall be measured at the eight points radially separated by 45 degrees, as shown in Figure 9.2.4.12.4. The measurements shall be taken from the bottom of the helmet shell to a flat base beneath the headform. The front area shall include measurement points 1, 2, and 3, the side areas shall include measurement points 4 and 8, and the back area shall include measurement points 5, 6, and 7. If there is a lower point of the helmet shell in the front area than the measurements taken at points 1, 2, and 3, then that point shall be measured also and shall be considered the initial lowest point of the helmet shell in the front area.

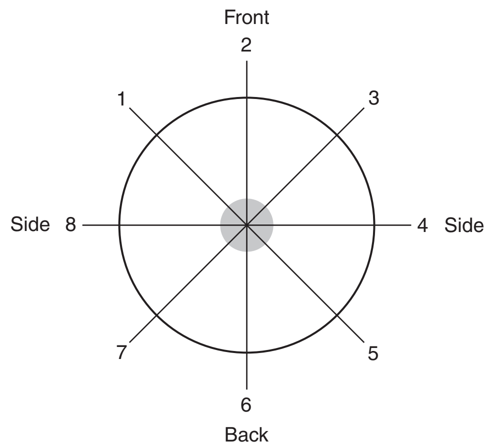


FIGURE 9.2.4.12.4 Helmet Shell Measurement Points.

9.2.4.12.5 If any helmet components in the front area are lower than the lowest point of the helmet shell in the front area, then the lowest point of those components shall be measured.

9.2.4.12.6 The headform with helmet attached shall be placed in the center of the test oven with the centerline of the front of the helmet facing the airflow. Only one helmet specimen shall be tested at a time.

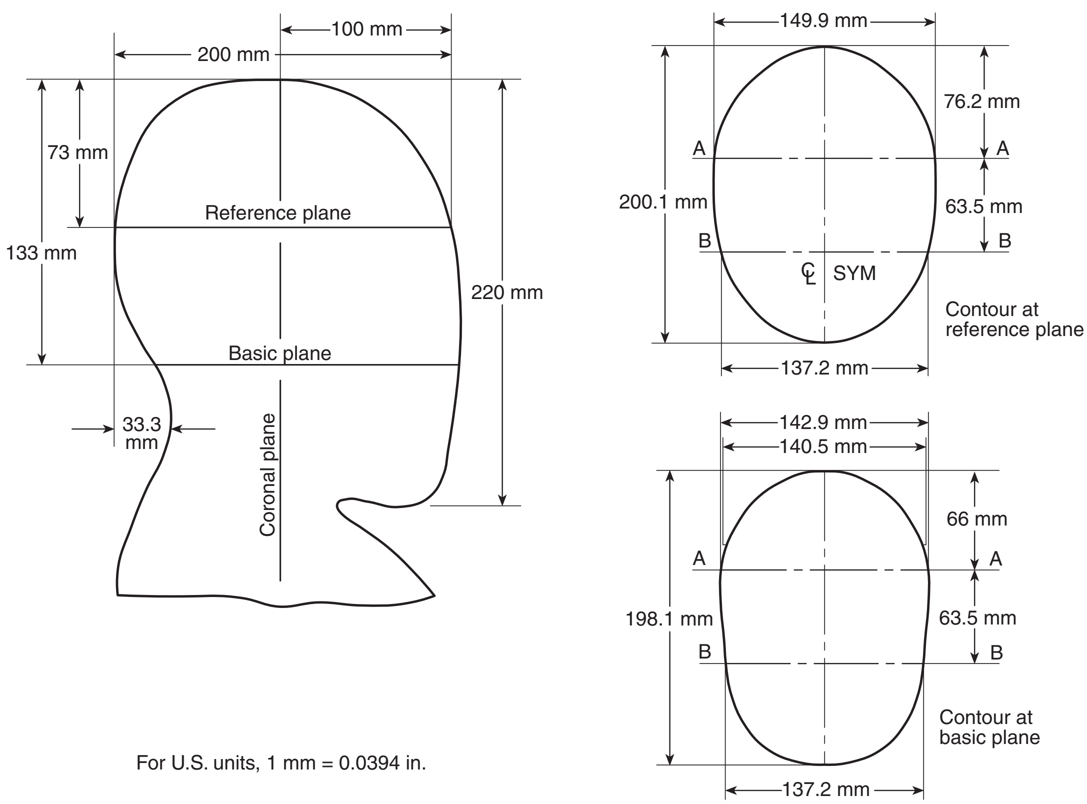


FIGURE 9.2.4.12.3 Nonconductive Test Headform.

9.2.4.12.7 The minimum interior dimensions of the test oven shall be 610 mm × 610 mm × 610 mm (24 in. × 24 in. × 24 in.).

9.2.4.12.8 The test thermocouple shall be positioned so that it is level with the horizontal centerline of a mounted test helmet. The thermocouple shall be equidistant between the vertical centerline of a mounted test helmet placed in the middle of the oven and the oven wall where the airflow enters the test chamber.

9.2.4.12.9 Following removal from the oven, the helmet shall be allowed to cool at room temperature for not less than 2 minutes.

9.2.4.12.10 The helmet shell shall then be measured as described in 9.2.4.12.4 to determine the shell distortion.

9.2.4.12.11 If there are any helmet components below the initial lowest point of the helmet shell in the front area, then the lowest point of those components shall be measured to determine component distortion.

9.2.4.12.12 The helmet shall be examined to ascertain any effects of the heat exposure.

9.2.4.12.13 Testing shall be performed as specified in 9.2.4.2 through 9.2.4.7. Thermal shrinkage shall not be measured.

9.2.4.13 Specific Requirements for Testing Gloves.

9.2.4.13.1 Samples for conditioning shall be whole gloves in size 76W.

9.2.4.13.2 The glove specimen dimensions shall be measured. The glove shall be made smooth and flattened in both directions to provide the most accurate measurement. A rigid ruler shall be used for the measurements. The length measurement of the glove specimen shall be from the tip of the middle finger to the end of the glove body on the palm side. The width measurement of the glove specimen shall be the width measurement on the palm side 25 mm (1 in.) below the base of the fingers.

9.2.4.13.3 The gloves shall then be conditioned as specified in 9.1.12.

9.2.4.13.4 The glove body shall then be filled with nominal 4 mm (⅛ in.) sized perforated soda-lime or borosilicate glass beads in the body of the glove and borosilicate glass rods in the fingers in the following manner:

(1) A borosilicate glass rod composite measuring 12.7 mm (½ in.) in diameter and 5 cm (2 in.) in length shall be placed in each of the five digits.
(2)* A lightweight bag constructed of 170 g/m^2 (5.0 oz/yd^2) or less heat-resistant material and measuring 120.5 mm (4.75 in.) high by 183.0 mm (7.20 in.) wide shall be filled with 375 mL of beads. The bag shall be sewn on all four sides with heat-resistant thread to keep the beads from spilling out. The bag filled with beads shall be placed inside the body of the glove.
(3) If the glove is of an extended gauntlet style where glove body materials continue into the glove interface component area and beyond, an extra bag of the same construction features described in 9.2.4.13.4(2) shall be used.
(4) The glass beads and rods shall be at a temperature of 21°C ± 3°C (71°F ± 5°F).
(5)* The opening of the glove shall be clamped together with the specimen suspended by the clamp in the oven such that the entire glove is not less than 50 mm (2 in.) from any oven surface and not less than 150 mm (6 in.) from any other specimen and airflow is parallel to the plane of the material. In the testing of gloves with wristlets, removing the wristlet to within 25 mm (1 in.) from its point of attachment shall be permitted if all of the wristlet is homogeneous and does not contain other materials for aiding in closing the glove sample.
(6) One to three glove specimens shall be placed in the test oven at one time.
(7) The glove specimens shall be suspended such that each specimen is the same distance from the airflow source so that no glove sample is blocking the airflow to other glove samples.

9.2.4.13.5 After the oven exposure, the glove specimen dimensions also shall be measured as described in 9.2.4.13.2 to determine pass or fail.

9.2.4.13.6 The percent change in the width and length dimensions of each specimen shall be calculated. Results shall be recorded and reported as the average of all three specimens in each dimension.

9.2.4.13.7 Specimens shall be donned and flexed as specified in 9.1.11 before and after the heat exposure.

9.2.4.13.8 Testing shall be performed as specified in 9.2.4.2 through 9.2.4.7.

9.2.4.14 Specific Requirements for Testing Footwear.

9.2.4.14.1 Samples for conditioning shall be whole boots.

9.2.4.14.2 Specimens shall be the whole footwear in men's size 9D.

9.2.4.14.3 Footwear specimens shall include sole, heel, and upper. Footwear specimens shall be filled to capacity with nominal 4 mm (⅛ in.) sized perforated soda-lime or borosilicate glass beads. Any closures shall be fastened. The top shall be filled and left open.

9.2.4.14.3.1 Where footwear has pull-up holes that fully penetrate the footwear from outside to inside, these holes shall be closed off with heat tape or other means so the boot can be filled with beads to full capacity.

9.2.4.14.4* The test thermocouple shall be positioned so that it is level with the horizontal centerline of a footwear test specimen. The thermocouple shall be equidistant between the vertical centerline of a footwear test specimen placed in the middle of the oven and the oven wall where the airflow enters the test chamber. The exact technique for supporting the boot in the oven shall be specified and provided as part of the test report.

9.2.4.14.5 The minimum interior dimensions of the test oven shall be 610 mm × 610 mm × 610 mm (24 in. × 24 in. × 24 in.).

9.2.4.14.6 Footwear specimens shall be placed in the center of the test oven with the centerline of the front of the specimen facing the airflow. Only one footwear specimen shall be tested at a time.

9.2.4.14.7 Testing shall be performed as specified in 9.2.4.2 through 9.2.4.7. Thermal shrinkage shall not be measured.

9.2.4.14.8 A minimum of three footwear items shall be tested.

9.2.4.14.9 Following removal from the oven, the specimen shall be allowed to cool at room temperature for not less than 5 minutes, +15/−0 seconds. Within 10 minutes,

+15/−0 seconds, after removal from the oven, the test specimen shall be examined inside and outside for evidence of ignition, melting, or separation.

9.2.4.14.9.1* Melting of any exterior component shall be recorded with the exception of small components that do not contribute to the required footwear protection. Exterior layers shall not display deformation that is more than 1.4 mm (0.055 in.) deep.

9.2.4.14.9.2 Footwear separation of 1.4 mm × 18 mm (0.055 in. × 0.71 in.) or more in any orientation shall be recorded and reported. Exterior layer seams shall not show separation of more than 18 mm (0.71 in.). Separation within 25 mm (1 in.) of the top line of the boot shall be excluded.

9.2.4.14.10 Each test specimen shall then be reconditioned as specified in 9.1.3 and then reexamined inside and outside for evidence of melting, separation, or ignition.

9.2.4.14.11 Footwear functionality shall be determined by flexing the specimen as specified in 9.1.19.

9.2.4.14.12 Specimens shall then be examined for evidence of sole separation, seam separation, or component breakage.

9.2.4.14.13 After flexing, the footwear specimen shall be marked with a water height line on the exterior at a height of 75 mm (3 in.) below the height of the boot as defined in 7.10.3.1 but no lower than 225 mm (8.86 in.) where measured up from the center of the insole at the heel as specified in 9.1.22.

9.2.4.14.13.1 Plain white paper toweling shall be placed inside the footwear specimen such that the paper toweling contacts all areas inside the footwear specimen to at least the water height line. The footwear specimen shall then be placed in a container that allows its immersion in tap water, treated with a dye and a surfactant that achieves a surface tension of 35 dynes/cm ± 5 dynes/cm, to the water height line.

9.2.4.14.13.2 The use of an inflatable, liquid-markable foot form shall be permitted to be used in lieu of the plain white paper toweling if it can be demonstrated that the foot form makes contact with the interior of the footwear up to the liquid height outside the footwear.

9.2.4.14.14 After 2 hours ± 10 minutes, the paper toweling shall be removed and examined for evidence of liquid leakage. The test specimen shall also be reexamined for evidence of sole separation or seam separation.

9.2.4.14.15* Footwear not remaining functional after flexing shall be recorded and reported as a failure for the tested specimen. The appearance of any liquid on the removed paper toweling shall be recorded and reported as a failure for the tested specimen. The general area of the failure shall be specified as part of the test report. One or more footwear specimens failing this test shall constitute failing performance.

9.2.4.15 Specific Requirements for Testing Lettering, Including Transfer Film.

9.2.4.15.1 Lettering, including transfer film, shall be applied to outer shell material, meeting the requirements of Chapters 4 through 9 of this standard, for testing as specified in 9.2.4.15.4.

9.2.4.15.2 Lettering specimens for heat resistance testing shall be at least a 150 mm (6 in.) square. Samples shall be selected where lettering is most dense.

9.2.4.15.3 Samples for conditioning shall be outer shell material of 1 m (1 yd) square with letters applied.

9.2.4.15.4 Testing shall be performed as described in 9.2.4.2 through 9.2.4.7. Thermal shrinkage shall not be measured.

9.2.4.16 Specific Requirements for Testing Hoods.

9.2.4.16.1 Samples for conditioning shall include complete hoods with labels.

9.2.4.16.2 Hoods shall be tested both before and after the conditioning specified in 9.1.2.

9.2.4.16.3 Testing shall be performed as specified in 9.2.4.4 through 9.2.4.6 unless modified herein.

9.2.4.16.4* Specimen face openings with elastic or manually adjustable face openings shall be placed over a hood measuring device as shown in Figure 9.2.4.16.4. This measuring device shall have marked graduations at 5 mm (0.2 in.) increments on its conical portion. Specimen face openings in the relaxed state shall slide freely over the top half of the device where the circumference measures 45.6 cm ± 0.6 cm (18.0 in. ± 0.25 in.). Specimen face openings shall then be placed around the lower half of the device where the circumference measures 54.5 cm ± 0.6 cm (21.5 in. ± 0.25 in.). Specimens shall then be visually inspected for gaps between the hood and the measuring device surface.

9.2.4.16.4.1 Specimen hoods with SCBA facepiece-specific openings shall be measured as specified in 9.8.10.5.1 through 9.8.10.5.3.

9.2.4.16.5 Hoods shall be donned on a nonconductive test headform as specified in Figure 9.2.4.12.3. Measurements shall also be made at the back and both sides of the hood from the top of the hood to the basic plane. The location of the basic plane on the hood shall be marked at each location.

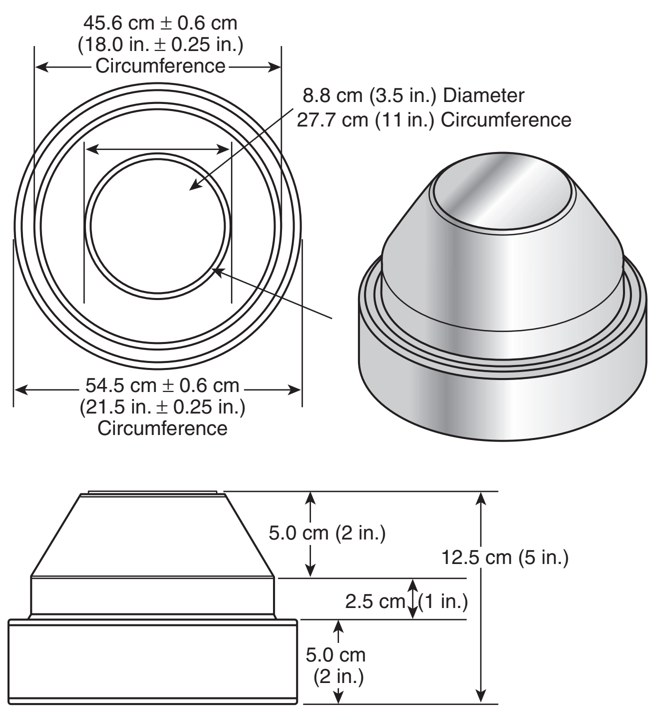


FIGURE 9.2.4.16.4 Hood Measuring Device.

9.2.4.16.6 The headform with hood donned shall be placed in the center of the test oven with the centerline of the front of the hood facing the airflow.

9.2.4.16.7 The minimum interior dimensions of the test oven shall be 610 mm × 610 mm × 610 mm (24 in. × 24 in. × 24 in.).

9.2.4.16.8 The test thermocouple shall be positioned so that it is level with the horizontal centerline of a mounted test hood. The thermocouple shall be equidistant between the vertical centerline of a mounted test hood placed in the middle of the oven wall where the airflow enters the test chamber.

9.2.4.16.9 Following removal from the oven, the hood shall be examined for evidence of ignition, melting, or separation. The hood shall be evaluated as described in 9.2.4.16.4. The distance from the top of the hood to the three marks along the basic plane shall also be measured.

9.2.4.16.10 Each of the three dimensions from the top of the hood to the marks along the basic plane before and after oven exposure shall be recorded and reported.

9.2.4.16.11 Observations of the following for specimens with elastic or manually adjustable face openings shall be recorded and reported:

(1) The ability of the face opening to slide freely over the top half of the hood measuring device
(2) An indication of the highest graduation on the cone for the sample if the face opening does not slide freely over the top of the hood measurement device
(3) Gaps between the hood face opening and the bottom half of the hood measuring device before and after heat exposure

9.2.4.16.11.1 Specimen hoods with SCBA facepiece openings shall be measured as specified in 9.8.10.5.1 through 9.8.10.5.3.

9.2.4.16.12 The percent shrinkage of each of the three dimensions from the top of the hood to the marks along the basic plane shall be individually calculated, recorded, and reported. The percent shrinkage of the face opening overlap on specimens with specific SCBA facepiece openings shall be individually calculated, recorded, and reported.

9.2.4.16.13* The average percent shrinkage of the three dimensions from the top of the hood to the marks along the basic plane for all specimens shall be calculated, recorded, and reported. The average percent shrinkage of the face opening overlap for each specimen with specific SCBA facepiece openings shall be individually calculated, recorded, and reported.

9.2.4.16.14* Pass or fail performance for specimens with elastic or manually adjustable face openings shall be based on the face opening being able to slide freely in the relaxed state over the top half of the hood measuring device and any observations of gaps between the hood face opening and the hood measuring device. Pass or fail performance for specimens designed to interface with a specific SCBA facepiece shall be based on the average percent shrinkage of the face opening overlap for each specimen.

9.2.4.16.15 Pass or fail performance shall also be based on the average percent shrinkage of the three dimensions from the top of the hood to the marks along the basic plane for each specimen. One or more hood specimens failing this test shall constitute failing performance.

9.2.4.17 Specific Requirements for Testing Helmet Chin Strap Materials.

9.2.4.17.1 Samples for conditioning shall be chin strap materials.

9.2.4.17.2 Specimens shall be 380 mm (15 in.) in length by the widest width of the chin strap used on the helmet.

9.2.4.17.3 Specimens shall be tested both before and after being subjected to the procedure specified in 9.1.2.

9.2.4.17.4 Thermal shrinkage shall be measured in the length direction only.

9.2.4.17.5 Testing shall be performed as specified in 9.2.4.2 through 9.2.4.7.

9.2.4.18 Specific Requirements for Testing Wristlet Materials.

9.2.4.18.1 Specimen length shall be 150 mm (6 in.). Specimen width shall be the same as utilized in the clothing item. Where wristlets are supplied in a tubular configuration, the specimen shall be slit in the lengthwise direction to provide a single layer.

9.2.4.18.2 Specimens shall be tested both before and after being subjected to the procedure specified in 9.1.2.

9.2.4.18.3 Testing shall be performed as specified in 9.2.4.2 through 9.2.4.7. The optional stretching frame shall not be utilized.

9.2.5 Thread Melting Test.

9.2.5.1 Application. This test method shall apply to each type of sewing thread used in the construction of protective garments, hoods, wristlets, gloves, helmets, helmet covers, shrouds, and footwear.

9.2.5.2 Samples. Samples for conditioning shall be lengths of thread 150 mm (6 in.) or greater.

9.2.5.3 Specimens.

9.2.5.3.1 A total of three different specimens of each thread type shall be tested.

9.2.5.3.2 All specimens shall be conditioned as specified in 9.1.3 prior to testing.

9.2.5.4* Procedure.

9.2.5.4.1 The melting temperature of specimens shall be determined in accordance with ASTM D7138, *Standard Test Method to Determine Melting Temperature of Synthetic Fibers*, using Procedure 1 or Procedure 2.

9.2.5.5 Report.

9.2.5.5.1 The melting point of the sample unit shall be the average of the results obtained from the specimens tested and shall be recorded and reported to the nearest degree C.

9.2.5.5.2 The pass/fail results for each specimen tested shall be recorded and reported.

9.2.5.6 Interpretation. One or more thread specimens failing this test shall constitute failing performance for the thread type.

9.2.6 Resistance to High-Temperature Blocking Test.

9.2.6.1 Application. This test method shall apply to proximity firefighting garment outer shell materials, proximity firefighting glove outer shell materials, proximity firefighting helmet outer covers, and proximity firefighting helmet shrouds.

9.2.6.2 Specimens. Specimens shall be tested after being subjected to the procedure specified in 9.1.3.

9.2.6.3 Procedure.

9.2.6.3.1 Blocking test procedure shall be as stated in Method 5872, *Temperature, High, Effect on Cloth Blocking*, of Federal Test Method Standard 191A, *Textile Test Methods*.

9.2.6.3.2 Following each test procedure, the test specimen shall be examined to determine pass or fail performance.

9.2.6.4 Report. Any evidence of blocking shall be recorded and reported.

9.2.6.5 Interpretation. Failure of any one specimen shall constitute failure of the unit of product.

9.2.7 Conductive Heat Resistance Test 1.

9.2.7.1 Application.

9.2.7.1.1 This test method shall apply to glove body composites representative of the palm of the gloves and footwear upper material.

9.2.7.1.2 Modifications for this test method for testing glove composites shall be as specified in 9.2.7.7.

9.2.7.1.3 Modifications for this test method for testing footwear composites shall be as specified in 9.2.7.8.

9.2.7.2 Samples.

9.2.7.2.1 Samples for conditioning shall be whole boots and glove composite pouches as specified in 9.2.7.7.2.

9.2.7.2.2 Samples shall be conditioned as specified in 9.1.3.

9.2.7.3 Specimens.

9.2.7.3.1 A total of three specimens of gloves and three specimens of footwear shall be tested for each condition.

9.2.7.3.2 The thickness of each specimen shall be measured in accordance with ASTM D1777, *Standard Test Method for Thickness of Textile Materials*, within 4 hours of removal from conditioning as described in ASTM D1776 /D1776M, *Standard Practice for Conditioning and Testing Textiles*.

9.2.7.3.3 The weight of each specimen shall be measured in accordance with the method in ASTM D3776/D3776M, *Standard Test Methods for Mass Per Unit Area (Weight) of Fabric*, within 4 hours of removal from conditioning as described in ASTM D1776 /D1776M, *Standard Practice for Conditioning and Testing Textiles*.

9.2.7.4 Procedure. Specimens shall be tested in accordance with ASTM F1060, *Standard Test Method for Evaluation of Conductive and Compressive Heat Resistance (CCHR)*, with the following modifications:

(1) Specimens shall be tested using an exposure temperature of 280°C (536°F). The pressure applied during the test shall be as specified in 9.2.7.7 and 9.2.7.8.
(2) The time in seconds to pain and to second-degree burn and blister, as predicted by the Stoll Human Tissue Burn Tolerance Criteria, shall be recorded.
(3) The section of the apparatus lowering the specimen, sensor, and weighed system shall travel at a constant rate of speed. The specimen shall be lowered parallel to the hot plate. The recorder/computer shall be activated automatically by a mechanical or electrical contact when the specimen contacts the hot plate.
(4) Calibration shall be performed at 280ºC, +3/−0°C. (536°F, +5/−0°F). A calibration media shall be used that generates a 6- to 7-second time to pain value and a 10- to 12-second time to second-degree burn value.

9.2.7.5 Report.

9.2.7.5.1 The time to pain and time to second-degree burn for each specimen shall be recorded and reported.

9.2.7.5.2 The average time to pain and time to second-degree burn shall be calculated, recorded, and reported.

9.2.7.5.3 Where the time to pain or time to second-degree burn is greater than 30 seconds, the time to pain or time to second-degree burn shall be recorded and reported as ">30 seconds" for time to pain and ">30 seconds" for time to second-degree burn.

9.2.7.5.4 The thickness of each specimen shall be reported.

9.2.7.5.5 The unit area weight of each specimen shall be reported.

9.2.7.6 Interpretation. Pass or fail determinations shall be based on the average time to pain and time to second-degree burn of all specimens tested.

9.2.7.7 Specific Requirements for Testing Gloves.

9.2.7.7.1 Specimens shall be representative of the glove body composite construction at the palm of the glove at the following glove areas as described in 9.1.17: A-P, B-P, C-P, D-P, E-P, F-P, G-P, H-P, I-P, A-PS, B-PS, C-PS, D-PS, E-PS, F-PS, H-PS, and I-PS. Specimens shall be representative of each glove body composite construction at the palm of the hand. All variations in composite construction, including number of layers and the order of layering of composite materials, shall constitute a new composite and shall be tested separately.

9.2.7.7.2 For glove body composites, specimens for conditioning shall be in the form of a pouch as described in 9.1.14.

9.2.7.7.3 Specimens shall be tested after being subjected to the procedure specified in 9.1.3 both before and after laundering as specified in 9.1.12 for a total of two conditions.

9.2.7.7.4 Specimens shall also be tested after being subjected to wet conditioning as specified in 9.1.8 both before and after laundering as specified in 9.1.12 for a total of two conditions.

9.2.7.7.5 Testing shall be performed as specified in 9.2.7.2 through 9.2.7.6.

9.2.7.7.6 After the specimens are conditioned as specified in 9.2.7.7.2 and 9.2.7.7.4, the pouch and necessary stitching shall be cut to form 100 mm × 150 mm (4 in. × 6 in.) or 150 mm × 150 mm (6 in. × 6 in.) specimens for testing. Specimens shall not include seams where multiple layers are involved, except in the following cases:

(1) Where a ridged area or similar stitching is used to create specific performance characteristics rather than for glove assembly
(2) Where size constraints of a material make it necessary to allow stitching to create the sample size required. Stitch-

ing shall be of the same type as is used in the actual glove construction.

9.2.7.7.7 The pressure applied during the test shall be 3.45 kPa ± 0.35 kPa (0.5 psi ± 0.05 psi) for specimens representative of the glove body composite construction at the palm of the glove as described in 9.2.7.7.1.

9.2.7.8 Specific Requirements for Testing Footwear Upper Materials.

9.2.7.8.1 Specimens shall consist of each composite of the footwear upper used in the actual footwear construction, including the tongue but excluding the gusset, with the layers arranged in proper order. Where a composite is identical to another composite except for additional reinforcement layer(s), the composite with no reinforcement layers shall be tested.

9.2.7.8.2 Testing shall be performed as specified in 9.2.7.2 through 9.2.7.6.

9.2.7.8.3 A pressure of 3.45 kPa ± 0.35 kPa (0.5 psi ± 0.05 psi) shall be applied during the test.

9.2.8 Conductive Heat Resistance Test 2.

9.2.8.1 Application. This test method shall apply to the protective footwear sole.

9.2.8.2 Samples.

9.2.8.2.1 Samples for conditioning shall be whole footwear with removable insoles in place.

9.2.8.2.2 Samples shall be conditioned as specified in 9.1.3.

9.2.8.3 Specimens. A minimum of three complete footwear items, including booties where provided, shall be tested.

9.2.8.4 Apparatus. The apparatus shall consist of an electric hotplate measuring 305 mm × 305 mm (12 in. × 12 in.) capable of maintaining a temperature of 260°C (500°F), Type J or Type K thermocouples, and a meter to read the thermocouple temperatures.

9.2.8.5 Procedure.

9.2.8.5.1 The thermocouples shall be taped to the insole surface of the specimen next to the foot in the following locations, as shown in Figure 9.2.8.5.1:

(1) Directly above the center of the ball of the footwear
(2) Directly above the center of the heel of the footwear
(3) Directly above the toe to heel center of the arch of the footwear, at the inside junction between the upper and the sole

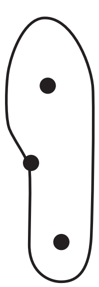


FIGURE 9.2.8.5.1 Thermocouple Locations.

9.2.8.5.2 The hot plate shall be heated to a temperature of 260°C ± 5°C (500°F ± 10°F) and shall maintain this temperature throughout the test period.

9.2.8.5.3 The specimen shall be filled with 4.55 kg ± 0.25 kg (10 lb ± 0.5 lb) of 10 mm ± 1 mm (0.39 in. ± 0.039 in.) steel balls. The weight of the steel balls shall be evenly distributed inside the boot. The specimen shall be placed on the plate in the upright position for 20 minutes, +15/−0 seconds.

9.2.8.5.4 The thermocouple temperatures shall be recorded at 20 minutes, +15/−0 seconds, after the specimen is placed on the heated hot plate.

9.2.8.6 Report.

9.2.8.6.1 The temperature at 20 minutes of exposure shall be recorded and reported for each test location for each specimen.

9.2.8.6.2 The average temperature at 20 minutes of exposure for each test location for all specimens shall also be calculated, recorded, and reported.

9.2.8.7 Interpretation. The average temperature at 20 minutes of exposure for each test location for all specimens shall be used to determine pass or fail performance.

9.2.9 Conductive Heat Resistance Test 3.

9.2.9.1 Application. This test method shall apply to proximity footwear upper material.

9.2.9.2 Samples.

9.2.9.2.1 Samples for conditioning shall be whole footwear.

9.2.9.2.2 There shall be at least three samples of footwear.

9.2.9.3 Specimens.

9.2.9.3.1 A total of three specimens of footwear shall be tested.

9.2.9.3.2 Footwear specimens shall be cut from portions of the footwear upper or from a composite that is representative of footwear upper construction at the thinnest part. Specimens shall consist of each composite of footwear upper used in the actual footwear construction, including the tongue but excluding the gusset, with the layers arranged in proper order. Where a composite is identical to another composite except for additional reinforcement layer(s), the composite with no reinforcement layers shall be tested.

9.2.9.3.3 Specimens shall be conditioned as specified in 9.1.3.

9.2.9.4 Procedure. Specimens shall be tested in accordance with ASTM F1060, *Standard Test Method for Evaluation of Conductive and Compressive Heat Resistance (CCHR)*, with the following modifications:

(1) Specimens shall be tested using an exposure temperature of 100°C (212°F). The pressure applied during the test shall be 3.45 kPa, ±0.35 kPa (0.5 psi, ±0.05 psi).
(2) The test exposure duration shall be 10 minutes.

9.2.9.5 Report. The maximum temperature during the 10-minute exposure shall be recorded and reported.

9.2.9.6 Interpretation. Pass/fail determinations shall be based on the average temperature of all specimens tested.

9.2.10 Conductive and Compressive Heat Resistance (CCHR) Test.

9.2.10.1 Application. This test method shall apply to the shoulder areas and the knee areas of protective garments.

9.2.10.2 Samples.

9.2.10.2.1 Samples shall consist of composites representative of all layers of the shoulder areas and knee areas used in the actual construction of the protective garment. Different samples shall be made representing each different composite combination used by the garment manufacturer.

9.2.10.2.2 Samples shall measure 200 mm × 200 mm (8 in. × 8 in.) and shall be prepared of the composite layers. The sample of the composite layers shall be sewn along two adjacent sides, with the layers arranged in the same order and orientation as intended to be worn.

9.2.10.2.3 All samples shall first be conditioned as specified in 9.1.2.

9.2.10.3 Specimens.

9.2.10.3.1 A minimum of six specimens for testing shall be taken from the samples after the conditioning specified in 9.2.10.2.3.

9.2.10.3.2 The thickness of each specimen shall be measured in accordance with ASTM D1777, *Standard Test Method for Thickness of Textile Materials*, within 4 hours of removal from conditioning as described in ASTM D1776 /D1776M, *Standard Practice for Conditioning and Testing Textiles*.

9.2.10.3.3 The specimens shall measure 150 mm × 150 mm (6 in. × 6 in.) and shall be cut from the sample excluding the sewn areas so that the composite layers comprising the specimen are not sewn together at any point.

9.2.10.3.4 Specimens for both wet condition testing and dry condition testing shall then be conditioned as specified in 9.1.3.

9.2.10.3.5 The weight of each specimen shall be measured and reported to the nearest gram.

9.2.10.3.6 Specimens shall be conditioned for wet condition testing as specified in 9.2.10.3.7.

9.2.10.3.7 For wet testing, the innermost layer of the composite specimen shall then be further conditioned as follows prior to testing:

(1) Blotter paper measuring 225 mm × 225 mm (9 in × 9 in) shall be saturated in distilled water.
(2) Two sheets of the saturated blotter paper shall be run together through a wringer that meets the requirements of 10.2 of AATCC TM70, *Test Method for Water Repellency: Tumble Jar Dynamic Absorption Test*.
(3) The innermost layer of the composite specimen shall be placed between two sheets of blotting paper.
(4) The innermost layer of the composite specimen, between the two sheets of blotting paper, shall be placed into a 4-L (1-gal) size air and liquidtight bag and the bag shall be sealed closed.
(5) The innermost layer of the composite specimen between the two sheets of blotting paper shall be conditioned in the air and liquidtight bag at room temperature for at least 24 hours, and shall not be removed from conditioning more than 5 minutes prior to testing.
(6) After removal from conditioning, the innermost layer shall be removed from the blotting paper, and the composite specimen shall be reassembled with all layers arranged in the same order and orientation as intended to be worn.
(7) The overall weight of the wet specimen shall be measured and reported to the nearest gram.

9.2.10.3.8 A minimum of three specimens shall be tested for shoulder areas in the wet condition. A minimum of three specimens shall be tested for knee areas in the wet condition.

9.2.10.4 Apparatus. The test apparatus shall be in accordance with ASTM F1060, *Standard Test Method for Evaluation of Conductive and Compressive Heat Resistance (CCHR)*, with the following modifications:

(1) For the shoulder area CCHR rating, the sensor assembly shall be modified so that the pressure applied to the test specimens shall be 140 g/cm^2 ± 1.4 g/cm^2 (2 psi ± 0.2 psi).
(2) For the knee area CCHR rating, the sensor assembly shall be modified so that the pressure applied to the test specimens shall be 562 g/cm^2 ± 56 g/cm^2 (8 psi ± 0.8 psi).

9.2.10.5 Procedure. Specimens shall be tested in accordance with ASTM F1060, *Standard Test Method for Evaluation of Conductive and Compressive Heat Resistance (CCHR)*, with the following modifications:

(1) Specimens shall be tested using an exposure temperature of 280°C, +3/−0°C (536°F, +5/−0°F).
(2) Time “zero” shall be the time that the sensor and specimen are placed in direct contact with the exposure surface.
(3) The time to a second-degree burn shall be measured up to 60 seconds as allowed by the equation for extrapolating the Stoll curve.
(4) A determination shall be made if the time to second-degree burn is equal to or exceeds 25.0 seconds.
(5) Specimens showing a second-degree burn time that is equal to or greater than 25 seconds shall be considered to have demonstrated passing performance. Specimens that have a second-degree burn time that is less than 25 seconds shall be considered to have demonstrated failing performance.
(6) Calibration shall be performed at 280°C, +3/−0°C (536°F, +5/−0°F), using a calibration media that produces between 6- and 7-second time to pain values and between 10- and 12-second time to second-degree burn.

9.2.10.6 Report.

9.2.10.6.1 The thickness and dry weight for each specimen shall be reported.

9.2.10.6.2 The wet weight for wet conditioning specimens shall be reported for each specimen.

9.2.10.6.3 The difference between the wet weight and dry weight for each specimen shall be calculated and reported.

9.2.10.6.4 The time to second-degree burn shall be reported for each specimen.

9.2.10.6.5 The number of specimens demonstrating passing performance and the number of specimens showing failing performance shall be reported separately for the shoulder area and the knee area under both dry and wet conditions.

9.2.10.7 Interpretation. Shoulder area and knee area composites shall be considered to have demonstrated passing performance when there are no reported failures for any specimen under either dry or wet conditions.

9.2.11 Radiant Heat Resistance Test 1.

9.2.11.1 Application. This test method shall apply to protective footwear.

9.2.11.2 Samples.

9.2.11.2.1 Samples for conditioning shall be complete footwear.

9.2.11.2.2 In lieu of complete footwear, it shall be permitted to use composite samples measuring 150 mm x 150 mm (6 in. x 6 in.) that have all layers representative of the material composites used in the construction of the footwear upper.

9.2.11.2.3 Samples shall be tested after being subjected to the conditioning procedure specified in 9.1.3.

9.2.11.3 Specimens.

9.2.11.3.1 A minimum of three complete footwear items, including booties where provided, shall be tested.

9.2.11.3.2 Where composite samples are tested in lieu of complete footwear items, a minimum of three composite samples for each unique composite used in the construction of the footwear upper shall be tested.

9.2.11.4 Apparatus. The apparatus shall consist of the following:

(1) Radiometer of the Schmidt-Boelter or Gardon-type with radiant heat flux transducer, with a diameter of 25 mm (1 in.), a minimum viewing angle of 150 degrees, a minimum spectral response flat within 3 percent over a range of at least 1.0 μm to 10.0 μm, and an overall accuracy of at least ±5 percent of the reading
(2) Radiant panel with an effective radiating surface of not less than 150 mm × 150 mm (6 in. × 6 in.) and an emittance approximating that of a blackbody of 1000K ± 200K (1340°F ± 360°F)
(3) Thermocouple with meter
(4) Test chamber that prevents interference from air movement
(5) Where composite samples are tested in lieu of complete footwear items, a sample holder constructed to hold a 150 mm × 150 mm (6 in. × 6 in.) sample with a 89 mm × 89 mm ± 3 mm (3.5 in. × 3.5 in. ± ⅛ in.) exposure window to support and position the center of the footwear composite specimen vertically in a flat orientation at the correct distance from the radiant panel source

9.2.11.5 Procedure.

9.2.11.5.1 Tests shall be done on each area of the footwear upper, including the tongue but excluding the gusset, that consists of a different composite. Where a composite is identical to another composite except for additional reinforcement layer(s), the composite with no reinforcement layers shall be representative of the composite with reinforcement layer(s).

9.2.11.5.2 The radiant panel shall be placed in front of the radiometer, parallel to the plane tangent to the radiometer. The radiant panel shall be adjusted to obtain a stable, uniform irradiance of 1.0 W/cm^2, +0.01/−0 W/cm^2, over a minimum 75 mm (3 in.) diameter circle located on the above plane and centered at the center of the test area. Calibration shall be achieved when the irradiance changes by less than 10 percent during a 3-minute period.

9.2.11.5.3 The thermocouple shall be affixed with thermally conductive adhesive to the inside surface of the lining next to the foot in the center of the test area. The radiometer shall be replaced with the protective footwear, with the test area oriented parallel to the plane tangent to the heat source at the same distance from the heat source. The area shall be exposed for 30 seconds, +5/−0 seconds.

9.2.11.5.4 The thermocouple temperature shall be recorded at 30 seconds, +5/−0 seconds, of exposure.

9.2.11.6 Report.

9.2.11.6.1 The temperature at 30 seconds of exposure shall be recorded and reported for each area of the footwear upper for each specimen.

9.2.11.6.2 The average temperature at 30 seconds of exposure for each area of the footwear upper for all specimens shall also be calculated, recorded, and reported.

9.2.11.6.3 Where complete footwear is evaluated, photographs shall be provided indicating the specific location of the radiant heat exposure.

9.2.11.6.4 Where specific damage is noted to either areas of exposed completed footwear or composite samples, photographs shall be provided to the show the condition of the sample along with observations of any damage caused by the radiant heat exposure.

9.2.11.7 Interpretation. The average temperature at 30 seconds of exposure for each area of the footwear upper for all specimens tested shall be used to determine pass or fail performance.

9.2.12 Radiant Heat Resistance Test 2.

9.2.12.1 Application. This test method shall apply to proximity protective footwear.

9.2.12.2 Samples. Samples for conditioning shall be complete footwear.

9.2.12.3 Specimen Preparation.

9.2.12.3.1 A minimum of three complete footwear items shall be tested.

9.2.12.3.2 Specimens shall be conditioned in accordance with 9.1.3.

9.2.12.4 Apparatus. The apparatus shall consist of the following:

(1) Radiometer of the Schmidt-Boelter or Gardon type with radiant heat flux transducer with a diameter of 25 mm (1 in.), a minimum viewing angle of 150 degrees, a minimum spectral response flat within 3 percent over a range of at least 1.0 μm to 10.0 μm, and an overall accuracy of at least ±5 percent of the reading.

(2) Radiant panel with an effective radiating surface of not less than 150 mm × 150 mm (6 in. × 6 in.) and an emittance approximating that of a blackbody of 1000K ± 200K (1340°F ± 360°F)
(3) Thermocouple with meter
(4) Test chamber that prevents interference from air movement
(5) A means of holding the boot in place so that boot material shrinkage does not cause movement of the boot away from the panel

9.2.12.5 Procedure.

9.2.12.5.1 Tests shall be done on each area of the footwear upper, including the tongue but excluding the gusset, which consists of a different composite. Where a composite is identical to another composite except for additional reinforcement layer(s), the composite with no reinforcement layers shall be representative of the composite with reinforcement layer(s).

9.2.12.5.2 The radiant panel shall be placed in front of the radiometer, parallel to the plane tangent to the radiometer. The radiant panel shall be adjusted to obtain a stable, uniform irradiance of 4.0 W/cm^2, +0.4/−0.0 W/cm^2 (1.0 cal/cm^2/sec, +0.01/−0.0 cal/cm^2/sec), over a minimum 75 mm (3 in.) diameter circle located on the above plane and centered at the center of the test area. Calibration shall be achieved when the irradiance changes by less than 10 percent during a 3-minute period.

9.2.12.5.3 The thermocouple shall be affixed with thermally conductive adhesive to the inside surface of the lining next to the foot in the center of the test area. The radiometer shall be replaced with the protective footwear with the test area oriented parallel to the plane tangent to the heat source at the same distance from the heat source. The area shall be exposed for 100 seconds, +5/−0 seconds.

9.2.12.5.4 The thermocouple temperature shall be recorded at 100 seconds of exposure.

9.2.12.6 Report.

9.2.12.6.1 The temperature at 100 seconds of exposure shall be reported for each specimen.

9.2.12.6.2 The average temperature at 100 seconds of exposure for all specimens shall also be calculated and reported.

9.2.12.7 Interpretation. The average temperature at 100 seconds of exposure for all specimens tested shall be used to determine pass/fail performance.

9.2.13 Radiant Heat Resistance Test 3.

9.2.13.1 Application. This test shall apply to helmet shell systems.

9.2.13.2 Samples.

9.2.13.2.1 One sample helmet shell shall be used.

9.2.13.2.2 The sample helmet shall have any reflective outer covering in place as intended for use, but shall have all shock absorbing and thermally insulating materials removed from the interior.

9.2.13.3 Specimens. Specimens shall be conditioned as specified in 9.1.3.2.

9.2.13.4 Apparatus.

9.2.13.4.1 The test apparatus shall be the radiant exposure chamber as specified in 9.1.6.

9.2.13.4.2 The sensor shall be an exposed bead Type J or K30 AWG thermocouple that will be connected to a recording device that is capable of reading degrees centigrade.

9.2.13.5 Calibration Procedure. The chamber shall be calibrated according to the calibration procedure specified in 9.1.6 to obtain a stable uniform irradiance of 1.0 W/cm^2 ± 0.1 W/cm^2.

9.2.13.6 Procedure.

9.2.13.6.1 One specimen helmet shell, with any reflective outer covering in place as intended for use but with all shock absorbing and/or thermally insulating materials removed from the interior, shall be used.

9.2.13.6.2 An exposed bead Type J or K30 AWG thermocouple shall be fastened to the inner surface of the specimen helmet shell in such a way that the thermocouple bead is in contact with the shell material. The thermocouple bead shall be permitted to be placed at any location within a 100 mm (4 in.) diameter of where the front rear axis of the center line of the shell and the intersection of the bitragion coronal meet. There shall be no internal or external projections greater than 2 mm ($\frac{1}{16}$ in.) in height on the shell within 25 mm (1 in.) of the thermocouple bead in any direction. The thermocouple shall be connected to a recording device that reads degrees centigrade.

9.2.13.6.3 The specimen helmet with thermocouple shall be placed in the radiant exposure chamber specified in 9.1.6. With the radiant panel adjusted to provide a stable uniform irradiance of 1.0 W/cm^2 ± 0.1 W/cm^2 in accordance with 9.1.6, the sample shall be placed in the chamber so that the thermocouple location is in the center of the area of radiant exposure.

9.2.13.6.4 The specimen shall be exposed to an irradiance of 1.0 W/cm^2 ± 0.1 W/cm^2 for 180 seconds.

9.2.13.6.5 Thermocouple temperatures shall be recorded at the beginning and at the end of the 180 seconds.

9.2.13.7 Report. The difference of the initial temperature and the temperature at 180 seconds shall be recorded and reported.

9.2.13.8 Interpretation. Any rise in temperature greater than 25°C (78°F) shall constitute failure of this test.

9.2.14 Radiant Protective Performance Test.

9.2.14.1 Application.

9.2.14.1.1 This test method shall apply to garment outer shell materials, glove outer shell materials, helmet faceshields, helmet outer covers, and helmet shrouds.

9.2.14.1.2 Modifications to this test method for testing garment outer shell and glove outer shell materials shall be as specified in 9.2.14.7.

9.2.14.2 Samples. Samples for conditioning shall be garment and glove outer shell materials, helmet faceshields, helmet outer covers, and helmet shrouds.

9.2.14.3 Specimens.

9.2.14.3.1 Five specimens of each sample shall be conditioned in accordance with 9.1.3 prior to testing.

9.2.14.3.2 Test specimens shall be 75 mm × 250 mm (3 in. × 10 in.).

9.2.14.3.3 All specimens excluding helmet faceshields shall be conditioned by means of abrading the sample before removing it from the conditioned atmosphere. Specimens shall be tested for radiant heat not more than 5 minutes after removal from conditioning.

9.2.14.3.4 All specimens shall be conditioned on an oscillating drum abrasion apparatus as specified in ASTM D4157, *Standard Test Method for Abrasion Resistance of Textile Fabrics (Oscillatory Cylinder Method)*. The specimens shall be mounted on the oscillating drum of the apparatus. The abradant shall be No. 6 hard-textured cotton duck conforming to the construction, weight, and strength of Type I of Federal Specification CCC-C-419, *Cloth, Duck, Unbleached, Plied-Yarns, Army and Numbered*, and shall be cut into strips 45 mm (1⅞ in.) wide by 230 mm (9 in.) long with the long dimension in the warp or wale direction. The abradant shall be mounted in the specimen holding clamps under a tension of 13.5 N (3 lbf) and a head load of 1.36 kg (3 lb). A new abradant shall be used for each test, and the contact area of the abradant shall be free of slubs, knots, or other weave imperfections. The test specimens shall be subjected to 300 abrasion cycles.

9.2.14.3.5 The thickness of each specimen shall be measured in accordance with ASTM D1777, *Standard Test Method for Thickness of Textile Materials*, within 4 hours of removal from conditioning as described in ASTM D1776 /D1776M, *Standard Practice for Conditioning and Testing Textiles*.

9.2.14.3.6 The weight of each specimen shall be measured in accordance with the method in ASTM D3776/D3776M, *Standard Test Methods for Mass Per Unit Area (Weight) of Fabric*, within 4 hours of removal from conditioning as described in ASTM D1776 /D1776M, *Standard Practice for Conditioning and Testing Textiles*.

9.2.14.4 Procedure.

9.2.14.4.1 Specimens shall be tested in accordance with ASTM F1939, *Standard Test Method for Radiant Heat Resistance of Flame Resistant Clothing Materials with Continuous Heating*.

9.2.14.4.2 The selected test exposure shall be 2 cal/cm^2 as provided for in the test method.

9.2.14.4.3 The following provisions of ASTM F1939 shall not be required:

(1) Section 9.2, Laundering of Laboratory Samples
(2) Section 9.4, Determination of Test Specimen Average Thickness
(3) Section 9.5, Determination of Test Specimen Average Surface Density

9.2.14.5 Report.

9.2.14.5.1 Five specimens shall be tested, and the intersect time shall be determined.

9.2.14.5.2 The average intersect time of the five specimens shall be calculated, recorded, and reported.

9.2.14.5.3 The thickness of each specimen shall be reported.

9.2.14.5.4 The unit area weight of each specimen shall be reported.

9.2.14.6 Interpretation. The average intersect time of all specimens of an item shall be used to determine pass or fail performance.

9.2.14.7 Modifications for Testing Garment Outer Shell and Glove Outer Shell Materials.

9.2.14.7.1 The garment and glove outer shell material test specimens shall be 75 mm × 250 mm (3 in. × 10 in.) with the long dimension in the warp or wale direction.

9.2.14.7.2 Specimens shall be tested as specified in 9.2.14.2 through 9.2.14.7.

9.2.14.8 Modifications for Testing Helmet Faceshields.

9.2.14.8.1 The specimen holder assembly plates shall have a thickness of 3 mm ± 0.1 mm to minimize deformation of the holder by the specimen.

9.2.14.8.2 The specimen holder assembly front plate shall have a center cut-out of 64 mm × 125 mm (2½ in. × 5 in.).

9.2.14.8.3 The test specimen shall be a minimum of 100 mm × 137 mm (4 in. × 5½ in.). The test specimen shall be cut from a faceshield with the long dimension representing the vertical direction as worn.

9.2.14.8.4 The faceshield shall be mounted with only enough force to secure the faceshield in the sample holder. The mounting screws shall not be tightened to the point of distorting the faceshield or sample holder.

9.2.15 Transmitted and Stored Thermal Energy Test.

9.2.15.1 Application.

9.2.15.1.1 This test method shall apply to garment sleeve composites containing enhancements as defined in 8.2.4 exterior to the outer shell.

9.2.15.1.2 Modifications to this test method for testing garment sleeve composites containing enhancements exterior to the outer shell shall be as specified in 9.2.15.7.

9.2.15.1.3 Modifications to this test method for testing the glove body composite at the back of the glove shall be as specified in 9.2.15.8.

9.2.15.1.4 Modifications to this test method for testing particulate blocking hoods shall be as specified in 9.2.15.9.

9.2.15.2 Samples. Samples shall measure 150 mm × 150 mm ± 6 mm (6 in. × 6 in. ± ¼ in.) and consist of all layers representative of the item to be tested.

9.2.15.2.1 Samples shall not be stitched to hold individual layers together during testing.

9.2.15.2.2 Enhancements shall be sewn to the center of the outer shell of the composite if they cannot meet the sample measurement requirements.

9.2.15.3 Specimens.

9.2.15.3.1 Transmitted and stored thermal energy testing shall be conducted on five specimens.

9.2.15.3.2 Garment sleeve composites shall be conditioned in accordance with Section 9.3 of ASTM F2731, *Standard Test Method for Measuring the Transmitted and Stored Energy of Firefighter Protective Clothing Systems*.

9.2.15.4 Procedure. Transmitted and stored thermal energy testing shall be conducted in accordance with Procedure B of ASTM F2731, *Standard Test Method for Measuring the Transmitted and Stored Energy of Firefighter Protective Clothing Systems*, with the modification specified in 9.2.15.4.1.

9.2.15.4.1 For garment sleeve composites, the exposure time shall be for a period of 120 seconds, +1/−0 seconds.

9.2.15.5 Report. The average time to second-degree burn shall be calculated and reported. If no burn injury occurs, the time to second-degree burn shall be reported as "no burn."

9.2.15.6 Interpretation. Pass/fail determination shall be based on the average reported time to second-degree burn of all specimens tested.

9.2.15.7 Specific Requirements for Testing Garment Sleeve Composites Containing Enhancements Exterior to the Outer Shell.

9.2.15.7.1 A three-layer composite shall be used to test enhancements exterior to the outer shell.

9.2.15.7.2 The composite shall be constructed using a layer of 7.5 oz/yd^2 natural woven 93 percent meta-aramid, 5 percent para-aramid, 2 percent antistat fiber, 4.7 oz/yd^2 ± 0.2 oz/yd^2, expanded PTFE laminated to a woven aramid fabric, and a layer of 3.8 oz/yd^2 ± 0.3 oz/yd^2, aramid needle punched nonwoven, quilted to 3.4 oz/yd^2, aramid plain weave thermal barrier material.

9.2.15.7.3 Additional layers found used in the construction of the garment shall be placed in the composite as found in the garment.

9.2.15.8 Specific Requirements for Testing Glove Body Composites at the Back of the Glove.

9.2.15.8.1 Specimens shall be representative of the glove body composite construction at the back of the glove at the following glove areas described in 9.1.17: A-A, B-B, the 25 mm (1 in.) of C-B adjacent to the wrist crease, D-B, and E-B.

9.2.15.8.2 The thickness of each specimen shall be measured in accordance with ASTM D1777, *Standard Test Method for Thickness of Textile Materials*, within 4 hours of removal from conditioning as described in ASTM D1776 /D1776M, *Standard Practice for Conditioning and Testing Textiles*, and provided in the report.

9.2.15.8.3 The weight of each specimen shall be measured in accordance with the method in ASTM D3776/D3776M, *Standard Test Methods for Mass Per Unit Area (Weight) of Fabric*, within 4 hours of removal from conditioning as described in ASTM D1776 /D1776M, *Standard Practice for Conditioning and Testing Textiles*, and provided in the report.

9.2.15.8.4 Glove body composites at the back of the glove shall be conditioned as specified in 9.1.9.

9.2.15.8.5 The specimens shall be tested as specified in 9.2.15.4 with the exception that the radiant heat exposure period shall continue until the second-degree burn point is reached. No compression period shall be used for this testing.

9.2.15.8.6 The testing shall be run on separate samples at each of the three moisture conditions specified in 9.1.9.

9.2.15.9 Specific Requirements for Testing Particulate Blocking Hoods.

9.2.15.9.1 Specimens for conditioning shall measure 150 mm x 150 mm ± 6 mm (6 in. x 6 in.± ¼ in.).

9.2.15.9.2 Specimens shall consist of a composite constructed of all layers used in the particulate blocking hoods, oriented in the order as worn.

9.2.15.9.3 A total of 5 specimens in each condition shall be tested.

9.2.15.9.4 One set of specimens shall be preconditioned as specified in 9.1.9 with the following modifications:

(1) The volume of water applied shall be 3.4 grams ± 0.2 grams.
(2) The water shall be applied to the innermost layer of the composite and be tested within 2 minutes after preconditioning.

9.2.15.9.4.1 A second set of specimens shall be tested in a dry condition.

9.2.15.9.5 Transmitted and stored thermal energy testing shall be conducted in accordance with Procedure B of ASTM F2731, *Standard Test Method for Measuring the Transmitted and Stored Thermal Energy of Firefighter Protective Clothing Systems,* with the following modifications:

(1) The upper mounting plate shall be replaced with an alternate upper mounting plate whose thickness shall not exceed 3 mm (⅛ in.). Alternate methods meeting the minimum thickness requirements shall be permitted to be used to achieve specimen mounting.
(2) The exposure time shall be for a period of 120 seconds, + 1/− 0 seconds, or until a time to predicted second-degree burn is achieved up to 240 seconds. No compression period shall be used for this testing.

9.2.15.9.6 The average time to second-degree burn shall be calculated, recorded, and reported for each test condition (dry and wet). If no burn injury occurs with the maximum exposure period of 240 seconds, the time to second-degree burn shall be reported as "no burn."

9.2.16* Thermal Protective Performance (TPP) Test.

9.2.16.1 Application.

9.2.16.1.1* This test method shall apply to multilayer protective garment composites, glove body composites, glove interface component composites, wristlets, helmet ear covers, shrouds, and hoods, including single layer knit hoods that are worn in contact with the skin.

9.2.16.1.2 Modifications to this test method for testing garment composites shall be as specified in 9.2.16.8.

9.2.16.1.3 Modifications to this test method for testing hoods shall be as specified in 9.2.16.9.

9.2.16.1.4 Modifications to this test method for testing wristlets shall be as specified in 9.2.16.10.

9.2.16.1.5 Modifications to this test method for testing glove body composites shall be as specified in 9.2.16.11.

9.2.16.1.6 Modifications to this test method for testing glove interface components other than wristlets shall be as specified in 9.2.16.12.

9.2.16.1.7 Modifications to this test method for testing helmet ear covers shall be as specified in 9.2.16.13.

9.2.16.2 Samples. Samples shall measure 150 mm × 150 mm ± 6 mm (6 in. × 6 in. ± ¼ in.) and shall consist of all layers representative of the clothing item to be tested.

9.2.16.3 Specimens.

9.2.16.3.1 Thermal protective performance testing shall be conducted on three specimens.

9.2.16.3.2 Specimens shall be tested after the conditioning as specified in 9.1.3.

9.2.16.3.3 The thickness of each specimen shall be measured in accordance with ASTM D1777, *Standard Test Method for Thickness of Textile Materials*, within 4 hours of removal from conditioning as described in ASTM D1776 /D1776M, *Standard Practice for Conditioning and Testing Textiles*.

9.2.16.3.4 The weight of each specimen shall be measured in accordance with the method in ASTM D3776/D3776M, *Standard Test Methods for Mass Per Unit Area (Weight) of Fabric*, within 4 hours of removal from conditioning as described in ASTM D1776 /D1776M, *Standard Practice for Conditioning and Testing Textiles*.

9.2.16.4 Apparatus. The test apparatus specified in ISO 17492, *Clothing for protection against heat and flame — Determination of heat transmission on exposure to both flame and radiant heat*, shall be used.

9.2.16.5* Procedure. Thermal protective performance testing shall be performed in accordance with ISO 17492, *Clothing for protection against heat and flame — Determination of heat transmission on exposure to both flame and radiant heat*, with the following modifications:

(1) An exposure heat flux of 84 kW/m^2 ± 2 kW/m^2 (2.0 cal/cm^2s ± 0.05 cal/cm^2s) shall be used.
(2) The contact configuration shall be used for testing of all material specimens.
(3) The thermal threshold index analysis method shall be used with calculations using the heat flux in calories per square centimeter per second and reported as the TPP rating.
(4) The radiant thermal flux source shall consist of nine 500W T3 translucent (frosted) quartz infrared lamps.
(5) The specimen mounting plate and specimen holding plate shall be stainless steel having a density of 7850 ± 200 kg/m^3.

9.2.16.6 Report.

9.2.16.6.1 The individual test TPP rating of each specimen shall be recorded and reported.

9.2.16.6.2 The average TPP rating shall be calculated and reported.

9.2.16.6.3 Where a TPP rating is greater than 60, then the TPP rating shall be recorded and reported as “>60.”

9.2.16.6.4 The thickness of each specimen shall be reported.

9.2.16.6.5 The unit area weight of each specimen shall be reported.

9.2.16.7 Interpretation.

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

9.2.16.7.2 Where an individual result from any test set varies more than ±8 percent from the average result, the results from the test set shall be discarded and another set of specimens shall be tested.

9.2.16.8 Specific Requirements for Testing Garments.

9.2.16.8.1 Specimens shall consist of outer shell, moisture barrier, and thermal barrier. Winter liners shall not be included in the test composite. Collar lining fabric shall be permitted to be included in the protective garment collar fabric composite specimen. Specimens shall not include seams. Specimens shall not be stitched to hold individual layers together during testing.

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

9.2.16.8.3 Testing shall be performed as described in 9.2.16.2 through 9.2.16.7.

9.2.16.9 Specific Requirements for Testing Protective Hoods.

9.2.16.9.1 Specimens shall consist of materials from the portion of the protective hood that covers the neck and facial area. Specimens shall not include seams. Specimens shall not be stitched to hold individual layers together during testing.

9.2.16.9.2 Samples for conditioning shall include hood material that is a minimum of 175 mm (7 in.) square.

9.2.16.9.3 Testing shall be performed as described in 9.2.16.2 through 9.2.16.7.

9.2.16.10 Specific Requirements for Testing Protective Wristlets.

9.2.16.10.1 Specimens shall consist of materials from the portion of the protective wristlet that covers the wrist area or from the wristlet glove interface component. Specimens shall not include seams. Specimens shall not be stitched to hold individual layers together during testing.

9.2.16.10.2 Samples for conditioning shall include wristlet material that is a minimum of 180 mm (7 in.) square.

9.2.16.10.3 Testing shall be performed as described in 9.2.16.2 through 9.2.16.7.

9.2.16.11 Specific Requirements for Testing Protective Glove Body Composites.

9.2.16.11.1 Samples for conditioning shall be glove body composite pouches as specified in 9.2.16.11.3.

9.2.16.11.2 Specimens shall be representative of each glove body composite construction. All variations in composite construction, including number of layers and the order of layering of composite materials, shall constitute a new composite and shall be tested separately. Where a composite is identical to another composite except for additional reinforcement layer(s), the composite with no reinforcement layers shall be representative of the composite with reinforcement layer(s).

9.2.16.11.3 For glove body composites, samples for conditioning shall be in the form of a pouch as described in 9.1.14.

9.2.16.11.4 Specimens shall be tested both before and after conditioning as specified in 9.1.12 and then conditioned as specified in 9.1.3.

9.2.16.11.5 After conditioning, the pouch and stitching shall be cut to form 175 mm × 175 mm (7 in. × 7 in.) specimens for testing. Specimens shall not include seams where multiple layers are involved, except in the following cases:

(1) Where a ridged area or similar stitching is used to create specific performance characteristics rather than for glove assembly
(2) Where size constraints of a material make it necessary to allow stitching in order to create the sample size required

9.2.16.11.6 Stitching shall be of the same type as is used in the actual glove construction.

9.2.16.11.7 Specimens shall not be stitched to hold individual layers together during testing.

9.2.16.11.8 Testing shall be performed as described in 9.2.16.2 through 9.2.16.7.

9.2.16.11.9 The requirement of 9.2.16.7.2 shall not apply.

9.2.16.12 Specific Requirements for Testing Protective Glove Interface Components Other Than Wristlet Composites.

9.2.16.12.1 Samples for conditioning shall be glove interface component composite swatches as specified in 9.2.16.12.3.

9.2.16.12.2 Specimens shall be representative of the glove interface component composite construction. All variations in composite construction, including number of layers and the order of layering of composite materials, shall constitute a new composite and shall be tested separately. Where a composite is identical to another composite except for additional reinforcement layer(s), the composite with no reinforcement layers shall be representative of the composite with reinforcement layer(s).

9.2.16.12.3 For glove interface component composites, samples for conditioning shall be in the form of a pouch as described in 9.1.14.

9.2.16.12.4 Specimens shall be tested both before and after conditioning as specified in 9.1.12 and then conditioned as specified in 9.1.3.

9.2.16.12.5 After conditioning, the stitching shall be cut to form 175 mm × 175 mm (7 in. × 7 in.) specimens for testing. Specimens shall not include seams where multiple layers are involved, except in the following cases:

(1) Where a ridged area or similar stitching is used to create specific performance characteristics rather than for glove assembly
(2) Where size constraints of a material make it necessary to allow stitching in order to create the sample size required.

9.2.16.12.6 Stitching shall be of the same type as is used in the actual glove construction.

9.2.16.12.7 Specimens shall not be stitched to hold individual layers together during testing.

9.2.16.12.8 Testing shall be performed as described in 9.2.16.2 through 9.2.16.7.

9.2.16.12.9 The requirements of 9.2.16.7.2 shall not apply.

9.2.16.13 Specific Requirements for Testing Helmet Ear Covers and Shrouds.

9.2.16.13.1 Specimens shall consist of materials from the portion of the ear covers that cover the ear and neck area or from the portion of the shroud that covers the head, face, and neck area. Specimens shall not include seams. Specimens shall not be stitched to hold individual layers together during testing.

9.2.16.13.2 Samples for conditioning shall include ear cover material that is a minimum of 175 mm (7 in.) square.

9.2.16.13.3 Testing shall be performed as described in 9.2.16.2 through 9.2.16.7.

9.2.17 Flame Resistance Test 3.

9.2.17.1 Application. This test method shall apply to the protective glove body, glove interface components, and glove extension composites.

9.2.17.2 Samples.

9.2.17.2.1 Samples shall be prepared for each glove body composite, each glove interface component, and each glove extension composite.

9.2.17.2.2 Samples for conditioning other than wristlets shall be prepared pouches as described in 9.1.14.

9.2.17.2.3 Wristlet samples shall consist of wristlet material.

9.2.17.2.4 Samples other than wristlets shall be conditioned as specified in 9.1.12 followed by the conditioning specified in 9.1.3.

9.2.17.2.5 Wristlet samples shall be conditioned as specified in 9.1.2, followed by the conditioning specified in 9.1.3.

9.2.17.2.6 Separate samples shall be conditioned as specified in 9.1.3 only.

9.2.17.3 Specimens.

9.2.17.3.1 After conditioning, the necessary stitching shall be cut to form 50 mm × 150 mm (2 in. × 6 in.) specimens for testing.

9.2.17.3.2 Three specimens shall be tested after the conditioning specified in 9.2.17.2.4 for other than wristlet samples or 9.2.17.2.5 for wristlet samples of.

9.2.17.3.3 Three additional specimens shall be tested after the conditioning specified in 9.2.17.2.6.

9.2.17.4 Apparatus.

9.2.17.4.1 The test apparatus specified in Method 5905.1, *Flame Resistance of Material; High Heat Flux Flame Contact, of Federal Test Method Standard 191A, Textile Test Methods*, shall be used.

9.2.17.4.2 A freestanding flame height indicator shall be used to assist in adjusting the burner flame height.

9.2.17.4.2.1 The flame height indicator shall mark a flame height of 75 mm (3 in.) above the top of the burner.

9.2.17.4.3 A specimen support assembly shall be used that consists of a frame and steel rod of 2 mm (1⁄16 in.) in diameter to support the specimen in an L-shaped position as shown in Figure 9.2.17.4.3.

9.2.17.4.4 The horizontal portion of the specimen shall be not less than 50 mm (2 in.).

9.2.17.4.5 The vertical portion of the specimen shall be not less than 100 mm (4 in.).

9.2.17.4.6 The specimen shall be held at each end by spring clips under light tension as shown in Figure 9.2.17.4.3.

9.2.17.5 Procedure.

9.2.17.5.1 A balance shall be used to determine the weight of each specimen to the nearest 0.1 g (0.04 oz) before and after testing.

9.2.17.5.2 The burner shall be ignited.

9.2.17.5.2.1 The test flame shall be adjusted to a height of 75 mm (3 in.) with the gas on/off valve fully open and the air supply completely and permanently off, as it is important that the flame height be closely controlled.

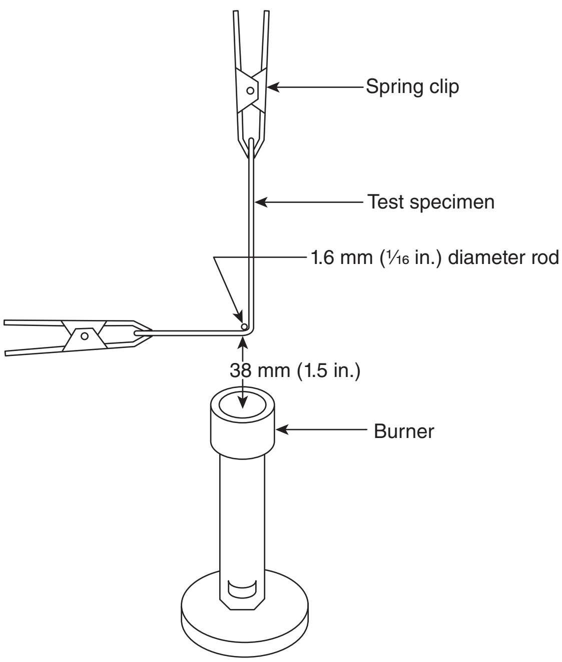


FIGURE 9.2.17.4.3 Relationship of Test Material to Burner.

9.2.17.5.2.2 The 75 mm (3 in.) height shall be obtained by adjusting the orifice in the bottom of the burner so that the top of the flame is level with the marked flame height indicator.

9.2.17.5.3 With the specimen mounted in the support assembly, the burner shall be moved so that the middle of the folded corner projects into the flame 38 mm (1½ in.) as shown in Figure 9.2.17.4.3.

9.2.17.5.4 The burner flame shall be applied to the specimen for 12 seconds.

9.2.17.5.4.1 After 12 seconds, the burner shall be removed.

9.2.17.5.5 The afterflame time shall be measured as the time, in seconds, to the nearest 0.2 second that the specimen continues to flame after the burner is removed from the flame.

9.2.17.5.6 Each layer of the specimen shall be examined for melting or dripping.

9.2.17.5.7 Each tested sample shall be reconditioned as specified in 9.1.3 and then weighed to the nearest 0.1 g (0.04 oz).

9.2.17.5.8 The specimen then shall be further examined for char length.

9.2.17.5.8.1 The char length shall be determined by measuring the length of the tear through the center of the charred area as specified in 9.2.17.5.8.2 through 9.2.17.5.8.7.

9.2.17.5.8.2 The specimen shall be folded lengthwise and creased, by hand, along a line through the highest peak of the charred area.

9.2.17.5.8.3 The hook shall be inserted into a hole punched in the specimen in accordance with the following:

(1) The hole shall be 6 mm (¼ in.) in diameter or less.
(2) The hole shall be punched out for the hook at one side of the charred area that is 6 mm (¼ in.) from the adjacent outside edge, at the point where the specimen contacted the steel rod, and 6 mm (¼ in.) away from the point where the specimen contacted the steel rod in the 101 mm (4 in.) direction as shown in Figure 9.2.17.5.8.3.

9.2.17.5.8.4 A weight shall be attached to the hook so that the weight and hook together equal the total tearing weight required by Table 9.2.17.5.8.4 based on the weight of the composite specimen.

9.2.17.5.8.5 A tearing force shall be applied gently to the specimen by grasping the side of the material at the edge of the

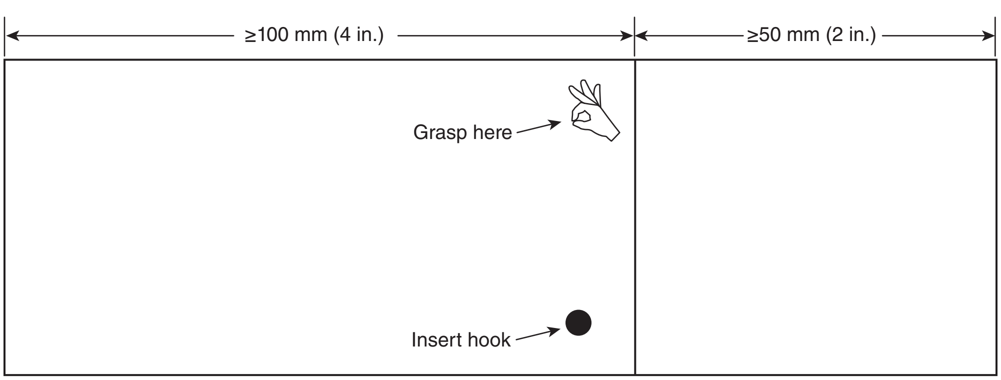


FIGURE 9.2.17.5.8.3 Position of Hole and Side to Grasp for Determining Char Length.

Table 9.2.17.5.8.4 Determination of Tearing Weight

Specified Weight per Square Yard of Material Before Any Fire-Retardant Treatment or Coating		Total Tearing Weight for Determining Charred Length	
g/m^2	oz/yd^2	kg	lb
68–203	2.0–6.0	0.1	¼
>203–508	>6.0–15.0	0.2	½
>508–780	>15.0–23.0	0.3	¾
>780	>23.0	0.45	1

char opposite the load as shown in Figure 9.2.17.5.8.3 and raising the specimen and weight clear of the supporting surface.

9.2.17.5.8.6 The end of the tear shall be marked off on the edge.

9.2.17.5.8.7 The char length measurement shall be made along the undamaged edge.

9.2.17.6 Report.

9.2.17.6.1 The afterflame time and char length shall be recorded and reported for each specimen.

9.2.17.6.1.1 The average afterflame time and char length shall be calculated, recorded, and reported.

9.2.17.6.1.2 The afterflame time shall be recorded and reported to the nearest 0.2 second.

9.2.17.6.1.3 The char length shall be recorded and reported to the nearest 2.5 mm (0.10 in.).

9.2.17.6.2 The percent consumed shall be calculated using the following formula:

[9.2.17.6.2]

$$\text{Percent consumed} = \frac{W - R}{W} \times 100$$

where:
W = original conditioned weight
R = conditioned weight 24 hours after testing

9.2.17.6.2.1 The percent consumed shall be recorded and reported for each specimen to the nearest 0.1 percent.

9.2.17.6.2.2 The average percent consumed shall be calculated, recorded, and reported to the nearest 0.1 percent.

9.2.17.6.3 Observations of melting or dripping for each specimen shall be recorded and reported.

9.2.17.7 Interpretation. Pass or fail performance shall be based on melting or dripping, the average afterflame time, and the average char length.

9.3 Physical Hazard Test Methods.

9.3.1 Tear Resistance Test.

9.3.1.1 Application.

9.3.1.1.1 This test shall apply to garment outer shell, moisture barrier, and thermal barrier materials.

9.3.1.1.2 This test shall also apply to woven materials used in hood, helmet cover, shroud, and wristlet materials.

9.3.1.1.3 This test shall also apply to bootie materials where a bootie is used as part of the garment construction.

9.3.1.2 Samples.

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

9.3.1.2.2 Samples shall be tested after being conditioned as specified in 9.1.3.

9.3.1.2.3 All samples, except for outer shell materials, shall be tested after being conditioned as specified in 9.1.2.

9.3.1.2.4 Separate outer shell samples shall be tested after being conditioned as specified in 9.1.21.

9.3.1.2.5 Separate outer shell samples shall be tested after being conditioned according to the following sequence:

(1) Outer shell material shall be cut into 610 mm × 457 mm ± 13 mm (24 in. × 18 in. ± ½ in.) samples and sewn around the cut edge to prevent fraying.
(2) Samples shall be subjected to 40 hours of continuous light exposure in accordance with ASTM G155, *Standard Practice for Operating Xenon Arc Lamp Apparatus for Exposure of Materials*, using Cycle 8 exposure conditions. Both inner and outer filters shall be borosilicate. Exposure duration shall not include dark cycles.
(3) Samples shall be subjected to the procedure in 9.1.3.

9.3.1.3 Specimens. A minimum of five specimens in each of the warp or machine direction and the fil, or cross-machine, direction shall be tested.

9.3.1.4 Procedure.

9.3.1.4.1 Specimens shall be tested in accordance with ASTM D5587, *Standard Test Method for the Tearing Strength of Fabrics by Trapezoid Procedure.*

9.3.1.4.2 Slippage of the specimen shall not be permitted.

9.3.1.5 Report.

9.3.1.5.1 The tear resistance of an individual specimen shall be the average of the five highest peak loads of resistance registered.

9.3.1.5.2 The tear strength of each specimen shall be recorded and reported to the nearest 0.5 N (0.1 lbf) of force.

9.3.1.5.3 An average tear strength shall be calculated, recorded, and reported for warp and filling directions.

9.3.1.6 Interpretation.

9.3.1.6.1 Pass or fail performance shall be based on the average tear resistance in the warp and filling directions only when testing specimens prepared according to 9.3.1.2.2 through 9.3.1.2.4 only.

9.3.1.6.2 Failure in any one direction shall constitute failure for the material.

9.3.2 Breaking Strength Test.

9.3.2.1 Application. This test shall apply to garment outer shell and collar lining materials used in protective garments.

9.3.2.2 Samples.

9.3.2.2.1 Samples for conditioning shall be 1 m (1 yd) square of material.

9.3.2.2.2 Samples shall be conditioned to the procedure specified in 9.1.2 at 10 cycles.

9.3.2.3 Specimens. Five specimens in each of the warp and filling directions shall be tested from each sample.

9.3.2.4 Procedure. Specimens shall be tested for breaking strength in accordance with ASTM D5034, *Standard Test Method for Breaking Strength and Elongation of Textile Fabrics (Grab Test).*

9.3.2.5 Report.

9.3.2.5.1 The breaking strength of each specimen shall be recorded and reported.

9.3.2.5.2 The average breaking strength shall be calculated, recorded, and for the warp and filling directions.

9.3.2.6 Interpretation.

9.3.2.6.1 Pass or fail performance shall be based on the average breaking strength in the warp and filling directions.

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

9.3.3 Burst Strength Test.

9.3.3.1 Application. This test shall apply to knit materials used in protective garments, hoods, and wristlets.

9.3.3.2 Samples.

9.3.3.2.1 Samples shall be conditioned as specified in 9.1.3.

9.3.3.2.2 Samples for conditioning shall be 1 m (1 yd) square of knit material for materials provided in roll form, and 1 m (1 yd) in length for knit materials provided in tubular form.

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

9.3.3.4 Procedure. Specimens shall be tested as specified in ASTM D6797, *Standard Test Method for Bursting Strength of Fabrics Constant-Rate-of-Extension (CRE) Ball Burst Test.*

9.3.3.5 Report. The burst strength of each specimen shall be recorded and reported. The average burst strength of all specimens shall be calculated, recorded, and reported.

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

9.3.4 Seam-Breaking Strength Test.

9.3.4.1 Application.

9.3.4.1.1 This test method shall apply to seams used in protective clothing items, including booties where present, clothing item wristlets, glove interface components, and hoods.

9.3.4.1.2 Modifications to this test method for testing clothing item wristlets and glove interface components shall be as specified in 9.3.4.7.

9.3.4.2 Samples.

9.3.4.2.1 Samples for conditioning shall be 1 m (1 yd) length of seam.

9.3.4.2.2 Samples shall be submitted for testing after being subjected to the procedure specified in 9.1.2.

9.3.4.3 Specimens.

9.3.4.3.1 A minimum of five seam specimens representative of the clothing item shall be tested for each seam type.

9.3.4.3.2 The five seam specimens shall be straight seams. Seam specimens shall be permitted to be cut from the finished clothing item or shall be permitted to be prepared by joining two pieces of the clothing item fabric. Where specimens are cut from finished clothing items, such specimens shall be conditioned after being cut from the finished clothing item.

9.3.4.3.2.1 Where two pieces of woven clothing item fabric are joined, the woven fabric seam specimen shall be prepared as specified in 10.3 of ASTM D1683/D1683M, *Standard Test Method for Failure in Sewn Seams of Woven Fabrics*, and shall use the same thread, seam type, and stitch type as used in the finished clothing item.

9.3.4.3.2.2 Where two pieces of knit or stretch woven clothing item fabric are joined, the knit fabric seam specimen shall be prepared as specified in 7.2.2 of ASTM D3940, *Standard Test Method for Bursting Strength (Load) and Elongation of Sewn Seams of Knit or Woven Stretch Textile Fabrics*, using the same thread, seam type, and stitch type as used in the finished clothing item.

9.3.4.3.2.3 Specimens of clothing item seam assemblies constructed from other than woven or knit textiles shall be tested as specified in 9.3.4.3.2.1.

9.3.4.3.2.4 Where a piece of woven clothing item fabric and a knit or stretch woven fabric are joined, the seam specimen shall be prepared as specified in 10.3 of ASTM D1683/D1683M, *Standard Test Method for Failure in Sewn Seams of Woven Fabrics*, and shall use the same thread, seam type, and stitch type as used in the finished clothing item.

9.3.4.4 Procedure.

9.3.4.4.1 All woven seam assemblies shall be tested in accordance with ASTM D1683/D1683M, *Standard Test Method for Failure in Sewn Seams of Woven Fabrics*. The test machine shall be operated at a rate of 305 mm/min (12 in./min).

9.3.4.4.2 All knit seam assemblies and all stretch woven seam assemblies shall be tested in accordance with ASTM D6797, *Standard Test Method for Bursting Strength of Fabrics Constant-Rate-of-Extension (CRE) Ball Burst Test.*

9.3.4.4.3 Combination woven and knit or stretch woven seam assemblies shall be tested in accordance with ASTM D1683/D1683M, *Standard Test Method for Failure in Sewn Seams of Woven Fabrics*. The test machine shall be operated at a rate of 304.8 mm/min (12 in./min).

9.3.4.5 Report.

9.3.4.5.1 The seam-breaking strength for each seam specimen shall be recorded and reported.

9.3.4.5.2 The average seam-breaking strength for each seam type shall also be recorded and reported.

9.3.4.5.3 The type of seams tested shall be recorded and reported as to whether the specimens were cut from the finished clothing item or prepared from fabric samples.

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

9.3.4.7 Specific Requirements for Testing Protective Clothing Item Wristlets and Glove Interface Components.

9.3.4.7.1 Specimens for conditioning and testing shall consist of seams taken from the wristlet/clothing item sleeve or the glove interface/glove body junction.

9.3.4.7.2 Whole gloves shall be permitted to be used for conditioning.

9.3.4.7.3 Glove specimens shall be conditioned as specified in 9.1.12 prior to testing.

9.3.4.7.4 Specimen sizes shall be 100 mm × 200 mm (4 in. × 8 in.), with the seam horizontally in the middle of the 100 mm (4 in.) dimension.

9.3.4.7.5 Evaluation for sewn seam strength in accordance with Section 11.1 of ASTM D1683/D1683M, *Standard Test Method for Failure in Sewn Seams of Woven Fabrics*, shall be used to determine pass or fail performance.

9.3.5 Helmet Top Impact Resistance Test (Force).

9.3.5.1 Application. This test shall apply to complete helmets.

9.3.5.2 Samples. Samples for conditioning shall be complete helmets. Externally mounted faceshield/goggle components shall be removed. Internally mounted faceshield components shall be removed except where the internal faceshield is an integral part of the structural integrity of the helmet. Front holders, which could interfere with the impacting of the helmet shell, shall be removed. Mounting holes shall remain.

9.3.5.3 Specimens.

9.3.5.3.1 Three helmet specimens shall be tested for each condition specified.

9.3.5.3.2 Specimens shall be conditioned for each environmental condition specified in 9.1.3, 9.1.4, 9.1.5, 9.1.6, and 9.1.7 prior to each impact.

9.3.5.3.3 If during testing for the conditions specified in 9.1.3, 9.1.4, and 9.1.7 the helmet is returned to the conditioning environment before the time out of that environment exceeds 4 minutes, the helmet shall be kept in the environment for a minimum of 3 minutes before resumption of testing with that helmet. If the time out of the environment exceeds 4 minutes, the helmet shall be returned to the environment for a minimum of 3 minutes for each minute or portion of a minute that the helmet remained out of the environment in excess of 4 minutes or for a maximum of 24 hours, whichever is less, before resumption of testing with that helmet.

9.3.5.4 Apparatus.

9.3.5.4.1 An aluminum ISEA size 7 headform shall be used. The headform shall have a mass of 3.6 kg ± 0.5 kg (8 lb ± 1 lb) and shall be of the nominal dimensions of the headform in Table 9.3.5.4.1 and Figure 9.3.5.4.1(a) through Figure 9.3.5.4.1(c).

9.3.5.4.2 A steel drop mass of 3.58 kg ± 0.05 kg (7.90 lb ± 0.10 lb) shall be used. The striking face of the drop mass shall be a spherical segment with a radius of 50 mm ± 8 mm (1⅞ in. ± 5⁄16 in.) and a chord length of at least 75 mm (3 in.).

9.3.5.4.3 An electronic force measurement system with the following minimum specifications shall be used:

(1) Range — 4450 N (1000 lbf)
(2) Peak force measurement accuracy — ±2.5 percent
(3) Resolution — 22 N (5 lbf)
(4) Load cell rigidity — 4.4×10^9 N/m (2.5×10^7 lbf/in.)
(5) Minimum mechanical resonant frequency of the headform/load cell system — 5000 Hz
(6) Load cell diameter — 75 mm (3 in.)

Table 9.3.5.4.1 Data for Contour Drawing of ISEA Headform (all dimensions in mm)

	Horizontal Plane	Distance from Datum Plane	Vertical Section												
			0°	15°	30°	45°	60°	75°	90°	105°	120°	135°	150°	165°	180°
	0-0	99	0	0	0	0	0	0	0	0	0	0	0	0	0
	1-1	95	22.5	22.5	23	25.5	26.5	28	28.5	31	33	36	39	38.7	40
	2-2	90	39.5	40	40	40.5	40.5	40.5	41.5	43.5	47.5	50	53	53	54.5
	3-3	85	53.5	54	55.7	51.5	50.5	50	51.5	53.5	57	60.5	64	64.5	65.5
	4-4	80	62.5	63	60.9	59	57	57	57.5	60.5	63.5	67.3	70.7	70.7	72.2
	5-5	70	72.5	74	71.5	68.2	65.5	64.5	65.3	68	72	75.7	79.1	80	82
	6-6	60	82	82	79.5	75	71.0	69.4	70.1	73	77.5	81.7	85.1	87.5	87.9
	7-7	50	87.3	87	84.5	79	74	71.5	72	75.7	80.9	85.8	89.4	91	92.3
	8-8	40	90.2	90.5	87.5	81.5	75.5	73.0	73.5	76.9	82.7	88.3	91.3	93.5	95
Datum	9-9	20	94.0	94	90.5	83.5	77.1	73.7	74.2	77.8	84.3	91	95.5	97.6	98.5
plane	10-10	0	96.5	96.5	93.0	84.6	77.5	73.5	74.2	79	85	92.5	96.5	98.8	99.9
	11-11	20	96.5	96.5	93.0	84.6	77.5	73.5	72	70	78.5	84	90	91	95
	12-12	40	96.5	96.5	93.0	84.6	77.5	73.5	70	63.5	70	75	81	82	84
	13-13	60	96.5	96.5	93.0	84.6	77.5	73.5	68	58	57.5	63	69	69	72
	14-14	80	96.5	96.5	93.0	84.6	77.5	73.5	66	54	48	53	59	60	63
	15-15	100	96.5	96.5	93.0	84.6	77.5	73.5	64	52	48	49	54	56	59
	16-16	115.9	96.5	96.5	96.5	96.5	96.5	96.5	96.5	96.5	96.5	96.5	96.5	96.5	96.5
	17-17	128.6	96.5	96.5	96.5	96.5	96.5	96.5	96.5	96.5	96.5	96.5	96.5	96.5	96.5

For SI units, 1 in. = 25.4 mm.
Note: All dimensions ±5 mm.

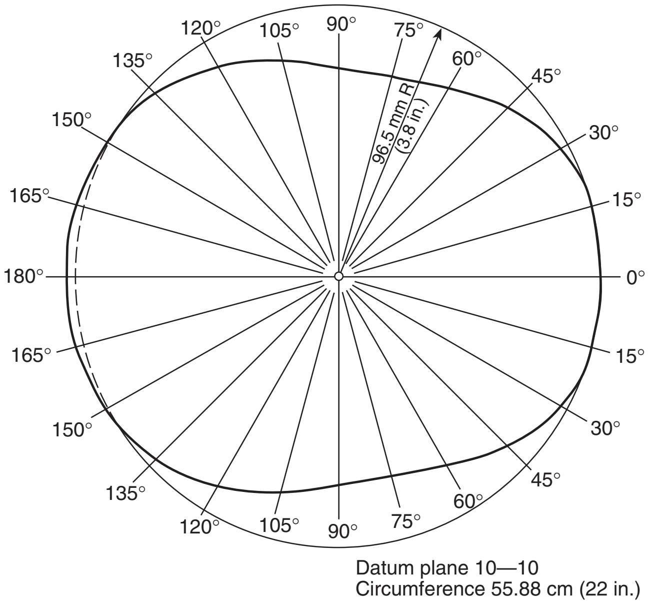


FIGURE 9.3.5.4.1(a) ISEA Size 7 Headform, Top.

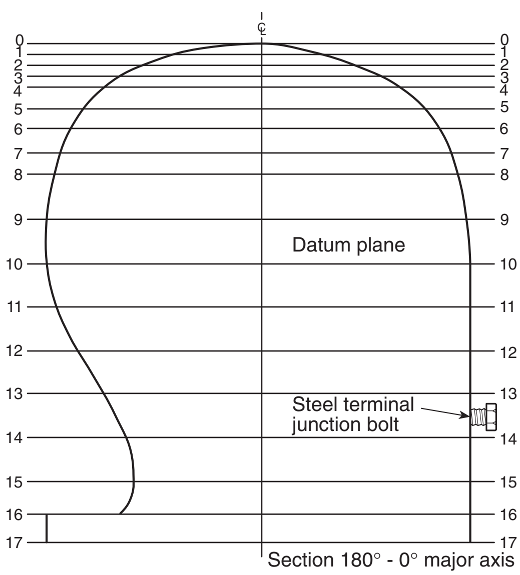


FIGURE 9.3.5.4.1(b) ISEA Size 7 Headform, Side with Modification for Steel Terminal Junction Bolt.

9.3.5.4.4 The system frequency response shall comply with SAE J211, *Instrumentation for Impact Test*, Channel Frequency Class 1000, specifications. The minimum mechanical resonant frequency shall be calculated from the following formula:

[9.3.5.4.4]

$$f = \frac{\left(\sqrt{kg/m}\right)}{2\pi}$$

where:
kg = load cell rigidity [N/m (lbf/ft)]
m = mass of the structure on top of the load cell [kg (slugs)]

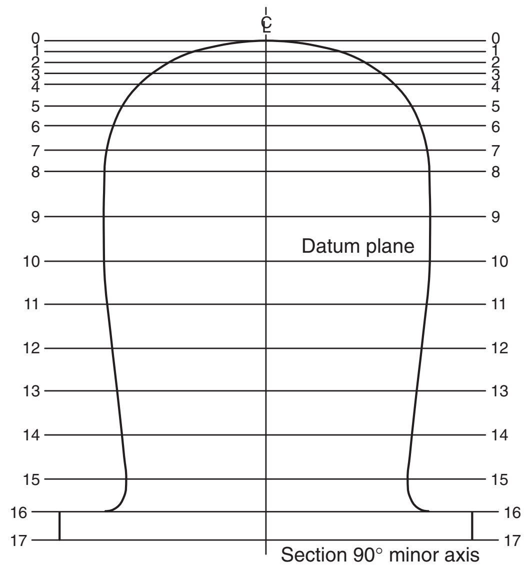


FIGURE 9.3.5.4.1(c) ISEA Size 7 Headform, Front.

9.3.5.4.5 All surfaces in contact with the load cell shall have a surface finish of at least 0.8×10^{-6} m (32×10^{-6} in.) rms. In addition, those surfaces in contact with the load cell shall be flat to within 12.7×10^{-6} m (500×10^{-6} in.).

9.3.5.4.6 The load cell shall have a backup mass of at least 540 kg (1200 lb). The load cell assembly shall be rigidly mounted between the headform structure and a steel plate at least 305 mm (1 ft) square and 25 mm (1 in.) thick. The backup mass shall be concrete or a rigid material of equal or greater density at least 0.185 m^2 (2 ft^2).

9.3.5.4.7 The surface of the steel plate, in the area of the load cell assembly mounting, shall be flat within ±0.15 mm (±0.005 in.) and within 1 degree of level. The steel plate shall be rigidly attached to, and in intimate contact with, the backup mass.

9.3.5.4.8 The vertical centerline of the drop mass, the headform, and the load cell shall all be colinear within 3 mm (1⁄8 in.). The sensitive axis of the load cell shall be aligned within 1 degree of vertical. The guide or guides shall be vertical, and in the case of a double guide system, parallel to within 6.4 mm per 3 m (1⁄4 in. per 10 ft) of length.

9.3.5.4.9* The instrumentation shall be calibrated. The equipment shall be checked for repeatability before and after each test series by impacting a standardized elastomeric shock pad. A minimum of three such impacts shall be recorded before and after testing. If the post-test average readings of the three impacts differ from the pretest average by more than 5 percent, the entire test series shall be discarded.

9.3.5.4.10 The test system shall be analyzed dynamically to ensure that any mechanical resonance associated with transducer mountings do not distort the output data.

9.3.5.4.11 Prior to testing, the instrumentation shall be allowed to warm up until stability is achieved.

9.3.5.4.12 Throughout calibration, verification, and testing, the ambient temperature shall be 20°C to 28°C (68°F to 82°F), and the relative humidity shall be 30 percent to 70 percent.

9.3.5.5 Procedure.

9.3.5.5.1 Specimen helmets shall be positioned according to the HPI as described in 9.1.13 on a headform. Where the crown clearance of the helmet is adjustable, the helmet shall be mounted with the least amount of clearance. Where the internal faceshield is an integral part of the structural integrity of the helmet, the faceshield shall be deployed as far as possible without interfering with the test equipment. Specimens shall be subjected to the environmental conditions specified in 9.1.3, 9.1.4, 9.1.5, 9.1.6, and 9.1.7 prior to each impact and within the specified time after being removed from conditioning.

9.3.5.5.2 The impactor shall be dropped from a height that yields an impact velocity within 2 percent of 5.47 m/sec (17.9 ft/sec). A means of verifying the impact velocity to within 2 percent for each impact shall be incorporated.

9.3.5.6 Report.

9.3.5.6.1 The results of each system verification shall be made part of the test results for specimens being tested.

9.3.5.6.2 The peak force and impact velocity shall be recorded and reported for each test.

9.3.5.7 Interpretation.

9.3.5.7.1 Pass or fail performance shall be determined for each specimen.

9.3.5.7.2 One or more helmet specimens failing this test shall constitute failing performance.

9.3.6 Helmet Impact Resistance Test (Acceleration).

9.3.6.1 Application. This test shall be applied to complete helmets.

9.3.6.2 Samples. Samples for conditioning shall be complete helmets. Externally mounted faceshield/goggle components shall be removed. Internally mounted faceshield/goggle components shall be removed except where the internal faceshield is an integral part of the structural integrity of the helmet. Front holders, which could interfere with the impacting of the helmet shell, shall be removed. Mounting holes shall remain.

9.3.6.3 Specimens.

9.3.6.3.1 Three helmet specimens shall be tested for each condition specified.

9.3.6.3.2 Specimens shall be conditioned for each environmental condition specified in 9.1.3, 9.1.4, 9.1.6, and 9.1.7 prior to each impact.

9.3.6.3.3 When testing helmets following the conditioning environments specified in 9.1.3, 9.1.4, and 9.1.7, and the helmet is returned to the conditioning environment before the time the helmet is out of that conditioning environment exceeds 4 minutes, the helmet shall be kept in the conditioning environment for a minimum of 3 minutes before resumption of testing with that helmet. When the time the helmet is out of the conditioning environment exceeds 4 minutes, before resumption of testing with that helmet, the helmet shall be returned to the conditioning environment for a minimum of 3 minutes for each minute, or portion of a minute, that the helmet remained out of the conditioning environment in excess of 4 minutes, or for a maximum of 24 hours, whichever is less.

9.3.6.4 Apparatus.

9.3.6.4.1 An ISO size J headform conforming to the nominal dimensions in Figure 9.3.6.4.1 shall be used. The ISO size J test headform shall exhibit no resonant frequencies below 3000 Hz, and it shall be made of any low-resonance alloy, such as magnesium K-1A.

9.3.6.4.2 A drop assembly shall be used. The drop assembly shall consist of the test headform, the accelerometer, and the moving portion of the headform guidance assembly. The drop assembly shall have a total mass of 5.17 kg ± 0.18 kg (11.4 lb ± 0.4 lb).

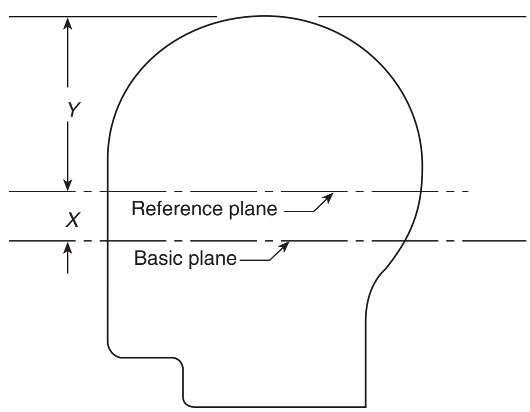
9.3.6.4.3 The guidance assembly shall comprise not more than 20 percent of the total mass of the drop assembly.

9.3.6.4.4 The center of mass of the drop assembly shall lie within a cone of 10 degrees included angle about the vertical, with the apex at the point of the targeted impact over the center of the test anvil.

9.3.6.4.5 A steel test anvil shall be used and shall have a smooth, flat striking surface 125 mm ± 15 mm (5 in. ± 1⁄16 in.) in diameter. The anvil shall be mounted securely on a steel plate at least 305 mm (1 ft) square and 25 mm (1 in.) thick. The steel plate shall be rigidly attached to and in intimate contact with a backup mass of at least 540 kg (1200 lb). The backup mass shall be of concrete or a rigid material of equal or greater density at least 0.185 m^2 (2 ft^2).

9.3.6.4.6 An electronic acceleration measurement system with the following minimum specifications shall be used:

(1) Range — 500 *g*n
(2) Peak acceleration measurement — ±2.5 percent accuracy
(3) Resonant frequency — 5000 Hz
(4) Accelerometer shock limit — 2000 *g*n
(5) Resolution — 5 *g*n



Headform	Size (mm)	*X* (mm)	*Y* (mm)
A	500	24	90
B	540	26	96
J	570	27.5	102.5
M	600	29	107
O	620	30	110

For U.S. units, 1 mm = 0.0394 in.

FIGURE 9.3.6.4.1 Location of Reference Plane.

9.3.6.4.7 The system frequency response shall comply with SAE J211, *Instrumentation for Impact Test*, Channel Frequency Class 1000, specifications. The time duration of acceleration levels shall be measured to within ±0.2 millisecond.

9.3.6.4.8* The instrumentation shall be calibrated. The equipment shall be checked for repeatability before and after each test series by impacting a standardized elastomeric shock pad. A minimum of three such impacts shall be recorded before and after testing. If the post-test average readings of the three impacts differ from the pretest average by more than 5 percent, the entire test series shall be discarded.

9.3.6.4.9 For calibration, the center of the reference anvil shall be aligned within 3 mm (⅛ in.) of the impact point on the headform. The sensitive axis of the accelerometer shall be aligned within 1 degree of vertical and shall be colinear within 3 mm (⅛ in.), with the center of the reference anvil and the impact point on the headform. The guide or guides shall be vertical and, in the case of a double guide system, parallel to within 6 mm per 3 m (¼ in. per 10 ft) of length.

9.3.6.4.10 The test system shall be analyzed dynamically to ensure that any mechanical resonance does not distort the output data.

9.3.6.4.11 Prior to testing, the instrumentation shall be allowed to warm up until stability is achieved.

9.3.6.4.12 Throughout calibration, verification, and testing, the ambient temperature shall be 20°C to 28°C (68°F to 82°F), and the relative humidity shall be 30 percent to 70 percent.

9.3.6.5 Procedure.

9.3.6.5.1 A conditioned specimen shall be positioned according to the HPI as described in 9.1.13 on a headform and shall be secured to the drop assembly by its retention system so as to maintain this position during the test. Where the crown clearance of the helmet is adjustable, the helmet shall be mounted with the least amount of clearance. No part of the helmet shell shall be cut away to accommodate the test system, and no part of the test system other than the anvil shall contact the helmet shell either as mounted or during an impact test. Where the internal faceshield is an integral part of the structural integrity of the helmet, the faceshield shall be deployed as far as possible without interfering with the test equipment.

9.3.6.5.2 The drop assembly with a helmet attached shall be dropped from a height that yields an impact velocity within 2 percent of 6.0 m/sec (19.7 ft/sec). A means of verifying the impact velocity within 2 percent for each impact shall be incorporated in the test system. The acceleration time duration values, peak acceleration, and impact velocity shall be recorded for each test. Each helmet shall be environmentally conditioned prior to each impact in each of the five impact areas specified in Figure 9.1.6.1. Test series number 1 shall require helmet specimens 5, 6, 8, and 10 to be impacted at the top, front, rear, and side impact areas. Helmet front, rear, and side targeted impact areas shall be at a distance of 63 mm, +13/−0 mm (2½ in., +0.5/−0 in.), above the test line as shown in Figure 9.1.6.1. The headform with mounted helmet shall be rotated such that the targeted helmet impact area is over the center of the anvil.

9.3.6.5.3 The impact areas shall be as specified in Figure 9.1.6.1. The top, front, left, right, and rear of the helmet shall be tested in this order. Each helmet test specimen shall be impacted in all five test areas. All five impacts shall occur on the same helmet.

9.3.6.5.3.1 Reattachment of components is allowed between impacts, but no broken components shall be replaced. The helmet test specimen shall continue to be tested as long as the specimen can be held on the test headform using existing components as originally received.

9.3.6.5.4 The top impact area shall consist of a 30 mm (1.2 in.) radius measured from a point located on the headform at the junction of the coronal plane and midsagittal plane.

9.3.6.5.5 The front impact test area shall consist of an area defined as extending forward on the headform from the front vertical transverse plane to the test line.

9.3.6.5.6 The rear impact test area shall consist of an area defined as extending backward on the headform from the rear vertical transverse plane extending down to the test line.

9.3.6.5.7 The side test areas shall consist of the areas between the top test area and test line extending from the rear vertical transverse plane and the front vertical transverse plane.

9.3.6.5.8 Each conditioned specimen in a series shall be impacted one on the top, front, left, right, and rear test areas of the helmets as defined in Figure 9.1.6.1. Helmets shall be tested in this order. At least one impact shall occur in each test area.

9.3.6.5.9* The initial point of contact of the helmet with the anvil shall not occur on the brim of the helmet.

9.3.6.6 Report.

9.3.6.6.1 The results of each system verification shall be made part of the test results for the specimens being tested.

9.3.6.6.2 The maximum acceleration, duration of acceleration above 200 *g*n, and duration of acceleration above 150 *g*n shall be recorded for each test.

9.3.6.7 Interpretation.

9.3.6.7.1 Pass or fail performance shall be determined for each specimen. If the helmet test specimen cannot be held on the test headform and impacted in all five locations, then this shall be considered failing performance.

9.3.6.7.2 One or more helmet specimens failing this test shall constitute failing performance.

9.3.7 Helmet Physical Penetration Resistance Test.

9.3.7.1 Application. This test method shall apply to protective helmets.

9.3.7.2 Samples. Samples for conditioning shall be complete helmets. Externally mounted faceshield/goggle components shall be removed. Internally mounted faceshield/goggle components shall be removed except where the internal faceshield is an integral part of the structural integrity of the helmet. Front holders, which could interfere with the impacting of the helmet shell, shall be removed. Mounting holes shall remain.

9.3.7.3 Specimens.

9.3.7.3.1 Three helmet specimens shall be tested for each condition as specified.

9.3.7.3.2 Specimens shall be conditioned for each environmental condition specified in 9.1.3, 9.1.4, 9.1.5, 9.1.6, and 9.1.7 prior to each physical penetration.

9.3.7.3.3 When testing helmets following the conditioning environments specified in 9.1.3, 9.1.4, and 9.1.7, and the helmet is returned to the conditioning environment before the time the helmet is out of that conditioning environment exceeds 4 minutes, the helmet shall be kept in the conditioning environment for a minimum of 3 minutes before resumption of testing with that helmet. When the time the helmet is out of the conditioning environment exceeds 4 minutes, before resumption of testing with that helmet, the helmet shall be returned to the conditioning environment for a minimum of 3 minutes for each minute, or portion of a minute, that the helmet remained out of the environment in excess of 4 minutes, or for a maximum of 24 hours, whichever is less.

9.3.7.4 Apparatus.

9.3.7.4.1 The ISO size J headform shall conform to the nominal dimensions in Figure 9.3.6.4.1. Above the test line, it shall have an electrically conductive surface that is electrically connected to the contact indicator.

9.3.7.4.2 The penetration striker shall have a mass of 1 kg, +0.02/−0.0 kg (2.2 lb, +0.01/−0.0 lb). The point of the striker shall be a cone with an included angle of 60 degrees ± 0.5 degree, a height of 38 mm (1½ in.), and a tip radius of 0.5 mm ± 0.1 mm (0.020 in. ± 0.004 in.). The hardness of the striking tip shall be Rockwell Scale C-60, minimum. The penetration striker shall be electrically connected to the contact indicator.

9.3.7.4.3 The contact indicator shall indicate when electrical contact has been made between the penetration striker and the conductive surface of the test headform. The contact indicator shall have a response time of less than 0.5 second.

9.3.7.4.4 The test shall be conducted at an ambient temperature of 20°C to 28°C (68°F to 82°F), and the relative humidity shall be 30 percent to 70 percent.

9.3.7.5 Procedure.

9.3.7.5.1 The environmentally conditioned helmet shall be positioned according to the HPI, as described in 9.1.13, on the test headform and secured by the helmet retention system or by other means that will not interfere with the test. Where the crown clearance of the helmet is adjustable, the helmet shall be mounted with the least amount of clearance. The helmet shall be positioned so that the penetration striker shall impact perpendicular to the helmet anywhere above the test line. Where the internal faceshield is an integral part of the structural integrity of the helmet, the faceshield shall be deployed as far as possible without interfering with the test equipment. The impact site shall be at least 75 mm (3 in.) from the center of a previous penetration or impact site.

9.3.7.5.2 The drop height of the penetration striker shall be adjusted so that the velocity at impact is at 7 m/sec ± 0.1 m/sec (23 ft/sec ± 0.5 ft/sec). A total of two penetration tests for each of the five environmental conditions specified in 9.1.3, 9.1.4, 9.1.5, 9.1.6, and 9.1.7 shall be conducted in such a manner that at least one penetration test shall be performed in each of the test areas defined in Figure 9.1.6.1. The helmet shall be environmentally conditioned prior to each penetration test. A minimum of two penetration test blows shall be applied at different test areas on each helmet.

9.3.7.6 Report. The pass or fail result for each helmet shall be recorded and reported.

9.3.7.7 Interpretation. One or more helmet specimens failing this test shall constitute failing performance.

9.3.8 Helmet Shell Retention Test.

9.3.8.1 Application. This test shall apply to protective helmets.

9.3.8.2 Samples.

9.3.8.2.1 Samples for conditioning shall be whole helmets.

9.3.8.2.2 Samples shall be conditioned as specified in 9.1.3.

9.3.8.3 Specimens. A minimum of three complete helmets shall be tested.

9.3.8.4 Apparatus.

9.3.8.4.1* The shell retention test fixtures shall consist of rigid material of sufficient thickness to facilitate firm attachment of the helmet shell while attached to a tensile testing machine.

9.3.8.4.2 The calibrated tensile test machine shall be capable of measuring the force applied to the retention system within 2 percent at the specified forces.

9.3.8.5 Procedure.

9.3.8.5.1 Specimens shall be positioned and secured in the tensile testing machine so that the helmet's reference plane is horizontal.

9.3.8.5.2 A pull force shall be applied to the helmet shell perpendicular to the reference plane. The force shall be applied to a maximum load of 356 N (80 lbf) within 30 seconds and shall be held at the maximum load for 1 minute, +5/−0 seconds.

9.3.8.6 Report.

9.3.8.6.1 Separation of the helmet shell from the helmet suspension system or the helmet retention system shall be recorded and reported.

9.3.8.6.2 The pass or fail result for each specimen shall be recorded and reported.

9.3.8.7 Interpretation. Any one specimen failing the test shall constitute failing performance for the item being tested.

9.3.9 Helmet Retention System Test.

9.3.9.1 Application. This test shall apply to protective helmets.

9.3.9.2 Samples.

9.3.9.2.1 Samples for conditioning shall be whole helmets.

9.3.9.2.2 Samples shall be conditioned as specified in 9.1.3.

9.3.9.3 Specimens. A minimum of three complete helmets shall be tested.

9.3.9.4 Apparatus.

9.3.9.4.1 The chin strap elongation test fixture shall consist of rigid material to facilitate firm attachment of the helmet assembly while attached to a tensile testing machine specified in 9.3.8.4.1.

9.3.9.4.2* A mechanical chin structure shall be designed for use with a calibrated tensile test machine. The mechanical chin structure shall consist of two rollers 13 mm (½ in.) in diameter with centers that are 75 mm (3 in.) apart.

9.3.9.4.3 The calibrated tensile test machine shall be capable of measuring the force applied to the retention system within 2 percent at the specified forces.

9.3.9.5 Procedure.

9.3.9.5.1 The test shall be conducted at an ambient temperature of 20°C to 28°C (68°F to 82°F), and the relative humidity shall be 30 percent to 70 percent.

9.3.9.5.2 Prior to testing, the test machine shall be allowed to warm up until stability is achieved.

9.3.9.5.3 The test fixture and mechanical chin structure shall be positioned so that the vertical straight line distance between the bottom of the rollers and the helmet reference plane is 110 ± 10 mm (4 ¼ in ± ⅜ in.), the chinstrap shall be passed around the rollers, and the helmet shall be positioned and secured to the fixture so that the helmet's reference plane is horizontal and so that the helmet rotation is prevented during the test. The chin strap shall be adjusted and preloaded to 45 N ± 5 N (10 lbf ± 1 lbf). The position of the rollers shall be measured and recorded to the nearest 0.5 mm (1⁄64 in.).

9.3.9.5.4* The force applied to the retention system shall be slowly increased to 445 N ± 5 N (100 lbf ± 1 lbf). The force shall be increased smoothly from 45 N to 445 N (10 lbf to 100 lbf) at a rate between 9 N/sec to 45 N/sec (2 lbf/sec to 10 lbf/sec).

9.3.9.5.5 Where using a tensile testing machine, the load rate shall be 25 mm/min (1 in./min) to a limit of 445 N (100 lbf).

9.3.9.5.6 The roller's position shall be measured and recorded again after the force has been maintained at 445 N (100 lbf) for 60 seconds, +15/−0 seconds. The difference between the second measurement and the first shall be the retention system elongation.

9.3.9.6 Report. The retention system elongation shall be reported and recorded for each helmet specimen.

9.3.9.7 Interpretation. One or more helmet specimens failing this test shall constitute failing performance.

9.3.10 Helmet Suspension System Retention Test.

9.3.10.1 Application. This test shall apply to protective helmets.

9.3.10.2 Samples.

9.3.10.2.1 Samples for conditioning shall be whole helmets.

9.3.10.2.2 Samples shall be conditioned as specified in 9.1.3.

9.3.10.3 Specimens. A minimum of 3 complete helmets shall be tested.

9.3.10.4 Apparatus.

9.3.10.4.1 The suspension system retention test fixtures shall consist of rigid material of sufficient thickness to facilitate firm attachment of the inverted helmet to the tensile test machine as shown in Figure 9.3.10.4.1.

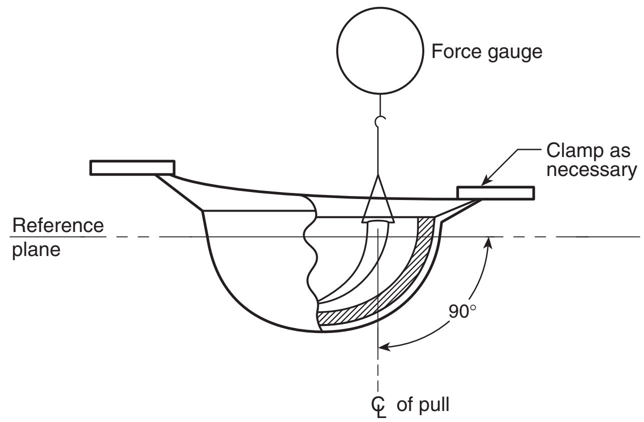


FIGURE 9.3.10.4.1 Suspension System Test Setup.

9.3.10.4.2 The calibrated tensile test machine shall be capable of measuring the force applied to the retention system within 2 percent at the specified forces.

9.3.10.4.3 A diagram or photograph showing the setup of the test apparatus with the strap positioned in the tensile test machine shall be provided.

9.3.10.5 Procedure.

9.3.10.5.1 Each helmet suspension strap shall be cut such that sufficient length of strap remains to be gripped by the movable jaw of the testing machine.

9.3.10.5.2 Specimens shall be positioned and secured in the tensile testing machine so that the helmet's reference plane is horizontal.

9.3.10.5.3 Each attachment point of the crown strap shall be tested by applying a pull force along the centerline of the suspension strap, perpendicular to the reference plane to a maximum load of 45 N ± 5 N (10 lbf ± 1 lbf). The force shall be increased from 0 N to 45 N ± 5 N (0 lbf to 10 lbf ± 1 lbf), at a load rate of 25 mm/min ± 5 mm/min (1 in./min ± 3⁄16 in./min). The entire width of the suspension strap shall be mounted within the movable jaw grip.

9.3.10.5.4 After application of the force is complete, the load shall be released and the suspension system shall be inspected for any separation from the helmet shell.

9.3.10.6 Report.

9.3.10.6.1 The individual pass or fail results for each attachment point shall be reported and recorded.

9.3.10.6.2 A diagram or photograph showing the attachment points failing the test shall be provided if failing results are reported.

9.3.10.7 Interpretation.

9.3.10.7.1 Separation of the helmet suspension from the helmet shall constitute failing performance.

9.3.10.7.2 One or more helmet specimens failing this test shall constitute failing performance.

9.3.11 Faceshield/Goggle Component Lens Impact Resistance Test.

9.3.11.1 Application. This test shall apply to complete helmets.

9.3.11.2 Samples. Samples for conditioning shall be complete helmets with faceshield component or goggle component. Goggle samples shall be permitted to be complete goggle components not attached to the helmet.

9.3.11.3 Specimens.

9.3.11.3.1 Where the manufacturer produces helmets with faceshield components, a minimum of three complete faceshield components shall be tested for each of the conditions specified in 9.3.11.3.3.

9.3.11.3.2 Where the manufacturer produces helmets with goggle components, a minimum of three complete goggle components shall be tested for each of the conditions specified in 9.3.11.3.3.

9.3.11.3.3 Samples shall be conditioned for each of the environmental conditions specified in 9.1.3, 9.1.4, 9.1.5, and 9.1.7.

9.3.11.3.4 When testing for the conditions specified in 9.1.3, 9.1.4, and 9.1.7 and when the faceshield/goggle component is returned to the conditioning environment before the time out of that conditioning environment exceeds 4 minutes, the faceshield/goggle shall be kept in the conditioning environment for a minimum of 3 minutes before resumption of testing with that helmet. When the time out of the conditioning environment exceeds 4 minutes, the faceshield/goggle shall be returned to the conditioning environment for a minimum of 3 minutes for each minute or portion of a minute that the faceshield/goggle remained out of the conditioning environment in excess of 4 minutes or for a maximum of 24 hours, whichever is less.

9.3.11.4 Test One, High Mass Impact.

9.3.11.4.1 Apparatus.

9.3.11.4.1.1 A facial feature headform as defined in 3.3.89 shall be used to hold the protective device. It shall be rigidly mounted in the horizontal position, face up, on a base that has a mass of 30 kg (66 lb) or greater. The static stiffness of the headform shall be such that, when a vertical downward force of 20 kg (44 lb) is applied to the forehead of the headform, the back of the headform shall not deflect more than 2 mm (1⁄16 in.).

9.3.11.4.1.2 The missile shall have a 30 degree conical tip with a 1 mm (1⁄25 in.) radius, shall weigh 500 g (17.6 oz), and shall have a diameter of 25 mm (1 in.). The missile shall be held in position over the headform, tip down, at the designated test height. The missile shall have a heat-treated steel tip.

9.3.11.4.1.3* The missile shall be dropped through a loose-fitting guide tube having a smooth internal diameter.

9.3.11.4.2 Procedure.

9.3.11.4.2.1 Only one faceshield/goggle component shall be tested at a time.

9.3.11.4.2.2 The helmet with faceshield/goggle component deployed shall be positioned according to the HPI as described in 9.1.13 on a headform. Where the crown clearance of the helmet is adjustable, the helmet shall be mounted with the most amount of clearance. Goggles shall be permitted to be placed directly on the headform without being attached to the helmet. The alignment shall be such that with the faceshield/goggle component deployed, when the missile is dropped, it points in line with one of the eyes of the headform.

9.3.11.4.2.3 The missile shall be dropped from a height of 1300 mm (51 3⁄16 in.). At least four specimens shall be tested.

9.3.11.4.3 Report. The pass or fail result for each device shall be recorded and reported.

9.3.11.5 Test Two, High Velocity Impact.

9.3.11.5.1 Apparatus.

9.3.11.5.1.1* The test apparatus shall consist of a device capable of propelling a steel ball reproducible at the velocity designated at 76 m/sec (250 ft/sec). The device shall show a sample standard deviation of not greater than 2 percent of 76 m/sec (250 ft/sec) based on a test series of 30 shots. The velocity of the steel ball shall be determined at a distance not greater than 250 mm (10 in.) from point of impact. The projectiles used in this test shall be 6 mm (1⁄4 in.) diameter steel balls weighing approximately 1.06 g (0.04 oz). These balls are damaged during impact and shall be changed frequently to avoid impacts at unexpected locations and large variations in velocity.

9.3.11.5.1.2 A facial feature headform as defined in 3.3.89 shall be used for mounting the helmet with faceshield/goggle component. The headform shall be capable of being rotated on a vertical axis through each corneal vertex in 15 degree increments, from a first position 15 degrees to the nasal side of straight-ahead viewing out to 90 degrees temporally, given that the headform is vertical such that the two eyes lie in a horizontal reference plane. The headform shall be capable of being raised 10 mm (0.394 in.) and lowered 10 mm (0.394 in.) with respect to the horizontal plane to carry out testing at the 90 degree angular position.

9.3.11.5.2 Procedure.

9.3.11.5.2.1 Only one faceshield/goggle component shall be tested at a time.

9.3.11.5.2.2 The helmet with faceshield/goggle component deployed shall be mounted to a facial feature headform as defined in 3.3.45 in accordance with the HPI as described in 9.1.13. Where the crown clearance of the helmet is adjustable, the helmet shall be mounted with the most amount of clearance. Goggles shall be permitted to be placed directly on the headform without being attached to the helmet.

9.3.11.5.2.3 The headform shall be adjusted so that the path of the projectile passes through the center of the left eye. It shall be then rotated to the first test position, which shall be 15 degrees to the nasal side. The faceshield/goggle component shall then be impacted at the test velocity at 0 degrees, 45 degrees, and 90 degrees. The impacts at the 45 degree and 90 degree positions shall be at either 10 mm (1⁄3 in.) above or 10 mm (1⁄3 in.) below the plane of the eyes. A single specimen or multiple specimens shall be permitted to be used for the impact testing. At least one impact shall be conducted on each specimen utilized.

9.3.11.5.2.4 The headform shall be adjusted so that the path of the projectile passes through the center of the right eye. It shall be then rotated to the first test position, which shall be 15 degrees to the nasal side. The faceshield/goggle component shall then be impacted at the test velocity at 0 degrees, at 45 degrees, and at 90 degrees. The impacts at the 45 degree and 90 degree positions shall be at either 10 mm (⅓ in.) above or 10 mm (⅓ in.) below the plane of the eyes. A single specimen or multiple specimens shall be permitted to be used for the impact testing. At least one impact shall be conducted on each specimen utilized.

9.3.11.6 Report. The pass or fail performance for each helmet shall be recorded and reported.

9.3.11.7 Interpretation. One or more helmet specimens failing this test shall constitute failing performance.

9.3.12 Faceshield/Goggle Component Lens Scratch Resistance Test.

9.3.12.1 Application.

9.3.12.1.1 This test method shall apply to faceshield/goggle component lenses.

9.3.12.1.2 Modifications to this test method for testing proximity firefighting helmet faceshield component lenses shall be as specified in 9.3.12.8.

9.3.12.2 Samples.

9.3.12.2.1 Samples for conditioning shall be faceshield/goggle component lenses.

9.3.12.2.2 Samples shall be conditioned as specified in 9.1.3.

9.3.12.3 Specimens.

9.3.12.3.1 A minimum of four faceshield/goggle component lenses shall be selected.

9.3.12.3.2 Seven specimens shall be chosen from a minimum of four lenses. Four specimens shall be taken from the left viewing area and three specimens shall be taken from the right viewing area. One of the four specimens taken from the left viewing area shall be the setup sample.

9.3.12.3.3 The left viewing area test specimens shall include all of the following criteria:

(1) The specimen shall be a square measuring 50 mm × 50 mm (2 in. × 2 in.).
(2) Two edges of the square section shall be parallel within ±2 degrees of the axis of the cylinder or cone in the center of the specimen.
(3) The specimen shall be taken from the left side of the faceshield/goggle component lens and shall, as a minimum, contain that portion of the lens that is directly in front of the pupil of the left eye as defined by positioning the helmet with a faceshield/goggle component deployed according to the HPI as described in 9.1.13 on a facial feature headform as defined in 3.3.89. Goggle samples shall be permitted to be complete goggle components not attached to the helmet.

9.3.12.3.4 The right viewing area test specimens shall include all of the following criteria:

(1) The specimen shall be a square measuring 50 mm × 50 mm (2 in. × 2 in.).
(2) Two edges of the square section shall be parallel within ±2 degrees of the axis of the cylinder or cone in the center of the specimen.
(3) The specimen shall be taken from the right side of the faceshield/goggle component lens and shall, as a minimum, contain that portion of the lens that is directly in front of the pupil of the right eye as defined by positioning the helmet with a faceshield/goggle component deployed according to the HPI as described in 9.1.13 on a facial feature headform as defined in 3.3.89. Goggle samples shall be permitted to be complete goggle components not attached to the helmet.

9.3.12.3.5 Each of the specimens shall be cleaned in the following manner:

(1) The specimen shall be rinsed with clean tap water.
(2) The specimen shall be washed with a solution of nonionic, low-phosphate detergent and water using a clean, soft gauze pad.
(3) The specimen shall be rinsed with clean tap water.
(4) The specimen shall be blown dry with filtered compressed air or nitrogen.

9.3.12.4 Apparatus.

9.3.12.4.1 The faceshield/goggle component lens scratch test apparatus shall be constructed in accordance with Figure 9.3.12.4.1.

9.3.12.4.2 The specimen holder shall be configured with a flat surface under the lens or with an inner radius support.

9.3.12.4.3 The pad holder shall consist of a cylinder 10 mm (⅜ in.) high and 25 mm (1 in.) in diameter with a radius of curvature equal to the radius of curvature of the outside of the lens in the viewing area ±0.25 diopter. This cylinder shall be rigidly affixed to the stroking arm by a No. 10-32 UNF threaded rod.

9.3.12.4.4 The pad shall be a Blue Streak M306M or equivalent wool felt polishing pad 30 mm (1³⁄₁₆ in.) in diameter.

9.3.12.4.5 The abrasive disc shall be made from 3M Part No. 7415, Wood Finishing Pad or equivalent. A disc 25 mm (1 in.) in diameter shall be cut from the abrasive sheet.

9.3.12.5 Procedure.

9.3.12.5.1 The haze of the specimen shall be measured using a haze meter in accordance with ASTM D1003, *Standard Test Method for Haze and Luminous Transmittance of Transparent Plastics*, and shall be recorded as follows:

(1) The haze shall be measured in the center of the sample ±1.6 mm (±¹⁄₁₆ in.).
(2) The specimen shall be repositioned to achieve the maximum haze value within the area specified in 9.3.12.5(1).
(3) The haze meter shall have a specified aperture of 22.3 mm (0.88 in.).
(4) The haze meter shall have a visual display showing 0.1 percent resolution.
(5) The haze meter shall be calibrated before and after each day's use following the procedures outlined in ASTM D1003, *Standard Test Method for Haze and Luminous Transmittance of Transparent Plastics*.

9.3.12.5.2 The setup sample shall be placed cover side up in the test apparatus specimen holder.

9.3.12.5.3 The pad holder, pad, and abrasive disc shall be installed on the stroking arm. The stroking arm shall be leveled to ±3 degrees by adjusting the threaded pin. The pin shall be

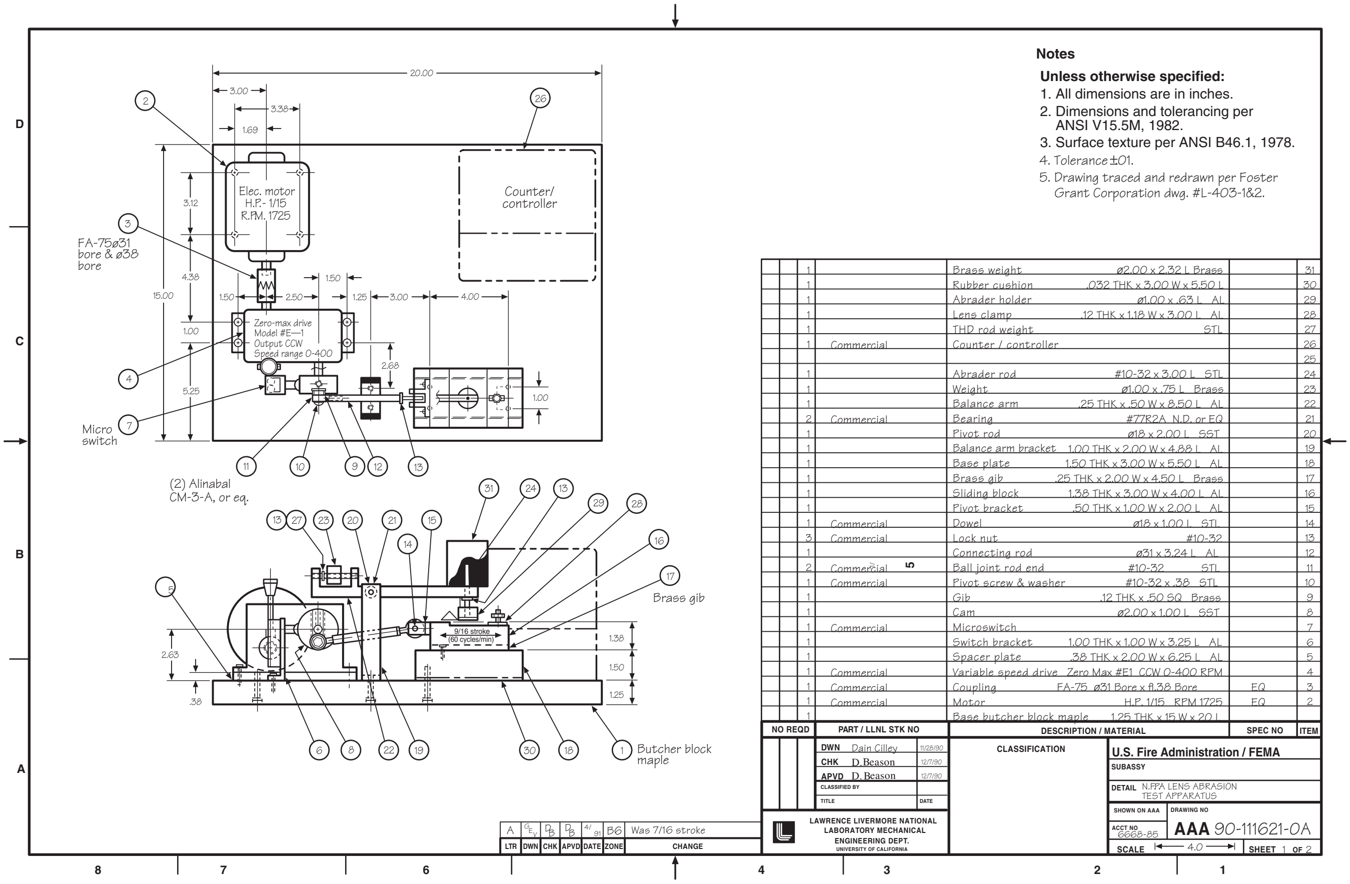


FIGURE 9.3.12.4.1 Faceshield/Goggle Component Lens Test Apparatus.

secured to prevent rotation of the pad holder. The axis of curvature of the pad holder shall be coincident with the axis of curvature of the lens.

9.3.12.5.4 The stroking arm shall be counterbalanced with the pad holder, pad, and abrasive disc in place.

9.3.12.5.5 The setup sample shall be replaced with one of the six specimens to be tested.

9.3.12.5.6 A test weight of 1 kg ± 8 g (2.2 lb ± 0.2 oz), shall be installed on the pin above the test specimen.

9.3.12.5.7 The test shall be run for 200 cycles ± 1 cycle. One cycle shall consist of a complete revolution of the eccentric wheel.

9.3.12.5.8 The length of stroke shall be 14 mm (17⁄32 in.), producing a pattern 38 mm (1½ in.) long. The frequency of the stroke shall be 60 cycles/min ± 1 cycle/min. The center of the stroke shall be within 1.6 mm (1⁄16 in.) of the center of the sample.

9.3.12.5.9 The specimen shall be removed and cleaned following the procedure specified in 9.3.12.3.5. The abrasive disc shall be discarded.

9.3.12.5.10 The testing steps specified in 9.3.12.5 shall be repeated five additional times with a new specimen and abrasive disc.

9.3.12.6 Report.

9.3.12.6.1 After each of the six specimens have been tested and cleaned, the haze of the specimen shall be measured following the procedure specified in 9.3.12.5.1, recorded, and reported.

9.3.12.6.2 The delta haze shall be calculated by subtracting the initial haze measurement from the final haze measurement.

9.3.12.7 Interpretation.

9.3.12.7.1 The six delta haze values shall be averaged.

9.3.12.7.2 The resultant value shall be compared to the value specified in 8.5.3 to determine pass or fail performance.

9.3.12.8 Specific Requirements for Testing Proximity Firefighting Helmet Faceshield Component Lenses. The abrasive disc pad shall be made from 3M Part #7445 Hand Pad or equivalent.

9.3.13 Proximity Faceshield Reflective Coating Adhesion Test.

9.3.13.1 Application.

9.3.13.1.1 This test method shall apply to proximity firefighting protective faceshields.

9.3.13.1.2 This test shall apply only to coated materials of the noted element components.

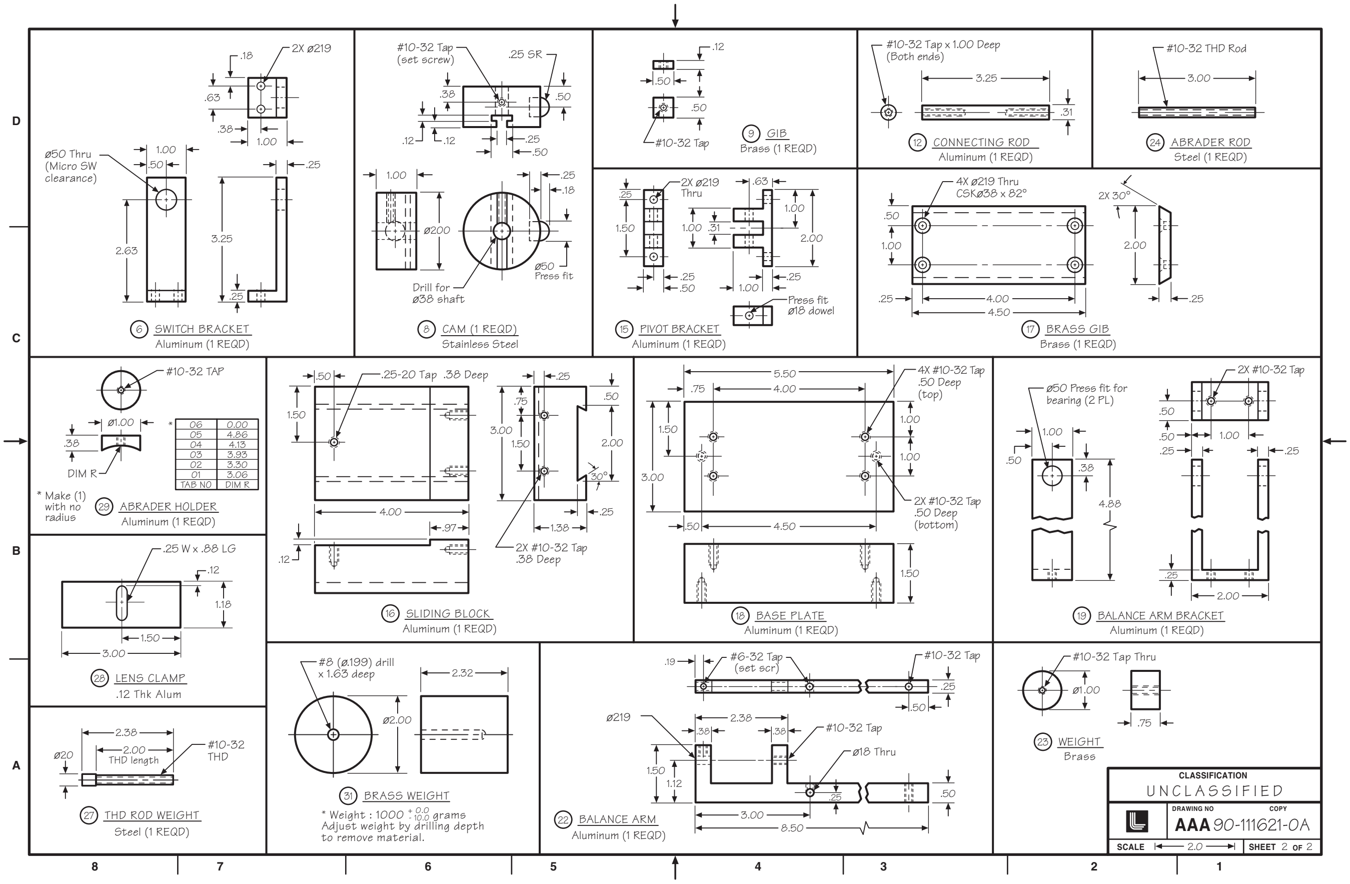


FIGURE 9.3.12.4.1 *Continued*

9.3.13.2 Samples. The samples shall be complete proximity faceshields or reflective coated faceshield material.

9.3.13.3 Specimens.

9.3.13.3.1 A minimum of two proximity faceshield component lenses shall be selected.

9.3.13.3.2 Five specimens shall be chosen from a minimum of two lenses. Two specimens shall be taken from the left viewing area and three specimens shall be taken from the right viewing area. One of the three specimens taken from the right viewing area shall be used as the setup sample.

9.3.13.3.3 All test specimens shall be as described in ASTM D3359, *Standard Test Methods for Rating Adhesion by Tape Test.*

9.3.13.4 Apparatus. The proximity faceshield adhesion test apparatus and equipment shall be in accordance with ASTM D3359, *Standard Test Methods for Rating Adhesion by Tape Test.*

9.3.13.5 Procedure.

9.3.13.5.1 The proximity faceshield adhesion test procedure shall be in accordance with ASTM D3359, *Standard Test Methods for Rating Adhesion by Tape Test.*

9.3.13.5.2 Adhesion value of the tape shall be determined in accordance with 9.4.7.4.6.

9.3.13.6 Report. The proximity faceshield report shall be in accordance with ASTM D3359, *Standard Test Methods for Rating Adhesion by Tape Test.*

9.3.13.7 Interpretation. The failure of any one specimen to the number 2B classification of ASTM D3359, *Standard Test Methods for Rating Adhesion by Tape Test*, shall constitute failure of the test.

9.3.14 Glove and Footwear Puncture Resistance Test.

9.3.14.1 Application. This test method shall apply to protective gloves and footwear uppers.

9.3.14.2 Samples. Samples for conditioning shall be complete gloves, glove composite pouches, or footwear upper sections.

9.3.14.3 Specimens.

9.3.14.3.1 A minimum of three specimens measuring at least 150 mm (6 in.) square shall be tested.

9.3.14.3.2 Specimens shall be tested after conditioning as specified in 9.1.3.

9.3.14.4 Procedure. Specimens shall be tested in accordance with ASTM F1342/F1342M, *Standard Test Method for Protective Clothing Material Resistance to Puncture,* Test Method A.

9.3.14.5 Report.

9.3.14.5.1 The puncture force in N (lbf) shall be recorded and reported for each puncture on each specimen.

9.3.14.5.2 The average puncture force in N (lbf) shall be recorded and reported for all specimens tested.

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

9.3.14.7 Specific Requirements for Testing Gloves.

9.3.14.7.1 Specimens shall be representative of each glove body composite construction. All variations in composite construction and the order of layering of composite materials shall constitute a new composite and shall be tested separately. Where a composite is identical to another composite except for additional reinforcement layer(s), the composite with no reinforcement layers shall be representative of the composite with reinforcement layer(s). Specimens shall not include seams except in the following cases:

(1) Ridged areas or similar where stitching is used to create specific performance characteristics rather than for glove assembly
(2) When there are size constraints of a material, making it necessary to allow stitching in order to create the sample size required

9.3.14.7.1.1 Stitching shall be of the same type as is used in the actual glove construction.

9.3.14.7.2 For glove body composites, samples for conditioning shall be in the form of a pouch as described in 9.1.14.

9.3.14.7.2.1 The pouch shall be conditioned as specified in 9.1.12.

9.3.14.7.3 Glove specimens shall also be tested after wet conditioning as specified in 9.1.8, representing a second separate test.

9.3.14.7.4 Testing shall be performed as specified in 9.3.14.2 through 9.3.14.6.

9.3.14.8 Specific Requirements for Testing Footwear Uppers.

9.3.14.8.1 Specimens shall consist of each composite of the footwear upper used in the actual footwear construction, including the tongue but excluding the gusset, with the layers arranged in proper order. Where a composite is identical to another composite except for additional reinforcement layer(s), the composite with no reinforcement layers shall be tested.

9.3.14.8.2 Testing shall be performed as specified in 9.3.14.2 through 9.3.14.6.

9.3.15 Glove and Footwear Cut Resistance Test.

9.3.15.1 Application.

9.3.15.1.1 This test method shall apply to glove body, glove interface component, and footwear upper materials.

9.3.15.1.2 Modifications to this test method for evaluation of glove body composites shall be as specified in 9.3.15.7.

9.3.15.1.3 Modifications to this test method for evaluation of glove interface components other than wristlets shall be as specified in 9.3.15.9.

9.3.15.1.4 Modifications to this test method for evaluation of wristlet glove interface components shall be as specified in 9.3.15.10.

9.3.15.1.5 Modifications to this test method for evaluation of footwear upper materials shall be as specified in 9.3.15.8.

9.3.15.2 Samples.

9.3.15.2.1 Glove body and glove interface components other than wristlet material samples shall be conditioned as specified in 9.1.12.

9.3.15.2.2 Glove wristlet interface components shall be conditioned as specified in 9.1.2.

9.3.15.2.3 Footwear upper material samples shall be conditioned as specified in 9.1.3.

9.3.15.3 Specimens. A minimum of three specimens, consisting of all layers, shall be tested.

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

9.3.15.5 Report.

9.3.15.5.1 The distance of blade travel shall be recorded and reported to the nearest 1 mm ($^3/_{64}$ in.) for each sample specimen.

9.3.15.5.2 The average distance of blade travel in mm (in.) shall be recorded and reported for all specimens tested.

9.3.15.6 Interpretation. The average blade travel distance shall be used to determine pass or fail performance.

9.3.15.7 Specific Requirements for Testing Glove Body Composites.

9.3.15.7.1 Samples for conditioning shall be glove body composite pouches as specified in 9.3.15.7.3.

9.3.15.7.2 Specimens shall be representative of each glove body composite construction. All variations in composite construction and the order of layering of composite materials shall constitute a new composite and shall be tested separately. Where a composite is identical to another composite except for additional reinforcement layer(s), the composite with no reinforcement layers shall be representative of the composite with reinforcement layer(s). Stitching shall be of the same type as is used in the actual glove construction.

9.3.15.7.3 For glove body composites, samples for conditioning shall be in the form of a pouch as described in 9.1.14.

9.3.15.7.4 After conditioning, the pouch and necessary stitching shall be cut to form 50 mm × 100 mm (2 in. × 4 in.) specimens for testing.

9.3.15.7.5 The swatch shall be permitted to be left stitched, restitched, or otherwise held together at the ends of the swatch for placement on the test apparatus. No stitching or binding mechanism shall be used in the test area except in the following cases:

(1) Ridged areas or similar where stitching is used to create specific performance characteristics rather than for glove assembly

(2) When there are size constraints of a material making it necessary to allow stitching in order to create the sample size required

9.3.15.7.5.1 Stitching shall be of the same type as is used in the actual glove construction.

9.3.15.7.6 Cut resistance testing shall be performed under a load of 300 g.

9.3.15.8 Specific Requirements for Testing Footwear Upper Materials.

9.3.15.8.1 Samples for conditioning shall be footwear uppers.

9.3.15.8.2 Specimens shall consist of each composite of footwear upper used in the actual footwear construction, including the tongue but excluding the gusset, with the layers arranged in proper order. Where a composite is identical to another composite except for additional reinforcement layer(s), the composite with no reinforcement layers shall be tested.

9.3.15.8.3 Cut resistance testing shall be performed under a load of 800 g.

9.3.15.9 Specific Requirements for Testing Glove Interface Components Other Than Wristlet Composites.

9.3.15.9.1 Samples for conditioning shall be glove interface component composite swatches as specified in 9.3.15.9.3.

9.3.15.9.2 Specimens shall be representative of each glove interface composite construction. All variations in composite construction and the order of layering of composite materials shall constitute a new composite and shall be tested separately. Where a composite is identical to another composite except for additional reinforcement layer(s), the composite with no reinforcement layers shall be representative of the composite with reinforcement layer(s). Stitching shall be of the same type as is used in the actual glove construction.

9.3.15.9.3 For glove interface component composites, samples for conditioning shall be in the form of a pouch as described in 9.1.14.

9.3.15.9.4 After conditioning, the stitching shall be cut to form 50 mm × 100 mm (2 in. × 4 in.) specimens for testing.

9.3.15.9.5 The swatch shall be permitted to be left stitched, restitched, or otherwise held together at the ends of the swatch for placement on the test apparatus.

9.3.15.9.6 No stitching or binding mechanism shall be used in the test area except in the following cases:

(1) Ridged areas or similar where stitching is used to create specific performance characteristics rather than for glove assembly
(2) When there are size constraints of a material making it necessary to allow stitching in order to create the sample size required.

9.3.15.9.6.1 Stitching shall be of the same type as is used in the actual glove construction.

9.3.15.9.7 Cut resistance testing shall be performed under a load of 300 g.

9.3.15.10 Specific Requirements for Testing Wristlet Glove Interface Components.

9.3.15.10.1 Samples for conditioning shall be wristlet glove interface component composite swatches as specified in 9.3.15.10.3.

9.3.15.10.2 Specimens shall be representative of the wristlet glove interface component composite construction.

9.3.15.10.3 For wristlet glove interface component composites, samples for conditioning shall include wristlet material.

9.3.15.10.4 After conditioning, the material shall be cut to form 50 mm × 100 mm (2 in. × 4 in.) specimens for testing. Specimens shall not include seams where multiple layers are involved.

9.3.15.10.5 The swatch shall be permitted to stitched, or otherwise held together at the ends of the swatch for placement on the test apparatus.

9.3.15.10.6 No stitching or binding mechanism shall be used in the test area.

9.3.15.10.7 Cut resistance testing shall be performed under a load of 300 g.

9.3.16 Glove Liner Retention Test.

9.3.16.1 Application. This test method shall apply to protective gloves.

9.3.16.2 Samples. Samples for conditioning shall be whole gloves.

9.3.16.3 Specimens.

9.3.16.3.1 A minimum of three whole gloves each for size 70W (wide) and size 76W (wide) with each liner type shall be tested.

9.3.16.3.2 Each digit of the glove shall be tested.

9.3.16.3.3 Specimens shall be conditioned as specified in 9.1.3.

9.3.16.4 Procedure.

9.3.16.4.1 Glove specimens shall be laundered as specified in 9.1.12 for 5 cycles.

9.3.16.4.2 Test subjects shall be selected so that their hand dimensions are as close as possible to the middle of the range for hand length and hand circumference for size 70W (wide) and size 76W (wide) gloves specified in Figure 7.7.4.1.

9.3.16.4.3 The test subject's hand shall then be completely submerged in room -temperature water [21°C ± 3°C (70°F ± 5°F)] for 10 seconds before donning the glove each time.

9.3.16.4.4 The glove shall be donned in accordance with the manufacturer's donning procedure. The test subject shall don one glove at a time.

9.3.16.4.5 The glove shall then be removed by grasping the fingertip of the middle finger and pulling the hand out of the glove.

9.3.16.4.6 Where the glove cannot be donned because of detachment of the inner liner or moisture barrier, the trial for that glove shall be stopped. If any fingers cannot be fully inserted into the glove, the trial for that glove shall be stopped.

9.3.16.5 Report. Results shall be recorded and reported as pass or fail for each glove.

9.3.16.6 Interpretation.

9.3.16.6.1 Any detachment of the inner liner or moisture barrier shall constitute failing performance.

9.3.16.6.2 Failure of either size shall constitute failure of the test.

9.3.17 Footwear Sole Abrasion Resistance Test.

9.3.17.1 Application. This test method shall apply to protective footwear soles with heels.

9.3.17.2 Samples.

9.3.17.2.1 Samples for conditioning shall be uniform cylinders of footwear sole and heel materials as specified in ISO 4649, *Rubber, vulcanized or thermoplastic — Determination of abrasion resistance using a rotating cylindrical drum device*.

9.3.17.2.2 Samples shall be conditioned as specified in 9.1.3.

9.3.17.3 Specimens. A minimum of three specimens of the footwear soles and heel materials shall be tested.

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

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

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

9.3.18 Footwear Eyelet and Stud Post Attachment Test.

9.3.18.1 Application. This test method shall apply to protective footwear eyelets and stud posts.

9.3.18.2 Samples.

9.3.18.2.1 Samples for conditioning shall be whole footwear.

9.3.18.2.2 The eyelet and stud post samples shall be conditioned as specified in 9.1.3.

9.3.18.3 Specimens.

9.3.18.3.1 Specimens shall total two eyelets and two stud posts on three separate footwear items.

9.3.18.3.2 Specimens shall be removed from the footwear and shall be 25 mm × 50 mm (1 in. × 2 in.).

9.3.18.4 Apparatus.

9.3.18.4.1 A tensile-testing machine shall be used with a traverse rate of 50 mm/min (2 in./min).

9.3.18.4.2 Clamps measuring 25 mm × 38 mm (1 in. × 1½ in.) shall have gripping surfaces that are parallel, flat, and capable of preventing slippage of the specimen during the test.

9.3.18.5 Procedure.

9.3.18.5.1 The stud post or eyelet puller shall be inserted or attached to the upper position of the tensile-testing machine.

9.3.18.5.2 The traverse rate shall be set at 50 mm/min (2 in./min).

9.3.18.5.3 The test eyelet or stud post shall be attached using the appropriate puller fixture.

9.3.18.5.4 The eyelet stay shall be clamped, but clamping the metal portion of the eyelets or stud hook in the lower clamps shall not be permitted.

9.3.18.5.5 The distance between the clamps and stud hooks or eyelets shall be 1.6 mm to 3.2 mm (1⁄16 in. to ⅛ in.).

9.3.18.5.6 The test shall then be started.

9.3.18.6 Report.

9.3.18.6.1 The force will reach a peak, decline slightly, and then increase to complete failure; however, the value at which the force first declines shall be recorded and reported as the initial failure point, since this is the separation point of the material around the eyelet or stud post.

9.3.18.6.2 The average force shall be calculated, recorded, and reported.

9.3.18.7 Interpretation. The average force shall be used to determine pass or fail.

9.3.19 Hook and Loop Fastener Tape Strength Test.

9.3.19.1 Application. This test shall apply to fastener tape used in the construction of garments.

9.3.19.2 Samples.

9.3.19.2.1 Sample size shall be defined in A-A 55126C, *Commercial Item Description, Fastener Tapes, Hook and Loop, Synthetic*.

9.3.19.2.2 Samples shall be washed for three washings as specified in AATCC TM61, *Test Method for Colorfastness to Laundering: Accelerated*, using the laundering conditions established for Test 3A.

9.3.19.3 Specimens. A minimum of four specimens shall be evaluated.

9.3.19.4 Procedures.

9.3.19.4.1 Fastener tape breaking strength shall be measured in accordance with ASTM D5035, *Standard Test Method for Breaking Force and Elongation of Textile Fabrics (Strip Method),* with the following modifications:

(1) Specimens shall be tested in the provided width only in lieu of the specified 100 mm (3.9 in.) width.
(2) Only specimens parallel to the length of the tape shall be tested.

9.3.19.4.2 Fastener tape shear strength shall be measured in accordance with ASTM D5169, *Standard Test Method for Shear Strength (Dynamic Method) of Hook and Loop Touch Fasteners*.

9.3.19.4.3 Fastener tape shear strength shall be measured in accordance with ASTM D5170, *Standard Test Method for Peel Strength ("T" Method) of Hook and Loop Touch Fasteners*.

9.3.19.5 Report. The average breaking strength, shear strength, and peel strength shall be calculated and recorded.

9.3.19.6 Interpretation. Pass or fail determinations shall be based on the average breaking strength, shear strength, and peel strength specified for Type 2, Class 1 and 4 fastener tapes as established in Table 1 of A-A 55126C, *Commercial Item Description, Fastener Tapes, Hook and Loop, Synthetic*.

9.3.20 Drag Rescue Device (DRD) Materials Strength Test.

9.3.20.1 Application.

9.3.20.1.1 This test shall apply to DRD materials and DRD seams, splices, and joints.

9.3.20.1.2 Modifications to this test method for testing DRD seams, splices, and joints shall be as specified in 9.3.20.7.

9.3.20.2 Samples.

9.3.20.2.1 Five samples shall be taken from each different DRD material.

9.3.20.2.2 Five samples shall be taken from each different type of DRD seam, splice, and joint.

9.3.20.2.3 Samples for conditioning shall be at least 1 m (1 yd) lengths of material including seams for seam testing.

9.3.20.3 Specimens.

9.3.20.3.1 Specimens shall be tested after being subjected to the conditioning specified in 9.1.2.

9.3.20.3.2 A total of five material specimens representative of the DRD materials shall be tested for each material type.

9.3.20.3.3 A minimum of five seam, splice, and joint specimens representative of the DRD seams, splices, and joints shall be tested for each seam, splice, and joint type.

9.3.20.4 Procedure. Specimens shall be tested for breaking strength only as specified in ASTM D6775, *Standard Test Method for Breaking Strength and Elongation of Textile Webbing, Tape and Braided Material*.

9.3.20.5 Report.

9.3.20.5.1 The breaking strength of each specimen shall be recorded and reported.

9.3.20.5.2 The average breaking strength of all specimens shall be calculated, recorded, and reported.

9.3.20.6 Interpretation. The average breaking strength shall be used to determine pass or fail performance.

9.3.20.7 Specific Requirements for Testing DRD Seams, Splices, and Joints.

9.3.20.7.1 The test specimen shall be as specified in ASTM D6775, *Standard Test Method for Breaking Strength and Elongation of Textile Webbing, Tape and Braided Material*, and shall include the seam, splice, and joint in the middle of the test specimen.

9.3.20.7.2 Testing shall be performed as specified in 9.3.20.4.

9.4 Liquid, Particulate, Biological, and Environmental Hazard Test Methods.

9.4.1 Water Absorption Resistance Test.

9.4.1.1 Application. This test method shall apply to the protective garment outer shell and collar lining materials.

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

9.4.1.3 Specimens.

9.4.1.3.1 Three specimens of outer shell material and collar lining material measuring at least 200 mm × 200 mm (8 in. × 8 in.) shall be tested separately for water absorption.

9.4.1.3.2 Specimens shall be tested after being subjected to the procedure specified in 9.1.2.

9.4.1.4 Apparatus. The test apparatus shall be as specified in AATCC TM42, *Test Method for Water Resistance: Impact Penetration Test*, with the following modifications:

(1) A metal roller approximately 115 mm (4½ in.) long and weighing 1 kg (2½ lb) shall be used.
(2) Metal embroidery hoops, measuring 150 mm to 180 mm (6 in. to 7 in.) in diameter shall be used for mounting the specimen.
(3) The spring clamp at the top of the test surface shall be replaced with a means for securing the embroidery hoop so that it is centered below the water spray.

9.4.1.5 Procedure.

9.4.1.5.1 The conditioned specimen shall be securely mounted in the metal embroidery hoop with sufficient tension to ensure a uniformly smooth surface.

9.4.1.5.2 The direction of the flow of water down the specimen shall coincide with the warp wise direction of the specimen as placed on the stand.

9.4.1.5.3 The mounted specimen shall be placed on the block with the center of the specimen directly beneath the center of the nozzle and the plane of the surface of the specimen at a 45 degree angle with the horizontal.

9.4.1.5.4 A 500 ml volume of distilled water at a temperature of 27°C ± 1°C (80°F ± 2°F), shall be poured quickly into the funnel and allowed to spray onto the specimen. For collar lining materials, the exposure surface shall be the surface of the fabric that is next to the skin when the collar is closed in the raised position.

9.4.1.5.5 The following operations shall then be executed as rapidly as possible:

(1) The specimen shall be removed from the hoops and placed between sheets of blotting paper on a flat horizontal surface. The metal roller shall be rolled quickly forward and back one time over the paper without application of any pressure other than the weight of the roller.
(2) A square 100 mm × 100 mm (4 in. × 4 in.) shall be cut out of the center of the wet portion of the specimen and weighed to the nearest 0.05 g. This weight shall be designated as the "wet weight." Not more than 30 seconds shall elapse between the time the water has ceased flowing through the spray nozzle and the start of the weighing.
(3) The same 100 mm (4 in.) square shall be conditioned as specified in 9.1.3 until it has dried and reached moisture equilibrium with the surrounding standard atmosphere for textiles. Following this conditioning it shall be reweighed. This weight shall be designated as the "dry weight."

9.4.1.5.6 The percent water absorption (PWA) shall be calculated using the following equation:

[9.4.1.5.6]

$$PWA = \left[(\text{Wet Weight} - \text{Dry Weight}) / (\text{Dry Weight}) \right] \times 100$$

9.4.1.6 Report.

9.4.1.6.1 The percent water absorbed for each specimen shall be recorded and reported.

9.4.1.6.2 The average percent water absorption shall be calculated, reported, and recorded.

9.4.1.7 Interpretation. The average percent water absorption shall be used for determining pass or fail performance.

9.4.2 Water Penetration Resistance Test.

9.4.2.1 Application. This test method shall apply to moisture barrier materials and booties where present.

9.4.2.2 Samples.

9.4.2.2.1 Samples for conditioning shall be at least 1 m (1 yd) square.

9.4.2.2.2 Samples for the conditioning specified in 9.1.5 shall be 150 mm (6 in.) squares cut from a sample subjected to the procedures specified in 9.1.2 and 9.1.3.

9.4.2.3 Specimens.

9.4.2.3.1 A minimum of five specimens of moisture barrier material shall be tested for each sequence of conditioning.

9.4.2.3.2 Specimens shall be tested after being subjected to the procedure specified in 9.1.3.

9.4.2.3.3 Specimens shall also be tested after conditioning as specified in 9.1.2, followed by 9.1.3, followed by 9.1.5.

9.4.2.4 Procedure.

9.4.2.4.1 Specimens shall be tested at 172 kPa (25 psi) in accordance with ASTM D751, *Standard Test Methods for Coated Fabrics*, Hydrostatic Resistance, Procedure A — Mullen Type Tester.

9.4.2.4.2 The surface of the material toward the exterior of the garment as worn shall be exposed to the water challenge.

9.4.2.4.3* There shall be no placement of a restraining cloth over the test specimen during the hydrostatic exposure.

9.4.2.5 Report. The pass or fail performance for each specimen shall be recorded and reported.

9.4.2.6 Interpretation.

9.4.2.6.1 The appearance of any water shall constitute failure.

9.4.2.6.2 One or more test failures of any specimen against any liquid shall constitute failure of the material.

9.4.3 Liquid Penetration Resistance Test.

9.4.3.1 Application.

9.4.3.1.1 This test method shall apply to garment moisture barrier materials and moisture barrier seams, footwear moisture barrier materials and moisture barrier seams, bootie moisture barrier materials and moisture barrier seams where present, and glove moisture barrier materials and moisture barrier seams.

9.4.3.1.2 Modifications to this test method for testing garment moisture barrier materials and moisture barrier seams and bootie moisture barrier materials and moisture barrier seams where present shall be as specified in 9.4.3.7.

9.4.3.1.3 Modifications to this test method for testing glove moisture barrier materials and moisture barrier seams shall be as specified in 9.4.3.8.

9.4.3.1.4 Modifications to this test method for testing footwear shall be as specified in 9.4.3.9.

9.4.3.2 Samples. Samples for conditioning shall be as specified in 9.4.3.7.1 for moisture barriers and moisture barrier seams, 9.4.3.8.2 for glove materials, and 9.4.3.9.1 for footwear materials.

9.4.3.3 Specimens.

9.4.3.3.1 A minimum of three specimens shall be tested for each material type.

9.4.3.3.2 Glove specimens shall be tested after being subjected to the following conditioning:

(1) Specimens shall first be subjected to the procedure specified in 9.1.12.
(2) Specimens shall then be conditioned as specified in 9.1.3.
(3) Specimens shall then be conditioned as specified in 9.1.5.
(4) Specimens shall then be conditioned as specified in 9.1.3.

9.4.3.3.3 Footwear specimens to be tested shall be conditioned as specified in 9.1.5 followed by 9.1.3.

9.4.3.3.4 Moisture barrier materials and moisture barrier seam specimens shall be tested after being twice subjected to the following conditioning:

(1) Specimens shall first be subjected to the procedure specified in 9.1.2.
(2) Specimens shall then be conditioned as specified in 9.1.3.
(3) Specimens shall then be conditioned as specified in 9.1.5.
(4) Specimens shall then be conditioned at a temperature of 21°C ± 3°C (70°F ± 5°F) and at a relative humidity of 65 percent ± 5 percent for at least 4 hours.

9.4.3.4 Procedure.

9.4.3.4.1 Liquid penetration resistance testing shall be conducted in accordance with ASTM F903, *Standard Test Method for Resistance of Materials Used in Protective Clothing to Penetration by Liquids*, using exposure Procedure C at a test temperature of 21°C, ± 3°C (70°F, ± 5°F) and relative humidity of 65 percent, ± 5 percent.

9.4.3.4.2* Each of the following liquids shall be tested separately against each test specimen:

(1) Aqueous film-forming foam (AFFF), 3 percent concentrate
(2) Battery acid (37 percent by weight sulfuric acid to water)
(3) Mineral oil-based hydraulic fluid
(4) Surrogate gasoline Fuel H as defined in ASTM D471, *Standard Test Method for Rubber Property–Effect of Liquids*, consisting of 42.5 percent toluene, 42.5 percent isooctane, and 15 percent ethanol, by volume, respectively
(5) Swimming pool chlorinating chemical containing at least 65 percent-free chlorine (saturated solution)

(6) Automobile antifreeze fluid (ethylene glycol, 90 percent by weight or higher concentration)

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

9.4.3.5 Report. The pass or fail performance for each specimen shall be recorded and reported.

9.4.3.6 Interpretation. One or more test failures of any specimen against any liquid shall constitute failure of the material.

9.4.3.7 Specific Requirements for Testing Moisture Barrier Materials and Moisture Barrier Seams.

9.4.3.7.1 Samples for conditioning shall be at least 380 mm (15 in.) square and shall consist of a composite constructed using a layer of 7.5 oz/yd^2 woven 93 percent meta-aramid, 5 percent para-aramid, 2 percent antistat fiber with a nonfluorinated finish, the moisture barrier, and a layer of 7.8 oz/yd^2 ± 0.3 oz/yd^2 thermal barrier consisting of a woven plain weave face cloth quilted to two layers of aramid nonwoven. Where the sample includes the seam, the moisture barrier layer shall be constructed with a straight center seam that shall extend across the entire 380 mm (15 in.) width of the specimen. The three-layer composite shall be stitched around the entire periphery.

9.4.3.7.1.1 Where the layer intended to be the moisture barrier is configured of a composite that includes outer shell, moisture barrier, or thermal barrier combinations, the samples to be conditioned shall be constructed using those materials.

9.4.3.7.2 The moisture barrier layer shall be removed from the four-layer composite samples after all conditioning has been completed and shall become the moisture barrier specimen.

9.4.3.7.2.1 Where the moisture barrier is configured as indicated in 9.4.3.7.1.1, specimens shall be permitted to be a composite of layers if the layer intended to be the moisture barrier is visible in the test cell and the specimen was preconditioned according to 9.4.3.7.1.1.

9.4.3.7.3 Testing shall be performed as specified in 9.4.3.3 through 9.4.3.6.

9.4.3.8 Specific Requirements for Testing Glove Moisture Barrier Materials and Glove Moisture Barrier Seams.

9.4.3.8.1 Specimens shall be representative of the glove moisture barrier and moisture barrier seams. Three specimens shall be tested.

9.4.3.8.2 Samples for conditioning shall be in the form of a pouch as described in 9.1.15.

9.4.3.8.3 The glove moisture barrier layers shall be removed from the multilayer composite samples after all conditioning has been completed and shall become the glove barrier test specimen.

9.4.3.8.4 Specimens for testing shall be the barrier layer only.

9.4.3.8.5 Testing shall be performed as specified in 9.4.3.2 through 9.4.3.6.

9.4.3.8.6 Where the moisture barrier material is continuous through the glove body, only the barrier straight seams shall be tested. The test cell shall include both the moisture barrier material and the straight moisture barrier seam. The seam shall be located in the approximate center of the test cell.

9.4.3.9 Specific Requirements for Testing Footwear Materials.

9.4.3.9.1 Samples for conditioning shall be whole footwear or footwear composite swatches. Footwear composite swatches shall be representative of the footwear construction.

9.4.3.9.2 Three specimens shall be representative of the moisture barrier, and three specimens shall be representative of each type of moisture barrier seam. The moisture barrier seam specimen shall be a straight seam.

9.4.3.9.3 Testing shall be performed as described in 9.4.3.2 through 9.4.3.6.

9.4.3.9.4 Specimens for testing shall be the barrier layer only.

9.4.4 Particulate Blocking Test.

9.4.4.1 Application. This test shall apply to hood particulate-blocking layers and seams or hood composites comprising the function of the particulate-blocking layer and composite seams.

9.4.4.2 Samples.

9.4.4.2.1 Samples for conditioning shall measure at least 380 mm × 380 mm (15 in. × 15 in.) and consist of composites constructed using all layers provided in the order that represents the particulate-blocking function of the hood.

9.4.4.2.2 An additional set of samples shall be prepared with straight seam samples where the composite layers are sewn together using a representative seam from the finished hood construction. The composite seam shall measure at least 380 mm^2 (15 in.^{2}) and the seam shall bisect the middle of the composite.

9.4.4.2.3* A reference sample shall be prepared that consists of a composite constructed using two layers of 9.0 oz/yd^2 ± 1.0 oz/yd^2, 100 percent meta-aramid, 1 × 1 rib knit with a stitch count of 37 courses/in. ± 2 courses/in. and 21 wales/in. ± 2 wales/in.

9.4.4.2.4 Sets of particulate-blocking-layer samples and composite seam samples shall be tested both before and after being twice subjected to the following conditioning:

(1) Specimens shall be first subjected twice to the procedure specified in 9.1.2.
(2) Specimens shall then be conditioned as specified in 9.1.3.
(3) Specimens shall then be conditioned as specified in 9.1.5.

9.4.4.3 Specimens.

9.4.4.3.1 The samples subjected to the full conditioning as specified in 9.4.4.2.4 shall become the particulate blocking test specimens.

9.4.4.3.1.1 Composite specimens and composite seam specimens shall be large enough to cover the testing area with sufficient overlap to prevent any particulate leakage.

9.4.4.3.1.2 Composite seam specimens shall be centered on the sample holder so that it is bisected by the seam.

9.4.4.3.2 The center of each conditioned sample shall be the specimen and considered to be the test area.

9.4.4.3.3 All specimens to be tested shall be conditioned as specified in 9.1.3.

9.4.4.3.4 All reference specimens to be tested shall be conditioned as specified in 9.1.3.

9.4.4.3.5 A total of three particulate-blocking layer composite specimens and three composite seam specimens shall be tested for each condition. One reference specimen shall be tested.

9.4.4.4 Apparatus. The test apparatus shall be as specified in ASTM F2299/F2299M, *Standard Test Method for Determining the Initial Efficiency of Materials Used in Medical Face Masks to Penetration by Particulates Using Latex Spheres*, with the following modifications:

(1) A stainless-steel reinforcement screen with a mesh size of 1 mm × 1 mm (0.04 in. × 0.04 in.) shall be used adjacent to the test specimen on the downstream side.
(2) Particle detection shall be accomplished with the use of a scanning mobility particle sizer (SMPS) or an optical particle counter (OPC) capable of measuring 0.1 μ at 100 percent counting efficiency.
(3) The material specimen cross section diameter shall be large enough to cover the testing area with sufficient overlap to prevent any particulate leakage from the sides of the specimen in the area of specimen that seals into the sample holder.

9.4.4.5 Procedure.

9.4.4.5.1 Prior to conditioning in 9.4.4.2.4 and testing, the composite and composite seam samples shall be tested for air permeability in accordance with ASTM D737, *Standard Test Method for Air Permeability of Textile Fabrics*.

9.4.4.5.1.1 Where the air permeability result is less than 0.28 $cm^3/s/cm^2$ (0.56 $ft/min/ft^2$), testing according to 9.4.4.5 is permitted to be waived and the results shall be reported as hood material or seam having an air permeability of less than 0.28 $cm^3/s/cm^2$ (0.56 $ft/min/ft^2$).

9.4.4.5.1.2 Where the air permeability result indicates testing of the composite is acceptable, the straight seam specimens shall be permitted to be tested in lieu of composite specimens. The seam shall be located in the center of the test area.

9.4.4.5.2* The latex sphere sizes used in testing shall range from 0.1 μm to 1.0 μm and shall be created using at least eight different known particle sizes from 0.1 μm to 1.0 μm.

9.4.4.5.3 The required face velocity shall be 1.0 L/min ± 0.1 L/min.

9.4.4.5.4 The efficiency for each specimen shall be calculated for each sequence for conditioning using the following equation:

[9.4.4.5.4]

$$\%\text{Efficiency} = \eta = [1 - (\text{downstream counts}/\text{upstream counts})] * 100$$

9.4.4.5.5 The average efficiency for each particle size shall be calculated for each test condition.

9.4.4.6 Report.

9.4.4.6.1 The final measurement airflow face velocity shall be recorded and reported in cm/s for each specimen.

9.4.4.6.1.1 The upstream and downstream particulate counts shall be recorded and reported for each particle size for each specimen.

9.4.4.6.1.2 The average percent efficiency for each particle size per test condition and type of sample (e.g., composite and composite seams) shall be recorded and reported.

9.4.4.6.2 Where testing in 9.4.4.5 is waived due to the air permeability result, the air permeability shall be recorded and reported along with the following statement:

"PARTICULATE BLOCKING TEST WAIVED FOR [sample name and identification] BECAUSE AIR PERMEABILITY WAS MEASURED AS BEING BELOW THE DETECTION LIMIT OF ASTM D737 AND IS PRESUMED TO HAVE A PARTICULATE BLOCKING EFFICIENCY OF 99% OR GREATER FOR EACH PARTICLE SIZE FROM 0.1 μm TO 1.0 μm."

9.4.4.7 Interpretation.

9.4.4.7.1 The lowest average percent efficiency in either test condition for each particle size and each type of sample shall be used to determine pass or fail performance.

9.4.4.7.2 Where the air permeability result is less than 0.028 $cm^3/s/cm^2$ (0.056 $ft^3/min/ft^2$), the performance requirements shall be waived and the material or seam shall be considered as having passing results.

9.4.5 Viral Penetration Resistance Test.

9.4.5.1 Application.

9.4.5.1.1 This test method shall apply to garment moisture barrier materials and moisture barrier seams, footwear moisture barrier materials and moisture barrier seams, and glove moisture barrier materials and moisture barrier seams.

9.4.5.1.2 Modifications to this test method for testing glove moisture barrier materials and moisture barrier seams shall be as specified in 9.4.5.7.

9.4.5.1.3 Modifications to this test method for testing footwear shall be as specified in 9.4.5.8.

9.4.5.2 Samples. Samples for conditioning shall be as specified in 9.4.5.7 for garment materials, 9.4.5.8 for glove materials, and 9.4.5.9 for footwear materials.

9.4.5.3 Specimens.

9.4.5.3.1 A minimum of three specimens shall be tested for each material type.

9.4.5.3.2 Glove specimens shall be tested after being subjected to the following conditioning:

(1) Specimens shall first be subjected to the procedure specified in 9.1.12.
(2) Specimens shall then be conditioned as specified in 9.1.3.
(3) Specimens shall then be conditioned as specified in 9.1.5.
(4) Specimens shall then be conditioned as specified in 9.1.3.

9.4.5.3.3 Footwear specimens to be tested shall be conditioned as specified in 9.1.5 followed by 9.1.3.

9.4.5.3.4 Moisture barrier material and moisture barrier seam specimens shall be tested after being twice subjected to the following conditioning:

(1) Specimens shall first be subjected to the procedure specified in 9.1.2.
(2) Specimens shall then be conditioned as specified in 9.1.3.
(3) Specimens shall then be conditioned as specified in 9.1.5.

(4) Specimens shall then be conditioned at a temperature of 21°C ± 3°C (70°F ± 5°F) and at a relative humidity of 65 percent ± 5 percent for at least 4 hours.

9.4.5.4 Procedure. Viral penetration resistance testing shall be conducted in accordance with ASTM F1671/F1671M, *Standard 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*.

9.4.5.4.1 The normal outer surface of the material shall be exposed to the viral challenge as oriented in the clothing item.

9.4.5.5 Report.

9.4.5.5.1 The pass or fail performance for each specimen shall be recorded and reported.

9.4.5.5.2 The assay titer in PFU/mL of the Phi-X174 bacteriophage shall be recorded and reported.

9.4.5.6 Interpretation. Specimens shall exhibit no more than 10 PFU/mL of Phi-X174 bacteriophage in the assay titer to pass the test. A failure of any specimen against any virus constitutes failure of the material.

9.4.5.7 Specific Requirements for Testing Moisture Barrier Materials and Moisture Barrier Seams.

9.4.5.7.1 Samples for conditioning shall be at least 380 mm (15 in.) square and shall consist of a composite constructed using a layer of 7.5 oz/yd^2 woven 93 percent meta-aramid, 5 percent para-aramid, 2 percent antistat fiber with a nonfluorinated finish, the moisture barrier, a layer of 7.8 oz/yd^2 ± 0.3 oz/yd^2, and a thermal barrier consisting of a woven plain weave face cloth quilted to two layers of aramid nonwoven. Where the sample includes the seam, the moisture barrier layer shall be constructed with a straight center seam that shall extend across the entire 380 mm (15 in.) width of the specimen. The three-layer composite shall be stitched around the entire periphery.

9.4.5.7.2 The moisture barrier layer shall be removed from the three-layer composite samples after all conditioning has been completed and shall become the moisture barrier test specimen.

9.4.5.7.3 Testing shall be as specified in 9.4.5.2 through 9.4.5.6.

9.4.5.8 Specific Requirements for Testing Glove Moisture Barrier Materials and Glove Moisture Barrier Seams.

9.4.5.8.1 Specimens shall be representative of the glove moisture barrier and moisture barrier seams. Three specimens shall be tested.

9.4.5.8.2 Samples for conditioning shall be in the form of a pouch as described in 9.1.15.

9.4.5.8.3 The glove moisture barrier layers shall be removed from the multilayer composite samples after all conditioning has been completed and shall become the glove barrier test specimen.

9.4.5.8.4 Specimens for testing shall be the barrier layer only.

9.4.5.8.5 Testing shall be performed as specified in 9.4.5.2 through 9.4.5.6.

9.4.5.8.6 Where the moisture barrier material is continuous throughout the glove body, only the barrier straight seams shall be tested. The test cell shall include both the moisture barrier material and the moisture barrier straight seam. The seam shall be located in the approximate center of the test cell.

9.4.5.9 Specific Requirements for Testing Footwear Materials.

9.4.5.9.1 Three specimens shall be representative of the moisture barrier, and three specimens shall be representative of each type of moisture barrier seam. The moisture barrier seam specimen shall be a straight seam.

9.4.5.9.2 Samples for conditioning shall be whole footwear, or footwear composite swatches. Footwear composite swatches shall be representative of the footwear construction.

9.4.5.9.3 Testing shall be as described in 9.4.5.2 through 9.4.5.6.

9.4.5.9.4 Specimens for testing shall be the barrier layer only.

9.4.6 Corrosion Resistance Test.

9.4.6.1 Application.

9.4.6.1.1 This test method shall apply to hardware items on protective garments, helmets, gloves, and footwear.

9.4.6.1.2 Modifications to this test method for testing garment and glove hardware shall be as specified in 9.4.6.7.

9.4.6.1.3 Modifications to this test method for testing helmet and partial eye/face protective devices shall be as specified in 9.4.6.8.

9.4.6.1.4 Modifications to this test method for testing footwear shall be as specified in 9.4.6.9.

9.4.6.2 Samples. Samples shall be conditioned as specified in 9.1.3.

9.4.6.3 Specimens. A total of three specimens of each hardware type shall be tested.

9.4.6.4 Procedure.

9.4.6.4.1 Specimens shall be tested in accordance with ASTM B117, *Standard Practice for Operating Salt Spray (Fog) Apparatus*. Hardware items shall be exposed to a 5 percent ± 1 percent saline solution for a period of 20 hours.

9.4.6.4.2 Immediately following the storage specified in 9.4.6.4.1 and prior to examination, specimens shall be rinsed under warm, running tap water and dried with compressed air.

9.4.6.4.3 Specimens shall then be examined visually with the unaided eye to determine the presence of corrosion.

9.4.6.4.4 A photograph of any specimen shall be taken to document the level of corrosion.

9.4.6.4.5 The functionality of each specimen shall be evaluated.

9.4.6.5 Report.

9.4.6.5.1 The presence of corrosion and the functionality for each specimen shall be recorded and reported.

9.4.6.5.2 Photographs showing any evidence of corrosion on a specimen shall be included as part of the report.

9.4.6.6 Interpretation. One or more hardware specimens failing this test shall constitute failing performance for the hardware type.

9.4.6.7 Specific Requirements for Testing Garment and Glove Hardware.

9.4.6.7.1 Samples for conditioning shall be whole hardware items.

9.4.6.7.2 A total of three specimens of each hardware type shall be tested.

9.4.6.8 Specific Requirements for Testing Helmets.

9.4.6.8.1 Samples for conditioning shall be whole helmets with the faceshield/goggle component attached.

9.4.6.8.2 A total of three different helmets shall be tested.

9.4.6.9 Specific Requirements for Testing Footwear.

9.4.6.9.1 Samples for conditioning shall be whole hardware items.

9.4.6.9.2 A total of three specimens of each hardware type shall be tested.

9.4.6.9.3 Functionality of the toe cap, sole plate, and ladder shank shall not be evaluated.

9.4.7 Coating/Laminate Wet Flex Test.

9.4.7.1 Application. This test method shall apply to garment outer shell materials, glove outer shell materials, helmet faceshields, footwear, helmet outer covers, and helmet shrouds.

9.4.7.2 Samples. Samples shall be conditioned as specified in 9.1.3.

9.4.7.3 Specimens. Specimens shall be 100 mm × 200 mm (4 in. × 8 in.) with the long dimension parallel to the warp or wale direction and shall be from the fabric lot used in the construction of the proximity protective garment.

9.4.7.3.1 Five specimens from each sample unit shall be tested with no two specimens containing the same yarns.

9.4.7.3.2 The specimens shall be immersed in water at 60°C ± 3°C (140°F ± 5°F), for 15 minutes.

9.4.7.3.3 Upon removal from the water, the test specimen shall be placed on two layers of absorbent-type blotters and covered by two additional layers.

9.4.7.3.4 The blotting paper shall conform to the requirements in AATCC TM35, *Test Method for Water Resistance: Rain Test.*

9.4.7.3.5 After placing the wet specimens between the blotters, a 4.5 kg (10 lb) weight, a steel rod 75 mm (3 in.) in diameter and 125 mm (5 in.) long, shall be rolled over the test specimen for four complete cycles, eight passes.

9.4.7.3.6 The specimen shall be removed from between the blotters and placed in the flexing device as specified in 9.4.7.3.4.

9.4.7.4 Apparatus.

9.4.7.4.1 The flexing device as shown in Figure 9.4.7.4.1(a) and Figure 9.4.7.4.1(b) shall be used.

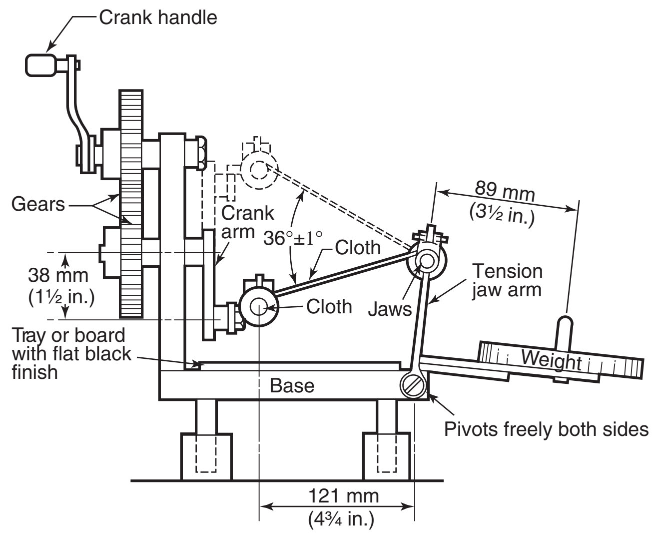


FIGURE 9.4.7.4.1(a) End View of Flexing Device.

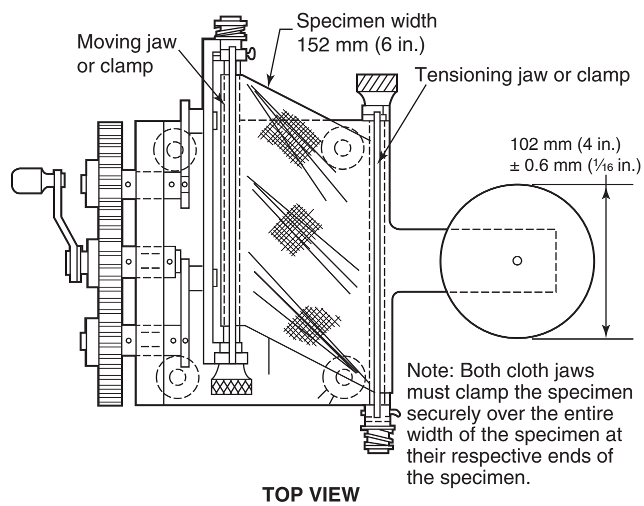


FIGURE 9.4.7.4.1(b) Top View of Flexing Device.

9.4.7.4.2 The flexing device shall have a suitable weight on the weight arm to produce a 13.5 N to 15.75 N (3 lb to 3.5 lb) tension on the specimen during flexing.

9.4.7.4.3 The tensioning jaw or clamp shall be so located that, with the tension jaw arm vertical, any point on the tensioning jaw would be the apex of a cone of motion generated between that point and the corresponding point of the moving jaw.

9.4.7.4.4 The crank arms shall be equal in effective length and in angular phase so that the moving jaw connecting the two arms remains parallel to the tension jaw throughout a complete revolution of the arms.

9.4.7.4.5 A tray or board, flat black in color and sufficiently large to catch any particles that are removed from the fabric, shall be cleaned before each test and examined for material particles after each test.

9.4.7.4.6 A motor-driven apparatus shall be permitted to be used in lieu of the manual device specified.

9.4.7.5 Procedure.

9.4.7.5.1 The specimens shall be taken directly from the blotter paper and placed in the flexing device with the warp or wale direction perpendicular to the jaw line.

9.4.7.5.2 The distance between jaw lines shall be 135 mm (5¼ in.).

9.4.7.5.3 The specimen shall be placed in the device with the moving jaw at bottom dead center, the tension jaw arm vertical, and the face of the cloth down.

9.4.7.5.4 Each jaw shall clamp the specimen across the entire width.

9.4.7.5.5 The crank handle shall be turned at a rate of 50 revolutions ± 10 revolutions per minute of the crank arms and moving jaw during the test.

9.4.7.5.6 The specimen shall be flexed for 1000 cycles, then removed from the apparatus, and shall be visually inspected to determine pass/fail.

9.4.7.6 Report. Evidence of any cracking or delamination shall be identified and defined and shall be recorded and reported.

9.4.7.7 Interpretation.

9.4.7.7.1 Any cracking or delamination closer than 22 mm (⅞ in.) from either jaw line shall not be considered.

9.4.7.7.2 Failure of any one specimen shall constitute failure of sample unit.

9.4.8 Coating/Laminate Adhesion After Wet Flex Test.

9.4.8.1 Application.

9.4.8.1.1 This test method shall apply to the following proximity firefighting protective ensemble elements: garment outer shell materials, glove outer shell materials, helmet outer covers, and helmet shrouds.

9.4.8.1.2 This test shall apply only to coated or laminated materials of the noted element components.

9.4.8.2 Samples. The same samples used in Section 9.4.7, Wet Flex Test, shall be the samples used for this test.

9.4.8.3 Specimens. The same specimens specified in 9.4.7.3 shall be the specimens used for this test.

9.4.8.4 Apparatus.

9.4.8.4.1 The tensile-testing machine described in ASTM D5034, *Standard Test Method for Breaking Strength and Elongation of Textile Fabrics (Grab Test)*, shall be used with the modification that all machine attachments for determining maximum load shall be disengaged and the speed of the pulling clamp shall be 505 mm/min (20 in./min).

9.4.8.4.2 Five 50 mm × 100 mm (2 in. × 4 in.) steel plates conforming to Class 301 or Class 304 of ASTM A666, *Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar*, which have been polished to a No. 4 finish shall be used.

9.4.8.4.3 A 38 mm (1½ in.) wide steel roller weighing 4.53 kg ± 0.06 kg (10 lb ± 2 oz), shall be used.

9.4.8.4.4 A pressure sensitive tape used for testing the adhesion of the coating or the laminate shall be used and shall have the required adhesion value specified in 9.4.8.4.6.11.

9.4.8.4.5 Candidate pressure sensitive tapes, for potential use in testing the adhesion of coatings or laminates, shall have the adhesion value of the candidate tapes be determined by the procedure specified in 9.4.8.4.6.12.

9.4.8.4.6 Procedure for Determining Adhesion Value of Candidate Pressure Sensitive Tapes.

9.4.8.4.6.1 The equipment specified in 9.4.8.4.1, 9.4.8.4.2, and 9.4.8.4.3 shall be used in the procedure for adhesion value determination.

9.4.8.4.6.2 Prior to each adhesion value determination procedure, the steel plates specified in 9.4.8.4.2 shall be thoroughly cleaned with diacetone alcohol, methyl alcohol, or methyl ethyl ketone, using a clean piece of lint-free wiping tissue.

9.4.8.4.6.3 Five specimens from the same production batch of each candidate pressure sensitive tape shall be tested. Each candidate tape specimen shall measure 25 mm × 200 mm (1 in. × 8 in.).

9.4.8.4.6.4 Each of the five tape specimens of one candidate tape sample, specified in 9.4.8.4.6.3, shall be applied to the clean surface of each of the five steel plates, specified in 9.4.8.4.2, so that it covers the entire length of the plate and extends 100 mm (4 in.) beyond one end of the plate.

9.4.8.4.6.5 Each candidate tape specimen shall be pressed down by passing the roller, specified in 9.4.8.4.3, over the tape six times, three times in each direction.

9.4.8.4.6.6 The free end of the candidate tape specimen shall be doubled back over the specimen 180 degrees, and 25 mm (1 in.) of the tape shall be peeled off the plate.

9.4.8.4.6.7 Each plate, with the candidate tape specimen affixed, shall be tested separately for adhesion value determination.

9.4.8.4.6.8 The plate shall be inserted and clamped in the bottom jaw of the tensile-testing machine, specified in 9.4.8.4.1, with the free end of the candidate tape specimen oriented downward.

9.4.8.4.6.9 The free end of the candidate tape specimen shall be looped upward and inserted and clamped in the upper jaw so as to peel the tape specimen from the plate when the jaw motion is started.

9.4.8.4.6.10 The minimum tension required to remove the remainder of the candidate tape specimen from the steel plate, excluding the final 25 mm (1 in.), shall be recorded by an autographic recording device.

9.4.8.4.6.11 The recorded minimum tension value of the candidate tape specimen shall be the adhesion value.

9.4.8.4.6.12 All five specimens of the candidate tape shall have an adhesion value of not less than 4.8 N/cm (2¾ lb/in.) width, and not more than 6.2 N/cm (3½ lb/in.) width for the pressure sensitive tape to be selected for use in testing the adhesion of the coating or the laminate.

9.4.8.5 Procedure.

9.4.8.5.1 Immediately after each of the five specimens has completed the testing specified in Section 9.4.7, Wet Flex Test, the five specimens shall be tested and evaluated for adhesion.

9.4.8.5.2 A razor cut design shall be symmetrically centered within the 100 mm × 200 mm (4 in. × 8 in.) of each of the five specimens. The cut design shall be two X cuts and three horizontal cuts and shall be made as shown in Figure 9.4.8.5.2. The cuts shall be made with a sharp razor blade through the coating or laminate and adhesive layers, but shall not cut through the base cloth.

9.4.8.5.3 Five 25 mm × 200 mm (1 in. × 8 in.) pieces of pressure sensitive tape, taken from a lot of material that has qualified for use in testing the adhesion of coatings or laminates by the procedure specified in 9.4.8.4.6, shall be used for adhesion testing.

9.4.8.5.4 One piece of the pressure sensitive tape, specified in 9.4.8.5.3, shall be used for each of the specimens.

9.4.8.5.5 The pressure sensitive tape shall be applied to the specimens so that it covers the entire length of the specimen, centered over the X cuts and horizontal cuts as shown in Figure 9.4.8.5.2, and extending 100 mm (4 in.) beyond one end of the specimen.

9.4.8.5.6 The pressure sensitive tape shall be pressed onto the specimen by passing the roller over the specimen six times, three times in each direction.

9.4.8.5.7 The free end of the pressure sensitive tape shall be doubled back over the specimen 180 degrees, and 25 mm (1 in.) of the pressure sensitive tape shall be peeled off the specimen.

9.4.8.5.8 The specimen shall then be inserted and clamped in the bottom jaw of the tensile-testing machine, specified in 9.4.8.4.1, with the free end of the pressure sensitive tape downward.

9.4.8.5.9 The free end of the tape shall be looped upward and inserted and clamped in the upper jaw of the tensile-testing machine so as to peel the pressure sensitive tape from the specimen when the jaw motion is started.

9.4.8.5.10 The jaw motion of the tensile-testing machine shall be engaged to peel the pressure sensitive tape from the specimen.

9.4.8.5.11 Following removal of the pressure sensitive tape, the tape and specimen shall be visually examined for compliance.

9.4.8.6 Report.

9.4.8.6.1 Evidence of any delamination shall be recorded and reported.

9.4.8.6.2 Evidence of any particulate on the pressure sensitive tape adhesive from the coating shall be recorded and reported.

9.4.8.7 Interpretation.

9.4.8.7.1 A moderate number of specks on the pressure sensitive tape adhesive from the coating shall not constitute failure.

9.4.8.7.2 Evidence of separation or removal of the surface coating shall constitute a failure.

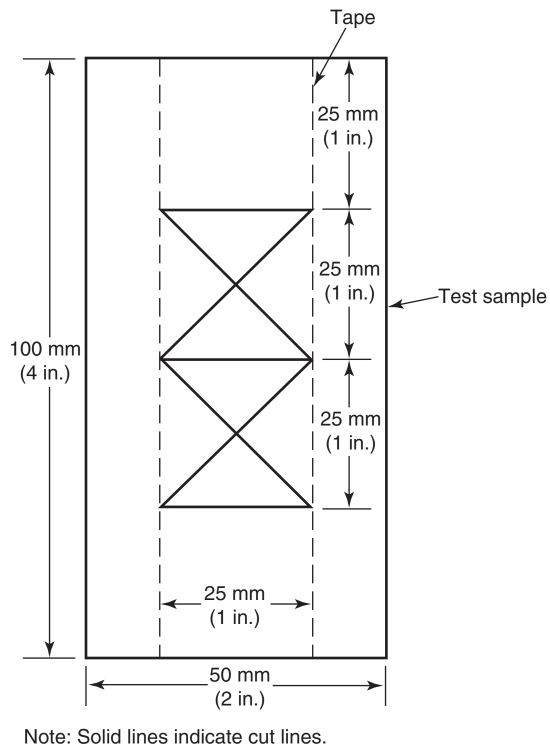


FIGURE 9.4.8.5.2 Cuts.

9.4.8.7.3 The failure of any one specimen shall constitute failure of the test.

9.4.9 Coating/Laminate Flex Resistance at Low Temperature Test.

9.4.9.1 Application. This test method shall apply to garment outer shell materials, glove outer shell materials, helmet faceshields, footwear, helmet outer covers, and helmet shrouds.

9.4.9.2 Samples.

9.4.9.2.1 Samples shall be taken from the fabric lot used in the construction of the garment.

9.4.9.2.2 Samples shall be conditioned as specified in 9.1.3.

9.4.9.3 Specimens.

9.4.9.3.1 A minimum of five specimens shall be tested.

9.4.9.3.2 Specimens shall measure 25 mm × 100 mm (1 in. × 4 in.), with the long dimension in the warp or wale direction.

9.4.9.4 Apparatus. The test jig as shown in Figure 9.4.9.4 shall be used.

9.4.9.5 Procedure.

9.4.9.5.1 The test samples and test jig, as shown in Figure 9.4.9.4, shall be conditioned for 4 hours at a temperature of −32°C (−25°F).

9.4.9.5.2 At the end of the conditioning period, with the jig and the test specimens still in the test atmosphere, the specimen shall be placed in the open jig with the rod in the center

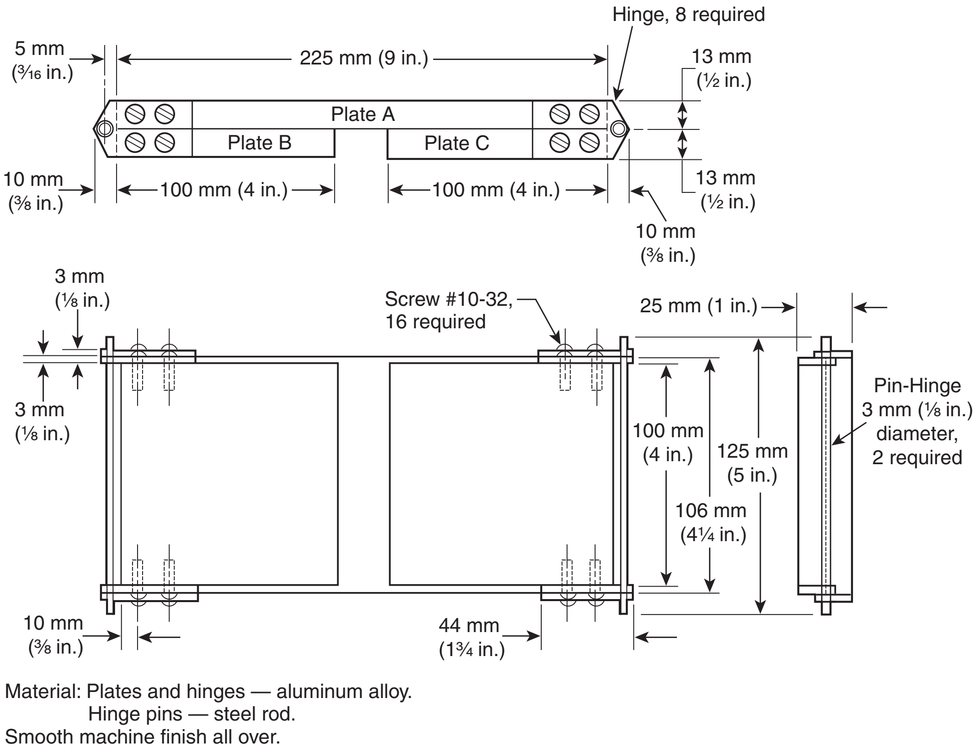


FIGURE 9.4.9.4 Jig Assembly — Resistance to Low Temperature Test.

of the fabric. The face of the fabric shall be positioned away from the rod.

9.4.9.5.3 The jig shall be closed in less than 3 seconds so that the specimen is bent face out around the rod until the back of the specimen touches itself.

9.4.9.5.4 The tested fabric shall be examined without magnification.

9.4.9.6 Interpretation. Failure of any one specimen shall constitute failure of sample unit of production.

9.4.10* Light Degradation Resistance Test.

9.4.10.1 Application. This test method shall apply to moisture barrier materials.

9.4.10.2 Samples.

9.4.10.2.1 Samples for conditioning shall be at least a 380 mm (15 in.) square and consist of a composite constructed using one layer of 7.5 oz woven 93 percent meta-aramid, 5 percent para-aramid, 2 percent antistat fiber, the moisture barrier being tested, and one layer of 3.8 oz ± 0.3 oz, aramid needle punched nonwoven, quilted to a 3.4 oz ± 0.2 oz, aramid woven plain weave thermal barrier material. The three-layer composite sample shall be stitched around the entire periphery.

9.4.10.2.2 Six composite samples shall be prepared.

9.4.10.3 Sample Preparation.

9.4.10.3.1 Sample composites shall be subjected to two cycles of the following conditioning:

(1) The sample shall first be subjected to the procedure specified in 9.1.2.
(2) The sample shall then be conditioned as specified in 9.1.3.
(3) The sample shall then be conditioned as specified in 9.1.5.
(4) The sample shall then be conditioned at a temperature of 21°C ± 3°C (70°F ± 5°F), and a relative humidity of 65 percent ± 5 percent for at least 4 hours.

9.4.10.3.2 After subjecting the composite to the conditioning procedure in 9.62.3.1, the three-layer composite shall be subjected to UV light in accordance with ASTM G155, *Standard Practice for Operating Xenon Arc Light Apparatus for Exposure of Non-Metallic Materials*, with the following modifications:

(1) Cycle 8 exposure conditions shall be used.
(2) Both inner and outer filters shall be borosilicate.
(3) The exposure duration shall not include dark cycles.
(4) Specimens shall be subjected to 40 hours of continuous light exposure.
(5) Three of the samples shall be oriented so that the outer shell is facing the light source.
(6) Three of the samples shall be oriented so that the thermal barrier is facing the light source.

9.4.10.3.3 Specimens shall be removed from the test apparatus and conditioned in a dark environment at a temperature of 21°C ± 3°C (70°F ± 5°F), and a relative humidity of 65 percent ± 5 percent, for at least 4 hours prior to testing.

9.4.10.4 Specimen Preparation.

9.4.10.4.1 The moisture barrier material layer shall be removed from the conditioned sample composite and cut into specimens measuring at least 150 mm (6 in.) square.

9.4.10.4.2 A minimum of six specimens shall be tested. Three specimens shall be cut from the samples where the outer shell was facing the light source and three specimens shall be cut from the samples were the thermal barrier was facing the light source.

9.4.10.5 Procedure.

9.4.10.5.1 Specimens shall be tested in accordance with ASTM D751, *Standard Methods for Testing Coated Fabrics*, Hydrostatic Resistance, Procedure B – Rising Column Water Method, Procedure 2, Sections 46–49, with the following modifications:

(1) An alternative test apparatus shall be permitted provided the exposed area of the specimen is at least 108 mm (4¼ in.) in diameter and the pressure can be applied uniformly over the exposure period at a precision of ± 0.1 kPa (± 0.2 psi).
(2) The applied pressure shall be 13.8 kPa (2 psi) for an exposure period of 1 minute.
(3) Restraining materials shall not be used.
(4) The performance of the specimen shall be discerned by a person with 20/20 vision, or vision corrected to 20/20, at a nominal distance of 305 mm (12 in.) with standard room illumination.

9.4.10.5.1.1 The moisture barrier specimen shall be placed in the apparatus with the film side facing away from the water source.

9.4.10.6 Report. The pass or fail performance for each specimen shall be recorded and reported.

9.4.10.7 Interpretation.

9.4.10.7.1 Evidence of water on the surface of the specimen during the exposure period shall constitute failing performance.

9.4.10.7.2 One or more test failures of any specimen shall constitute failure of material.

9.5 Overall Product Integrity Test Methods.

9.5.1 Whole Garment and Ensemble Liquid Penetration Test.

9.5.1.1 Application.

9.5.1.1.1 This test method shall apply to protective garments, protective coats with an integrated garment-glove interface, protective trousers with integrated booties, protective garments with integrated hoods, and protective garments that are being evaluated for optional liquid and particulate contaminant protection.

9.5.1.1.2 Modifications to this test method for testing protective coats and protective coats with an integrated garment-glove interface shall be as specified in 9.5.1.9.

9.5.1.1.3 Modifications to this test method for testing protective trousers and protective trousers with integrated booties shall be as specified in 9.5.1.10.

9.5.1.1.4 Modifications to this test method for testing protective coat and trouser sets or protective coveralls shall be as specified in 9.5.1.11.

9.5.1.1.5 Modifications to this test method for testing proximity firefighting ensemble garment elements shall be as specified in 9.5.1.12.

9.5.1.1.6 Modifications to this test method for testing garments for optional liquid and particulate contaminant protection shall be as specified in 9.5.1.13.

9.5.1.2 Samples.

9.5.1.2.1 Samples shall be complete garments or ensemble elements.

9.5.1.2.2 Samples shall be conditioned as specified in 9.1.3.

9.5.1.3 Specimens.

9.5.1.3.1 A minimum of three specimens shall be tested. Specimens shall consist of individual coats, trousers, coverall elements, or sets of coats and trousers elements for liquid and particulate contaminant protection. Each element shall have in place all layers that are required for the element to be compliant.

9.5.1.3.2 The size of the elements comprising the specimens shall be chosen to conform with the dimensions of the manikin for proper fit of the specimen on the manikin in accordance with the manufacturer's sizing system. The size of the elements comprising the specimen shall be the same size as the manikin in chest circumference, waist circumference, and inseam height.

9.5.1.3.3 Specimens to be tested shall be conditioned as specified in 9.1.3.

9.5.1.4 Sample Preparation. Samples to be conditioned shall be complete garments.

9.5.1.5 Apparatus. The apparatus and supplies for testing shall be those specified in ASTM F1359/F1359M, *Standard Test Method for Liquid Penetration Resistance of Protective Clothing or Protective Ensembles Under a Shower Spray While on a Manikin*, with the following modifications:

(1) The surface tension of the water used in testing shall be 35 dynes/cm ± 5 dynes/cm.
(2) The manikin used in testing shall be fully upright and have straight arms and legs with the arms positioned at the manikin's side.

9.5.1.6 Procedure. Liquid penetration testing of garments shall be conducted in accordance with ASTM F1359/F1359M, *Standard Test Method for Liquid Penetration Resistance of Protective Clothing or Protective Ensembles Under a Shower Spray While on a Manikin*, with the following modifications:

(1) Procedure B shall be used with an overall exposure period of 10 minutes with 2.5 minutes in each of the four orientations.
(2) Blocking of the specimen shall be as specified in 9.5.1.9, 9.5.1.10, and 9.5.1.11, as appropriate, for the type of specimen being tested.
(3) The method used for mounting of the manikin in the spray chamber shall not interfere with the water spray.
(4) The normal outer surface of the material shall be exposed to the liquid as oriented in the clothing item.
(5) Fluorescent or visible dyes shall not be used in the water for spraying the suited manikin.
(6) The manikin shall be positioned so that the manikin body is in a full vertical orientation with the manikin head looking forward, manikin legs straight, and manikin arms pointing downward by the sides of the manikin torso. The manikin joints shall be tightened to ensure that the manikin maintains this position during testing.

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

9.5.1.8 Interpretation.

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

9.5.1.8.2 In determining the compliance of the specific garments or ensemble being evaluated, one of the three specimens shall be permitted to display leakage on the liquid-absorptive garment of an area that is collectively not greater than 20 cm^2 (3.1 $in.^2$).

9.5.1.9 Specific Requirements for Testing Coats and Coats with an Integrated Garment-Glove Interface.

9.5.1.9.1 The liquid-absorptive garment shall only cover the upper torso and arms of the manikin from the middle of the manikin's neck, down to the manikin's waistline, and down to the manikin's wrist crease.

9.5.1.9.2 The coat shall be donned on the manikin in accordance with the manufacturer's instructions for proper wearing.

9.5.1.9.3 The coat collar shall be placed in the up position on the manikin with the collar closure system fastened in the closed position. The head of the manikin shall be sealed off with a plastic bag. The plastic bag shall extend downward over the collar a distance of not greater than 25 mm (1 in.) and be taped down using duct tape or similar waterproof tape. The tape shall not extend downward more than 75 mm (3 in.) from the top of the collar. The bottom edge of the tape and the plastic bag shall not come closer than 25 mm (1 in.) of the collar seam where a collar seam is present. Where present, the collar neck seam shall not be covered.

9.5.1.9.4 The test shall be conducted with the manikin's hands removed. The coat sleeve hem shall be taped smoothly to a can or an object of similar cylindrical, rigid shape of the same nominal diameter as the sleeve opening. The can or cylindrical object shall be fitted over the wristlet and under the coat's outer shell sleeve hem. The tape shall be duct tape or similar waterproof tape.

9.5.1.9.4.1 Where garments are supplied with an integrated garment-glove interface, the manikin's hands shall not be removed. The garment-glove combination shall be donned on the manikin in accordance with the manufacturer's instructions for proper wearing.

9.5.1.9.5 The coat shall be tested in conjunction with the protective trousers specified by the manufacturer, even where the trousers are not specifically evaluated in this test.

9.5.1.10 Specific Requirements for Testing Trousers.

9.5.1.10.1 The liquid-absorptive garment shall cover only the lower torso and legs of the manikin from the manikin's waistline down to the manikin's ankles.

9.5.1.10.2 The trousers shall be donned on the manikin in accordance with the manufacturer's instructions for proper wearing.

9.5.1.10.3 Trousers shall be tested in conjunction with the protective coat specified by the manufacturer, even where the coat is not specifically evaluated in this test.

9.5.1.10.4 Absorbent toweling or similar material shall be placed underneath the manikin in order to prevent water splashing up inside the trouser leg.

9.5.1.10.5 Where trousers are provided with integrated booties, outer footwear specified to be worn with the booties shall be donned on the manikin in accordance with the manufacturer's instructions for proper wearing.

9.5.1.11 Specific Requirements for Testing Coveralls.

9.5.1.11.1 The liquid-absorptive garment shall only cover the torso, arms, and legs of the manikin from the middle of the manikin's neck, down to the manikin's wrist crease, and down to 200 mm (8 in.) above the bottom of the heel.

9.5.1.11.2 The coverall or set of coat and trousers shall be donned on the manikin in accordance with the manufacturer's instructions for proper wearing.

9.5.1.11.3 The coat collar shall be placed in the up position on the manikin with the collar closure system fastened in the closed position. The head of the manikin shall be sealed off with a plastic bag. The plastic bag shall extend downward over the collar a distance of not greater than 25 mm (1 in.) and be taped down using duct tape or similar waterproof tape. The tape shall not extend downward more than 75 mm (3 in.) from the top of the collar. The collar neck seam shall not be covered.

9.5.1.11.4 The test shall be conducted with the manikin's hands removed. The knit wristlet shall be tucked up inside the sleeve to prevent the water from absorbing into the wristlet.

9.5.1.11.4.1 Where garments are supplied with an integrated garment-glove interface, the manikin's hands shall not be removed. The garment-glove combination shall be donned on the manikin in accordance with the manufacturer's instructions for proper wearing.

9.5.1.11.5 Absorbent toweling or similar material shall be placed underneath the manikin to prevent water splashing up inside the trouser leg.

9.5.1.11.6 Where trousers are provided with integrated booties, outer footwear specified to be worn with the booties shall be donned on the manikin in accordance with the manufacturer's instructions for proper wearing.

9.5.1.12 Specific Requirements for Testing Proximity Firefighting Ensemble Garment Elements.

9.5.1.12.1 Garment element specimens shall be complete proximity firefighting protective coats, protective trousers, or protective coveralls.

9.5.1.12.2 Specimens shall be conditioned as specified in 9.1.3.

9.5.1.12.3 Where the proximity firefighting garment design has passed the liquid penetration requirements specified for structural firefighting garments and the only change to the proximity garment is from a structural garment outer shell to a proximity garment outer shell, at least one specimen shall be tested.

9.5.1.12.4 Where the proximity firefighting garment design has not been tested for structural firefighting garment liquid penetration requirements, a minimum of three specimens shall be tested.

9.5.1.13 Specific Requirements for Testing Garments for Optional Liquid and Particulate Contaminant Protection.

9.5.1.13.1 Specimens for testing shall consist of liquid and particulate contaminant garment elements.

9.5.1.13.2 A total of three different specimens shall be evaluated.

9.5.1.13.3 Garment elements shall be conditioned as specified in 9.1.12.

9.5.1.13.4 The upper torso liquid-absorptive garment shall cover the upper torso and arms of the manikin from the middle of the manikin's neck, down to the manikin's waistline, and down to the manikin's wrist crease. The lower torso liquid-absorptive garment shall cover the legs of the manikin from the manikin's waistline down to the manikin's ankles. The garment or garments shall be made of fabric meeting the requirements specified in ASTM F1359/F1359M, *Standard Test Method for Liquid Penetration Resistance of Protective Clothing or Protective Ensembles Under a Shower Spray While on a Manikin*. The liquid-absorptive garment shall not interfere with the correct wearing of the ensemble.

9.5.1.13.4.1 Where the coat consists of an attached hood, the upper torso indicator garment shall also incorporate a hood.

9.5.1.13.5 Specimens provided in 9.5.1.13.1 shall be donned on the manikin in accordance with garment manufacturer's specifications.

9.5.1.13.6 The manikin with ensemble in place shall be evaluated as specified in ASTM F1359/F1359M, *Standard Test Method for Liquid Penetration Resistance of Protective Clothing or Protective Ensembles Under a Shower Spray While on a Manikin*, with the following modifications:

(1) Procedure A shall be used.
(2) If the garment does not have an integrated hood, a plastic bag shall be applied over the manikin head without the protective helmet as specified in 9.5.1.13.1.
(3) If the garment does have an integrated hood, applying duct tape to the interface between the SCBA-facepiece and the particulate-blocking hood while still using the helmet as part of the test specimen shall be permitted.
(4) The suited manikin shall be exposed to the liquid spray for 2.5 minutes in each of the four manikin orientations for a total of 10 minutes.

9.5.1.13.7 Following the test, the portions of the liquid-absorptive garment that are underneath the garments being evaluated shall be inspected to determine evidence of liquid leakage.

9.5.2 Whole Glove Liquid Integrity Test 1.

9.5.2.1 Application. This test shall apply to protective gloves.

9.5.2.2 Samples.

9.5.2.2.1 Samples for conditioning shall be whole gloves.

9.5.2.2.2 A minimum of three glove pairs each for size 70W (wide) and 76W (wide) shall be used for testing.

9.5.2.3 Specimens.

9.5.2.3.1 Specimens shall be tested after being subjected to the procedures specified in 9.1.12 and then conditioned as specified in 9.1.3.

9.5.2.3.2 Specimens shall also be tested after being subjected to the procedures specified in 9.1.5 and then conditioned as specified in 9.1.3.

9.5.2.4 Apparatus.

9.5.2.4.1* A water markable glove shall cover all areas of the tester's hand. The water markable glove shall be constructed of a fabric that is marked easily by water to determine leakage.

9.5.2.4.2 Water used for integrity testing shall be at a temperature of 20°C ± 3°C (68°F ± 5°F) and treated with a nonfoaming surfactant to lower its surface tension to less than 35 dynes/cm ± 5 dynes/cm.

9.5.2.4.3 The following equipment shall be used for the test procedure:

(1) A clear container(s) for submerging gloved hand(s)
(2) A stopwatch

9.5.2.5 Procedure.

9.5.2.5.1 Test subjects shall be selected so that their hand dimensions are as close as possible to the middle of the range for hand length and hand circumference as specified in Figure 7.7.4.1 provided for size 70W (wide) and size 76W (wide) gloves in 7.7.4.1.

9.5.2.5.2 After the conditioning described in 9.5.2.3, the wrist crease location shall be marked as described in 7.7.3.5 on each specimen around the entire glove +0/−3 mm (+0/−0.25 in.), and this shall be the maximum water height line.

9.5.2.5.2.1 Then, in the same manner, the minimum water height line shall also be marked on each specimen 25 mm ± 3 mm (1 in. ± 0.25 in.) below (towards the fingers) the location of the wrist crease around the entire glove.

9.5.2.5.3 The test subject shall don the specimen(s) over the water markable glove(s).

9.5.2.5.4 The test subject shall then immerse the donned specimen(s) straight down into the surfactant treated water to between the minimum and maximum water height lines for 5 minutes, +30/−0 seconds.

9.5.2.5.4.1 An observer shall be present to ensure that the specimen(s) is not immersed beyond the maximum water height line. If the test subject immerses the specimen(s) beyond the maximum water height line, the specimen(s) shall be retested after air drying and conditioning as specified in 9.1.3.

9.5.2.5.4.2 The test subject shall flex the specimen in a gentle, complete fist closing motion every 10 seconds with each fist closing motion taking 10 seconds± 2 seconds to complete. A complete fist-closing motion shall be when the ends of the glove fingertips make contact with the palm surface of the glove.

9.5.2.5.5 The specimen(s) shall then be removed from the test subject's hand, and the water markable glove(s) shall be inspected for water marks.

9.5.2.6 Report. The appearance of any water mark on the inner glove after testing any of the three gloves shall be recorded and reported.

9.5.2.7 Interpretation. The appearance of any water mark on the inner glove after testing any glove shall be considered leakage and shall constitute failing performance.

9.5.3 Particle Inward Leakage Test.

9.5.3.1 Application. This test shall apply to liquid and particulate protective garments.

9.5.3.2 Samples.

9.5.3.2.1 Samples shall consist of liquid and particulate garments combined with the following elements, specified by the manufacturer, for testing a full ensemble:

(1) A specific protective helmet certified to the firefighting protective helmet requirements of this standard
(2) A specific pair of protective gloves certified to the firefighting protective glove requirements of this standard where the glove is of a gauntlet style and the glove length measured from the tip of the longest glove finger to the edge of the gauntlet is no longer than 305 mm (12 in.)
(3) A specific pair of protective footwear certified to the firefighting protective footwear requirements of this standard where the height of the footwear, as measured from the sole wear surface, is no higher than 406 mm (16 in.)
(4) A specific particulate-blocking hood certified to the firefighting hood requirements of this standard
(5) An SCBA certified to Chapters 15 through 19

9.5.3.2.2 Garment elements shall be conditioned as specified in 9.1.2.

9.5.3.2.3 Samples shall then be conditioned at 21°C ± 6°C (70°F ± 11°F) and 50 percent ± 30 percent relative humidity for at least 4 hours.

9.5.3.3 Specimens.

9.5.3.3.1 Specimens for testing shall consist of the garment and the elements specified in 9.5.3.2.1.

9.5.3.3.2 A minimum of three specimens shall be tested.

9.5.3.3.3 Specimen garments, helmets, gloves, footwear, hoods, and SCBA facepieces shall be provided to fit or be adjustable to fit the selected test subjects in accordance with the manufacturer's sizing provisions that are specific to each ensemble.

9.5.3.3.4 The ensemble elements of the ensemble to be tested shall have been previously subjected to particle inward leakage testing unless it can be demonstrated that the ensemble or components are free of contamination.

9.5.3.4 Apparatus.

9.5.3.4.1 The test shall be conducted in a chamber large enough to conduct testing on at least one test subject.

9.5.3.4.2 The test chamber shall have a system capable of providing a stable, uniform airflow directed at the test subject.

9.5.3.4.3 The test chamber shall prevent significant aerosol contact with any areas of the facility not intended as exposure areas, to prevent contamination.

9.5.3.4.4 The test chamber shall have an aerosol generator capable of maintaining the aerosol mass concentration as specified in the procedure.

9.5.3.4.5 The challenge aerosol shall be a combination of amorphous silica, 50 percent by weight; tetraethylene glycol, 42 percent by weight; uranine, 6 percent by weight; and Tinopal™, 2 percent by weight.

9.5.3.4.6 Test subjects shall wear a suitably sized, close-fitting, one- or multiple-piece full-body garment made of black synthetic material that is sized to the individual test subject. The bodysuit must be clean and free of visible lint prior to donning the candidate garment ensemble.

9.5.3.4.6.1 This garment shall be referred to as the black indicator garment.

9.5.3.4.6.2 The arms of the respective black indicator garment shall extend down the test subject's arms to the wrist crease and the legs of the respective black indicator garment shall extend down to the test subject's ankles.

9.5.3.4.6.3 For garments without an integrated hood, the black indicator garment shall extend at least to the base of the test subject's neck, but is permitted to go higher.

9.5.3.4.6.4 For garments with integrated hoods, the top part of the black indicator garment shall include a hood that covers the test subject's head with the exception of the face area to allow for the uninhibited wearing of the selected SCBA-facepiece.

9.5.3.4.6.5 The full-body garment must be clean and free of visible lint prior to donning the candidate garment ensemble.

9.5.3.4.7 Visual inspection of the test subject, while wearing the indicator garment, shall be performed under illumination by black light in a dark room after doffing the candidate garments. Inspection shall be performed while the test participant is fully illuminated by black light with a wavelength of 365 nm.

9.5.3.4.8* A separate handheld black light with a wavelength of 365 nm and an intensity of 1200 μW/cm^2 at 380 nm shall be used to inspect areas where the presence of fluorescent particles could be unclear.

9.5.3.4.9 A 35 mm camera or digital equivalent with the capabilities and settings for taking photographs under UV light shall be provided for documenting the visual condition of the test subject before and after exposure to the aerosol.

9.5.3.4.10 The test facility shall have separate garment storage, donning, doffing, and control room areas to prevent contamination.

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

9.5.3.4.12 Test subjects shall be familiar with the use of structural firefighting protective clothing and equipment and with the selected respirator.

9.5.3.5 Procedure.

9.5.3.5.1 The test chamber shall be stabilized with the following conditions:

(1) Average wind speed shall be 47 m/sec ± 0.89 m/sec (10.0 mph ± 2 mph) at the fan outlet airflow station.
(2) Temperature shall be 21°C ± 6°C (70°F ± 5°F).

(3) Relative humidity shall be 45 percent ± 15 percent.
(4) Average aerosol concentration shall be 160 mg/m^3, ±25/−0 mg/m^3.
(5) Aerosol aerodynamic mass median diameter shall be 2.5 µm ± 0.5 µm.

9.5.3.5.2 The test subject shall don black indicator garments that cover the wearer's torso, arms, hands, legs, ankles, and head excluding the face. The indicator garments shall provide a dark uniform appearance under black light illumination.

9.5.3.5.3* At least 10 specific areas of the indicator garment shall be masked with a suitable tape or masking product that will remain in place during testing and not affect the appearance of the indicator garment under black light illumination.

9.5.3.5.3.1 At least 10 masked areas, with minimum dimensions of 25 mm × 50 mm (1 in. × 2 in.) shall be distributed over the indicator garment.

9.5.3.5.4 The test subject shall don the protective ensemble and respirator in accordance with the manufacturer's instructions in a clean area separate from the test chamber.

9.5.3.5.5 Once the test chamber has reached the conditions stated in 9.5.3.5.1, the test subject will enter the chamber and be positioned in the wind.

9.5.3.5.6 The 30-minute test period begins when the test subject is positioned in the wind.

9.5.3.5.7 During the 30-minute test period, the test subject shall perform the three stationary exercises as specified in Table C.2 of Test Operations Procedure (TOP) 10-2-022, *Chemical Vapor and Aerosol System-Level Testing of Chemical/Biological Protection Suits*.

9.5.3.5.8 At the conclusion of the 30-minute test period, the test subject shall exit the test chamber and enter the doffing area.

9.5.3.5.9 The test subject shall then be assisted to doff the ensemble to prevent contact of the outside surface of the ensemble with the subject's skin or indicator garment.

9.5.3.5.9.1 If accidental contact occurs, the specific location shall be noted and the test shall be repeated, or the specific affected area shall not be considered when interpreting whether or not the garment passes or fails.

9.5.3.5.10 After doffing, the masked areas shall be unmasked and the test subject shall be examined under black light in the viewing area for evidence of particulate inward leakage.

9.5.3.5.10.1 For coats without an integrated hood, only the upper portion of the black indicator garment up to the base of the neck shall be examined.

9.5.3.5.11 Photographs shall be taken of the test subject under black with the following minimum positions:

(1) Front, right, back, and left side of test subject's neck and head
(2) Front, right, back, and left side of test subject's upper torso
(3) Front, right, back, and left side of test subject's lower torso

9.5.3.5.12* A separate black light shall be used to inspect any areas where the presence of fluorescent particles might be unclear.

9.5.3.5.12.1 The exposure of the black light shall be bracketed to provide photographs with varying contrast to permit documentation of any observed fluorescence.

9.5.3.5.13 Specific areas of known fluorescent that are not attributed to other sources, (e.g., lint, cross-contamination during doffing, or residual detergent on the witness garment) shall be documented on a chart showing their specific location that is included as part of the report.

9.5.3.5.13.1 For inspection of the black indicator garment for protective garment sets that are without an integrated hood, areas to be inspected include the test subject's arms down to the wrist crease, test subject's legs down to the ankle area, and to the top of the test subject's neck.

9.5.3.5.14 Where fluorescence on the black indicator garment is observed or suspected, those specific areas shall be sampled for particle contamination using the procedures established in 9.5.3.6.

9.5.3.5.15 The laboratory shall be permitted, but is not required, to further sample any areas that are suspect for particle contamination using the procedures established in 9.5.3.6. These procedures, when used, shall be employed for documentation purposes only and shall not be used for interpreting compliance with the performance requirement.

9.5.3.6 Sampling and Analysis of Black Indicator Garment.

9.5.3.6.1 The test subject's black indicator garment shall be sampled to recover any particular contamination that has been deposited and appears visible during the black light examination using the following procedures:

(1) The number of areas sampled shall be limited to up to five areas that appear to show the greatest level of fluorescence when examined under the black light.
(2) One sample shall be taken from an area that shows no fluorescence during the examination under UV light and shall serve as a baseline level for testing.
(3) Garment-rinse sampling shall be performed by pressing a tube against the portion of the black indicator garment to be sampled and adding 20 mL of 0.01 N sodium hydroxide (NaOH).
(4) The solution shall be washed over the black indicator garment for approximately 10 seconds, then pipetted into a clean container.
(5) All samples shall be labeled before they are analyzed.
(6) For each of the black indicator garment-rinse samples, approximately 5 mL of each of the samples shall be analyzed in a fluorometer to determine the mass of aerosol that is present in the sample.
(7) The results shall be recorded and verified to identify and eliminate any errors in reading or recording the data.
(8) Test results shall be reported in µg/cm^2 at each sampling location.

9.5.3.7 After each trial, upon completion of the garment-rinse sampling and black light photography, the test subject shall shower.

9.5.3.8 Report. The report shall consist of the following elements:

(1) Photographic records documenting the test ensemble and results consisting of the following:
    (a) The identification and design details of the specific protective garment being evaluated.

   (b) The identification of the specific elements by manufacturer, style or model number, and size evaluated as part of the full test ensemble, including the protective helmet, protective gloves, protective footwear, particulate-blocking hood, and self-contained breathing apparatus.
   (c) A photograph of the front head-to-toe view of the test subject in the full test ensemble immediately before entering the aerosol chamber. Additional photographs of the test subject in the ensemble showing design details shall be included as warranted.
   (d) Black light photographs of the test subject after doffing.
   (e) If the post-exposure photographs show no aerosol deposits and show only the black indicator garment free of observed fluorescence, the following statement shall be permitted in lieu of post-exposure photographs: "No visible aerosol deposits were revealed in the photographs."

(2) The test conditions, including the following:
   (a) The challenge aerosol mass concentration averaged for the duration of the test
   (b) The average wind speed, temperature, and relative humidity for the test
   (c) Date of test and test operator

(3) Specific observations for the location of any deposited aerosol on the test subject's indicator garments as noted during visual observation under a black light
(4) Any notable observations by the test operators, especially ensemble interface openings, mask breaches, or poor fit of any ensemble elements
(5) Any supplemental test data sampling and analysis of the black indicator garments provided for documentation purposes only

9.5.3.9 Interpretation. The absence of any evidence of particulate inward leakage on any test subject's indicator garment as determined by visual inspection under a black light shall constitute passing performance.

9.5.3.9.1 Where the measurement of the surface concentrations of fluorescent particles are made, the specific surface concentration at each location shall be reported and be used to determine passing or failing performance.

9.6 Electrical Hazard Test Methods.

9.6.1 Electrical Insulation Test 1.

9.6.1.1 Application. This test method shall apply to protective helmets.

9.6.1.2 Samples.

9.6.1.2.1 Samples for conditioning shall be complete helmets.

9.6.1.2.2 Samples shall be conditioned as specified in 9.1.3.

9.6.1.3 Specimens. A minimum of three helmets shall be tested.

9.6.1.4 Apparatus.

9.6.1.4.1 The following equipment shall be provided for Procedure A:

(1) Source of 60 Hz alternating current variable from 0 to 2200 volts true rms
(2) Wiring and terminals for application of voltage to the water in the vessel
(3) Voltmeter to measure the applied voltage to within 2 percent
(4) Millimeter to measure the leakage current to within 2 percent
(5) Vessel, containing tap water, of sufficient size to submerge an inverted helmet to the dielectric test plane
(6) Frame for suspending the test specimen in water

9.6.1.4.2 The following equipment shall be provided for Procedure B:

(1) Source of 60 Hz alternating current variable from 0 to 2200 volts true rms
(2) Wiring and terminals for application of voltage across the crown of the test specimen
(3) Voltmeter to measure the applied voltage to within 2 percent
(4) Millimeter to measure the leakage current to within 2 percent
(5) Vessel, containing tap water, of sufficient size to completely submerge an inverted helmet
(6) Aluminum ISEA size 7 headform modified in accordance with Table 9.3.5.4.1 and Figure 9.3.5.4.1(a) through Figure 9.3.5.4.1(c)

9.6.1.5 Procedures.

9.6.1.5.1 Procedure A.

9.6.1.5.1.1 The helmet specimen shall be positioned according to the HPI as described in 9.1.13 on the ISO size J headform specified in Figure 9.3.6.4.1. Where the crown clearance of the helmet is adjustable, the helmet shall be mounted with the most amount of clearance.

9.6.1.5.1.2 The dielectric test plane specified in Figure 9.6.1.5.1.2 shall be marked as a line on the shell of the helmet. The dielectric test plane shall be the plane that passes through the point located 85 mm (3 in.) above the basic plane, where the basic plane and the midsagittal plane intersect at the front of the headform and the point located 60 mm (2 in.) above the basic plane, where the basic plane and the midsagittal plane intersect at the rear of the headform.

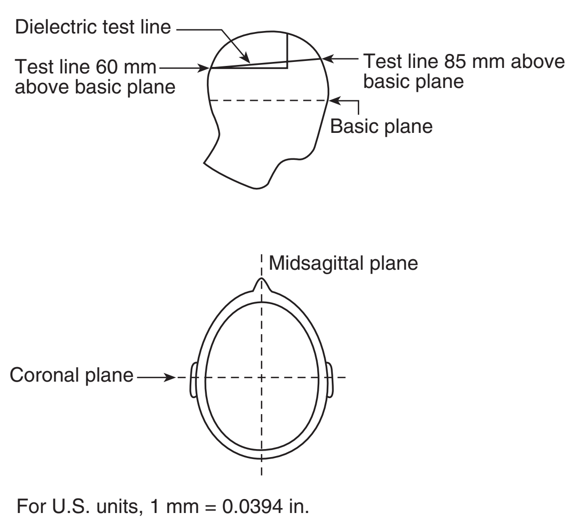


FIGURE 9.6.1.5.1.2 Test Setup.

9.6.1.5.1.3 The specimen shall be inverted and the inside of the specimen shall be filled with fresh tap water up to the dielectric test plane. The specimen shall then be submerged in the same type of water up to the same level as the water on the inside of the helmet. Care shall be taken to keep the unsubmerged portion of the test specimen dry so that flashover will not occur when voltage is applied.

9.6.1.5.1.4 A 60 Hz alternating current voltage shall be applied to the water in the vessel and increased to 2200 volts. The voltage shall be maintained at 2200 volts ± 2 percent, for 1 minute.

9.6.1.5.2 Procedure B.

9.6.1.5.2.1 The specimen and retention system shall be completely submerged in tap water for a period of 15 minutes +2/−0 minutes. The specimen shall be removed from the tap water and allowed to drain for not longer than 2 minutes.

9.6.1.5.2.2 The specimen shall then be positioned according to the HPI as described in 9.1.13 on the modified ISEA aluminum size 7 headform, with the chinstrap firmly secured to the headform by means of the conductive terminal junction bolt. Where the crown clearance of the helmet is adjustable, the helmet shall be mounted with the least amount of clearance.

9.6.1.5.2.3 A lead carrying 60 Hz alternating voltage shall be attached to all metal parts on the helmet's exterior, at or above the brim edge. A second pickup lead shall be attached to the terminal junction bolt. Voltage shall be applied to the external helmet shell lead and increased to 2200 volts ± 2 percent, volts. The voltage shall be maintained for 15 seconds.

9.6.1.6 Report. Any current leakage or evidence of breakdown shall be recorded and reported for each helmet.

9.6.1.7 Interpretation. One or more helmet specimens failing this test shall constitute failing performance.

9.6.2 Electrical Insulation Test 2.

9.6.2.1 Application. This test shall apply to protective footwear.

9.6.2.2 Samples.

9.6.2.2.1 Samples for conditioning shall be whole footwear.

9.6.2.2.2 Samples shall be conditioned as specified in 9.1.3.

9.6.2.3 Specimens. A minimum of three footwear elements in men's size 9D shall be tested.

9.6.2.4 Procedure. Specimens shall be tested in accordance with Section 9 of ASTM F2412, *Standard Test Methods for Foot Protection*, with the following modification: Specimens shall be tested to 14,000 V (rms).

9.6.2.5 Report. Any current leakage or evidence of breakdown shall be reported and recorded for each footwear item.

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

9.7 Physiological Hazard Test Methods.

9.7.1* Total Heat Loss (THL) Test.

9.7.1.1 Application.

9.7.1.1.1 This test method shall apply to structural firefighting protective garment element and protective hood interface component composites.

9.7.1.1.2 Modifications to this test method for testing particulate barrier protective hood interface components shall be as specified in 9.7.1.8.

9.7.1.2 Samples. Samples shall be conditioned at a temperature of 25°C ± 7°C (77°F ± 13°F) and a relative humidity of 65 percent ± 5 percent for at least 4 hours.

9.7.1.2.1 The minimum sample size shall be 51 cm × 51 cm (20 in. × 20 in.).

9.7.1.3 Specimens.

9.7.1.3.1 Total heat loss testing shall be conducted on at least three specimens.

9.7.1.3.2 Specimens shall consist of all layers in the structural firefighting protective garment or hood composite, arranged in the order and orientation as worn.

9.7.1.3.3 The thickness of each specimen shall be measured in accordance with ASTM D1777, *Standard Test Method for Thickness of Textile Materials*, within 4 hours of removal from conditioning as described in ASTM D1776 /D1776M, *Standard Practice for Conditioning and Testing Textiles*.

9.7.1.3.4 The weight of each specimen shall be measured in accordance with the method in ASTM D3776/D3776M, *Standard Test Methods for Mass Per Unit Area (Weight) of Fabric*, within 4 hours of removal from conditioning as described in ASTM D1776 /D1776M, *Standard Practice for Conditioning and Testing Textiles*.

9.7.1.4 Apparatus.

9.7.1.4.1 The test apparatus shall be as specified in ASTM F1868, *Standard Test Method for Thermal and Evaporative Resistance of Clothing Materials Using a Sweating Hot Plate*.

9.7.1.4.2 The dimensions for the sweating guarded hot plate shall be a 25.4 cm (10 in.) test plate with a 12.7 cm (5 in.) guard surrounding the test plate.

9.7.1.5* Procedure. Testing shall be conducted in accordance with ASTM F1868, *Standard Test Method for Thermal and Evaporative Resistance of Clothing Materials Using a Sweating Hot Plate*, using Part C, with the following modifications:

(1) The specimen shall be placed on the test plate with the side normally facing the human body toward the test plate.
(2) For multiple layers, the layers shall be arranged in the order and orientation as worn.
(3) Each layer shall be smoothed by hand to eliminate wrinkles or bubbles in each layer and, if necessary, the edges shall be secured.

(4) Once the test is started, no further adjustments to the specimen shall be made.

9.7.1.6 Report.

9.7.1.6.1 The average intrinsic thermal resistance (R_{cf}) of the sample shall be recorded and reported.

9.7.1.6.2 The average apparent intrinsic evaporative resistance (AR_{ef}) of the sample shall be recorded and reported.

9.7.1.6.3 The average total heat loss (Q_t) of the sample shall be determined and reported.

9.7.1.6.4 The thickness of each specimen shall be reported.

9.7.1.6.5 The unit area weight of each specimen shall be reported.

9.7.1.7 Interpretation.

9.7.1.7.1 Pass or fail determination shall be based on the average reported total heat loss measurement of all specimens tested.

9.7.1.7.2 If an individual result from any test set varies more than ±10 percent from the average result, the results from the test set shall be discarded and another set of specimens shall be tested.

9.7.1.8 Specific Requirements for Testing Barrier Protective Hood Interface Components. Specimens shall consist of all layers used in the barrier portions of the protective hood interface component composite arranged in their normal order.

9.7.2 Evaporative Resistance Test 1.

9.7.2.1 Application.

9.7.2.1.1 This test method shall apply to structural firefighting protective garment element composites.

9.7.2.1.2* Modifications to this test method for providing a sequence of testing to reduce the number of garment composites tested shall be performed as specified in 5.2.6.

9.7.2.2 Samples. Samples shall be conditioned as specified in 9.1.3 for at least 4 hours.

9.7.2.2.1 The minimum sample size shall be 51 cm × 51 cm (20 in. × 20 in.).

9.7.2.3 Specimens.

9.7.2.3.1 Evaporative resistance testing shall be conducted on at least three specimens.

9.7.2.3.2 Specimens shall consist of all layers in the structural firefighting protective garment composite, arranged in the order and orientation as worn.

9.7.2.4 Apparatus.

9.7.2.4.1 The test apparatus shall be as specified in ASTM F1868, *Standard Test Method for Thermal and Evaporative Resistance of Clothing Materials Using a Sweating Hot Plate.*

9.7.2.4.2 The dimensions for the sweating guarded hot plate shall be a 25.4 cm (10 in.) test plate with a 12.7 cm (5 in.) guard surrounding the test plate.

9.7.2.5 Procedure. Testing shall be conducted in accordance with ASTM F1868, *Standard Test Method for Thermal and Evaporative Resistance of Clothing Materials Using a Sweating Hot Plate,* using part B, with the following modifications:

(1) The specimen shall be placed on the test plate with the side normally facing the human body toward the test plate.
(2) For multiple layers, the layers shall be arranged in the order and orientation as worn.
(3) Each layer shall be smoothed by hand to eliminate wrinkles or bubbles in each layer and, if necessary, the edges shall be secured.
(4) Once the test is started, no further adjustments to the specimen shall be made.

9.7.2.6 Report. The average intrinsic evaporative resistance of the sample shall be reported and recorded in units of $Pa \cdot m^2/W$.

9.7.2.7 Interpretation.

9.7.2.7.1 Pass or fail determination shall be based on the average reported evaporative resistance measurements of all specimens tested.

9.7.2.7.2 If an individual result from any test set varies more than ± 10 percent from the average result, the results from the test set shall be discarded and another set of specimens shall be tested.

9.8 Functional Performance Test Methods.

9.8.1 Trim Retroreflectivity and Fluorescence Test.

9.8.1.1 Application.

9.8.1.1.1 This test method shall apply to trim materials used on protective garments and helmets.

9.8.1.1.2 Trim materials shall be tested for each procedure specified in 9.8.1.4.

9.8.1.2 Samples.

9.8.1.2.1 Samples for conditioning shall include 305 mm (12 in.) long sections of trim.

9.8.1.2.2 Samples shall be conditioned as specified in 9.1.3.

9.8.1.3 Specimens.

9.8.1.3.1 A minimum of three trim test specimens shall be tested.

9.8.1.3.2 Each trim test specimen shall be 100 mm (4 in.) in length by the width of the finished trim product.

9.8.1.3.3 Where retroreflective and nonretroreflective surface areas are combined to form a trim, the specimen shall consist of the retroreflective and nonretroreflective portions of the finished trim product.

9.8.1.4 Procedures.

9.8.1.4.1 Measurement of Coefficient of Retroreflection.

9.8.1.4.1.1 The coefficient of retroreflection (R_a) shall be determined in accordance with ASTM E809, *Standard Practice for Measuring Photometric Characteristics of Retroreflectors*, using the following modifications:

(1) Test distance shall equal 15.2 m (50 ft).
(2) Observation angle shall equal 0.2 degree.
(3) Entrance angle shall equal +5 degrees.

(4) Receiver shall be provided with an entrance aperture of 26 mm (1.024 in.), ±5 percent in diameter that is equivalent to 0.1 degree angular aperture.
(5) Exit aperture of the source shall be circular and 26 mm (1.024 in.), ±5 percent in diameter that corresponds to 0.1 degree angular aperture.
(6) Retroreflector reference angle shall equal 90 degrees.
(7) Datum mark shall be placed as specified by the trim manufacturer.

9.8.1.4.1.2 The coefficient of retroreflection (R_a) shall be calculated by the following equation:

[9.8.1.4.1.2]

$$Ra = \frac{R_I}{A_r}$$

where:
R_I = coefficient of luminous intensity measured as specified in 9.8.1.4.1.1
A_r = only the retroreflective surface area of the trim test specimen's surface area

(A) A_r shall be calculated by subtracting the nonretroreflective surface area from the test specimen's total surface area.

9.8.1.4.2 Evaluation of Fluorescence.

9.8.1.4.2.1 Trim fluorescence shall be determined by its colorimetric properties. The color shall be measured in accordance with the procedures defined in ASTM E991, *Standard Practice for Color Measurement of Fluorescent Specimens Using the One-Monochromator Method*, ASTM E1164, *Standard Practice for Obtaining Spectrometric Data for Object-Color Evaluation*, ASTM E2152, *Standard Practice for Computing the Colors of Fluorescent Objects from Bispectral Photometric Data*, and ASTM E2153, *Standard Practice for Obtaining Bispectral Photometric Data for Evaluation of Fluorescent Color,* using the following test specifications:

(1) A polychromatic illumination of D65
(2) A 45 degree/0 degree (or 0 degree/45 degree) geometry
(3) A 2 degree standard observer
(4) A black underlay with a Cap Y, luminance factor, less than 4

9.8.1.4.2.2 The chromaticity shall be within one of the areas defined in Table 9.8.1.4.2.2, and the Cap Y, luminance factor, shall be not less than the corresponding minimum for the respective color.

9.8.1.4.3 Rainfall Test.

9.8.1.4.3.1 Specimens of trim shall be tested when wet for retroreflectivity at a rate of 110 mm/hr (4$\frac{5}{16}$ in./hr) as specified in Appendix A, "Method of Measuring Wet Performance of Retroreflective Material," of ANSI/ISEA 107, *High-Visibility Safety Apparel.*

9.8.1.4.3.2 The coefficient of retroreflectivity (R_a) shall be measured as specified in 9.8.1.4.1, 2 minutes ± 15 seconds, after the rainfall exposure has been started.

9.8.1.4.4 Convective Heat Exposure Test.

9.8.1.4.4.1 Specimens of trim shall be tested for retroreflectivity after convective heat exposure as specified in 9.1.5.

Table 9.8.1.4.2.2 Color Requirements

Color	Chromaticity Coordinates		Minimum Luminance Factor (Cap Y)
Fluorescent yellow-green	0.387	0.610	70
	0.356	0.494	
	0.398	0.452	
	0.460	0.540	
Fluorescent orange-red	0.610	0.390	40
	0.535	0.375	
	0.570	0.340	
	0.655	0.344	
Fluorescent red	0.655	0.344	25
	0.570	0.340	
	0.595	0.315	
	0.690	0.310	

9.8.1.4.4.2 The coefficient of retroreflectivity (R_a) shall be measured as specified in 9.8.1.4.1.

9.8.1.4.4.3 The fluorescence shall be evaluated as specified in 9.8.1.4.2.

9.8.1.5 Report.

9.8.1.5.1 The coefficient of retroreflectivity (R_a) shall be recorded and reported for each specimen.

9.8.1.5.2 The average R_a of all specimens shall be calculated, recorded, and reported separately for each of the test procedures specified in 9.8.1.4.1, 9.8.1.4.3, and 9.8.1.4.4.

9.8.1.5.3 The number of fluorescent and nonfluorescent specimens shall be recorded and reported separately for each of the test procedures specified in 9.8.1.4.2 and 9.8.1.4.4.

9.8.1.6 Interpretation.

9.8.1.6.1 For trim retroreflectivity, pass or fail performance shall be determined using the average coefficient of retroreflection (R_a) reported for each group of specimens for each of the procedures specified in 9.8.1.4.1, 9.8.1.4.3, and 9.8.1.4.4.

9.8.1.6.2 For trim fluorescence, specimens that do not meet the chromaticity and luminance factor requirements shall be designated as nonfluorescent.

9.8.2 Faceshield/Goggle Component Lens Luminous (Visible) Transmittance Test.

9.8.2.1 Application. This test shall apply to faceshield/goggle component lenses.

9.8.2.2 Samples.

9.8.2.2.1 Samples for conditioning shall be complete faceshield/goggle components.

9.8.2.2.2 Samples shall be conditioned as specified in 9.1.3.

9.8.2.3 Specimens. A minimum of three faceshield/goggle component lenses shall be tested.

9.8.2.4 Apparatus. The standard source of radiant energy used in the measurement of luminous transmittance of filter lenses shall be a projection-type lamp No. T-8 or other high-powered, gas-filled, tungsten-filament incandescent lamp operated at the color temperature corresponding to Commission Internationale de l'Eclairage (CIE), Source A.

9.8.2.5* Procedure. Luminous transmittance shall be determined by one of the following means:

(1) By measuring the spectral transmittance and calculating the luminous transmittance through the use of published data on the spectral radiant energy of CIE Standard Illuminant A as specified in ISO/CIE 10526, *Calorimetric Illuminants*, and the relative luminous efficiency of the average eye
(2) By using a Gardner pivotal sphere haze meter and the standards of luminous transmittance maintained by the National Bureau of Standards

9.8.2.6 Report.

9.8.2.6.1 The percentage of light transmission shall be recorded and reported for each specimen.

9.8.2.6.2 The average light transmission of all specimens tested shall be calculated, recorded, and reported.

9.8.2.7 Interpretation. Pass or fail performance shall be based on the average light transmission measured.

9.8.3 Glove Donning Test.

9.8.3.1 Application. This test shall apply to protective gloves.

9.8.3.2 Samples.

9.8.3.2.1 A minimum of three glove pairs each for size 70W (wide) and size 76W (wide) shall be used for testing.

9.8.3.2.2 Samples for conditioning shall be whole gloves.

9.8.3.2.3 All glove opening configurations shall be considered for testing.

9.8.3.3 Specimens.

9.8.3.3.1 Specimens shall be conditioned as specified in 9.1.12 prior to testing.

9.8.3.3.2 Specimens shall be donned once after removal from the conditioning specified in 9.8.3.3.1 before beginning testing.

9.8.3.4 Procedure.

9.8.3.4.1 Test subjects shall be selected so that their hand dimensions are as close as possible to the middle of the range for hand length and hand circumference for size 70W (wide) and size 76W (wide) gloves specified in Figure 7.7.4.1. Three test subjects shall be selected for size 70W (wide) and three for size 76W (wide).

9.8.3.4.2 Each donning trial shall start with the glove lying in front of the test subject and shall end when the test subject's fingers are seated in the specimen glove.

9.8.3.4.3 The time to don one glove of the pair specimen shall be determined by measuring the time it takes for the test subject to don the single glove on three consecutive trials without altering the specimen glove linings between donning. The test subject shall be permitted to don either the right-hand glove or left-hand glove according to individual preference.

9.8.3.4.3.1 The glove shall be donned in accordance with the manufacturer's donning procedure.

9.8.3.4.3.2 The glove shall then be removed by grasping the fingertip of the middle finger and pulling the hand out of the glove.

9.8.3.4.3.3 The test subject shall wear the glove of the opposite hand during the test.

9.8.3.4.3.4 Where the glove cannot be donned because of detachment of the inner liner or moisture barrier, the trial for that glove shall be stopped. If any fingers cannot be fully inserted into the glove, the trial for that glove shall be stopped.

9.8.3.4.4 The dry hand donning time shall be the average of the first three dry hand donning times as determined in 9.8.3.4.3.

9.8.3.4.5 The test subject's hand shall then be completely submerged in room temperature water [21°C ± 3°C (70°F ± 5°F)] for 10 seconds before donning the glove each time.

9.8.3.4.6 Immediately after the hand-wetting procedure specified in 9.8.3.4.5, with no time lapse, the test subject shall then don one glove of the pair specimen. The test subject shall do this wetting and donning procedure for three consecutive trials as specified in 9.8.3.4.4 and 9.8.3.4.5. The times shall be recorded.

9.8.3.4.7 The wet hand donning time shall be the average of the first three wet hand donning times as determined in 9.8.3.4.6.

9.8.3.4.8 Each test subject shall perform the test with one pair of gloves.

9.8.3.5 Report.

9.8.3.5.1 The dry hand donning time shall be recorded and reported to the nearest 0.1 second for each trial.

9.8.3.5.2 The wet hand donning time shall be recorded and reported to the nearest 0.1 second for each trial.

9.8.3.5.3 The average dry hand and wet hand donning times shall be calculated, recorded, and reported for each size.

9.8.3.5.4 Any inner liner or moisture barrier separations shall be recorded and reported.

9.8.3.5.5 Any glove digits that do not allow full insertion shall be recorded and reported.

9.8.3.6 Interpretation.

9.8.3.6.1 Pass or fail determinations shall be made using the average dry hand and wet hand donning times for size 70W (wide) and size 76W (wide).

9.8.3.6.2 Failure of either size shall constitute failure of the test.

9.8.3.6.3 Any detachment of the inner liner and/or moisture barrier shall constitute failing performance.

9.8.3.6.4 Any glove digits that do not allow full insertion shall constitute failing performance.

9.8.4 Glove Hand Function Test.

9.8.4.1 Application. This test shall apply to gloves.

9.8.4.2 Samples.

9.8.4.2.1 Samples for conditioning shall be whole glove pairs.

9.8.4.2.2 Glove pair samples shall be conditioned as specified in 9.1.3.

9.8.4.3 Specimens.

9.8.4.3.1 A minimum of three glove pair specimens each for size 70W (wide) and size 76W (wide) shall be used for testing.

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

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

9.8.4.4 Apparatus. The apparatus shall be as specified in ASTM F2010/F2010M, *Standard Test Method for Evaluation of Glove Effects on Wearer Finger Dexterity Using a Modified Pegboard Test*, with the modification that the stainless steel pins shall have a medium knurled 30 degree (25 teeth/in.) surface.

9.8.4.5 Procedures. The testing procedures shall be as specified in ASTM F2010/F2010M, *Standard Test Method for Evaluation of Glove Effects on Wearer Finger Dexterity Using a Modified Pegboard Test*.

9.8.4.6 Report.

9.8.4.6.1 The average percentage of bare-handed control shall be recorded and reported for each test subject.

9.8.4.6.2 The average percentage of bare-handed control for all test subjects shall be recorded and reported for each size.

9.8.4.7 Interpretation.

9.8.4.7.1 The average percentage of bare-handed control for size 70W (wide) and size 76W (wide) shall be used to determine pass or fail performance.

9.8.4.7.2 Failure of either size shall constitute failure of the test.

9.8.5 Glove Grip Test.

9.8.5.1 Application. This test method shall apply to protective gloves.

9.8.5.2 Samples.

9.8.5.2.1 Samples for conditioning shall be whole glove pairs.

9.8.5.2.2 Sample glove pairs shall be wet conditioned as specified in 9.1.3.

9.8.5.3 Specimens.

9.8.5.3.1 A minimum of three glove pair specimens each for size 70W (wide) and 76W (wide) shall be used for testing.

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

9.8.5.3.3 Specimen glove pairs shall be tested for each material and construction combination.

9.8.5.3.4 Specimen glove pairs shall be tested after being wet conditioned as specified in 9.1.10.

9.8.5.4 Apparatus.

9.8.5.4.1 Pulling Device. The pulling device shall be a 32 mm (1¼ in.) diameter fiberglass pole attached to an overhead calibrated force measuring device in such a fashion that pulls on the pole will be perpendicular to the ground and downward in direction. This pole shall be used until surface degradation occurs. The force measuring system shall provide a graphical plot of force versus time.

9.8.5.5 Procedure.

9.8.5.5.1 Test subjects shall be selected so that their hand dimensions are as close as possible to the middle of the range for hand length and hand circumference as specified in Figure 7.7.4.1 for size 70W (wide) and size 76W (wide) gloves. At least three test subjects shall be selected for both size 70W (wide) and size 76W (wide).

9.8.5.5.2 The gloves shall be conditioned by the wetting procedure specified in 9.1.10 before each set of three pulls by the test subject as described below.

9.8.5.5.3 The pulling device shall be wet conditioned before each individual pull by wiping with a damp rag.

9.8.5.5.4 The test subject and the test subject's hand shall be positioned as shown in Figure 9.8.5.5.4(a) and Figure 9.8.5.5.4(b) and as described in the paragraphs that follow.

9.8.5.5.4.1 The test subject shall stand facing the pole with feet shoulder width apart.

9.8.5.5.4.2 While wearing specimen gloves, the test subject shall grasp the pole with the bottom of the bottom hand at a height equal to the height of the test subject.

FIGURE 9.8.5.5.4(a) Position of Test Subject's Body, Arms, and Hands with Respect to Pole. ***(Photo courtesy of Intertek Testing Services. Used by permission.)***

FIGURE 9.8.5.5.4(b) Close-up of Position of Test Subject's Hands on Pole. ***(Photo courtesy of Intertek Testing Services. Used by permission.)***

9.8.5.5.4.3 The test subject's hands shall be stacked on each other and the thumbs shall not overlap the fingers.

9.8.5.5.4.4 The test subject's body shall be distanced from the pole so that the forearms are approaching vertical and are in plane with the pole.

9.8.5.5.4.5 The test subject's elbows shall be shoulder width apart, rotated neither fully in (arms parallel to the pole) nor fully out (arms perpendicular to the pole).

9.8.5.5.5 The test subject shall pull the pole with as much pulling force as possible in a smooth, steady, swift, and nonjerking action for 5 seconds, +1/−0 seconds. The test subject shall minimize forward or backward movement during the pull as much as possible. The test subject shall not bend their knees or pull down with body weight during the pull. The test subject shall continue to pull until the test facilitator instructs the test subject to end the pull at 5 seconds, +1/−0 seconds.

9.8.5.5.6 The test subject shall repeat the pull described above for a total of three pulls.

9.8.5.6 Report. Any drop in force of greater than 30 percent in any 0.2-second interval, as measured in the graphical plot of force versus time, shall be recorded and reported.

9.8.5.7 Interpretation. Any drop in force greater than 30 percent in any 0.2-second interval shall constitute failing performance.

9.8.6 Glove Torque Test.

9.8.6.1 Application. This test method shall apply to protective gloves.

9.8.6.2 Samples.

9.8.6.2.1 Samples for conditioning shall be whole gloves.

9.8.6.2.2 Sample glove pairs shall be conditioned as specified in 9.1.3.

9.8.6.3 Specimens.

9.8.6.3.1 A minimum of three glove specimens each for size 70W (wide) and size 76W (wide) shall be used for testing.

9.8.6.3.2 Each specimen glove shall be tested in new, as-distributed condition.

9.8.6.3.3 Specimen gloves shall be tested for each material and construction combination.

9.8.6.4 Apparatus. The apparatus shall be as specified in ASTM F2961, *Standard Test Method for Characterizing Gripping Performance of Gloves Using a Torque Meter.*

9.8.6.5 Procedure. The testing procedures shall be as specified in ASTM F2961, *Standard Test Method for Characterizing Gripping Performance of Gloves Using a Torque Meter.*

9.8.6.6 Report. The average percentage of bare-handed control value shall be recorded and reported for each specimen glove size.

9.8.6.7 Interpretation.

9.8.6.7.1 The average percentage of bare-handed control value for size 70W (wide) and size 76W (wide) shall be used to determine pass or fail performance.

9.8.6.7.2 Failure of either size shall constitute failure of the test.

9.8.7 Glove Tool Test.

9.8.7.1 Application. This test shall apply to gloves.

9.8.7.2 Samples.

9.8.7.2.1 Samples for conditioning shall be whole glove pairs.

9.8.7.2.2 Glove pair samples shall be conditioned as specified in 9.1.3.

9.8.7.3 Specimens.

9.8.7.3.1 A minimum of three glove pair specimens each for size 70W (wide) and size 76W (wide) shall be used for testing.

9.8.7.3.2 Each glove pair specimen shall be tested as a complete set of gloves in new as-distributed condition.

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

9.8.7.4 Apparatus.

9.8.7.4.1 Glove tool testing shall be evaluated with the use of the following apparatus:

(1) A hand tool vertical test apparatus consisting of one 34 mm (1⅓ in.) horizontal board with one 34 mm (1⅓ in.) vertical board — with holes drilled 50 mm (2 in.) apart in a "T"-shaped fashion with a row of three holes

and a row of one hole directly under and in the center of the top row — attached in the middle of the horizontal board

(2) Four M12-1.75 mm (1⁄16 in.) × 63 mm (2.5 in.) partially threaded bolts, each with one nut and two washers
(3) 9.5 mm (3⁄8 in.) drive deep-well 19 mm (3⁄4 in.) socket
(4) 19 mm (3⁄4 in.) box-end wrench
(5) 9.5 mm (3⁄8 in.) drive torque wrench

9.8.7.5 Procedure.

9.8.7.5.1 Three test subjects with the proper hand size shall be selected for testing size 76W (wide) gloves, and three test subjects with the proper hand size shall be selected for testing size 70W (wide) gloves.

9.8.7.5.2 The test subject shall be proficient with performing this test method before conducting any tests.

9.8.7.5.3 The test subject shall use left or right hand as is comfortable for the two sides of the board however, the test subject shall not alternate hands for the same task during the test series.

9.8.7.5.4 Before each test trial, the bolts with one washer already on shall be spaced apart on one side of the vertical board, and the nuts shall be spaced apart on the other side, depending on the test subject’s comfort.

9.8.7.5.4.1 The box-end wrench shall be placed on the side with the bolts and the torque wrench shall be placed on the side with the nuts, both within close proximity to the test board.

9.8.7.5.4.2 The test facilitator shall hand each washer to the test subject during the test trials.

9.8.7.5.5 For each test trial, the test subject shall start on either end of the top row of holes as long as this procedure is repeated for all trials. The test subject shall complete all holes in order across the top row and then complete the hole in the bottom row. After completion of the bottom hole the trial shall be complete.

9.8.7.5.6 The stopwatch shall be started when the test subject picks up the first bolt.

9.8.7.5.7 In starting the test, the test subject shall pick up a bolt with washer already on with one hand and put it into the first hole.

9.8.7.5.8 The test facilitator shall hand the test subject the second washer on the opposite side of the board.

9.8.7.5.9 While holding the bolt, the test subject shall place the second washer on the bolt with the opposite hand on the other side of the board.

9.8.7.5.10 While holding the bolt, the test subject shall place the nut on the bolt with the opposite hand on the other side of the board.

9.8.7.5.11 The test subject shall hold the bolt with one hand and tighten the nut with the opposite hand until resistance is met.

9.8.7.5.12 The test subject shall then use the box-wrench to hold the bolt secure on one side with the same hand that was used to insert the bolt.

9.8.7.5.13 While securing the bolt with the box-wrench, the test subject shall use the torque wrench to tighten the nut with the opposite hand, applying 120 in. lb to simulate snug.

9.8.7.5.14 When the torque wrench clicks, that hole position shall be complete and the test subject shall then begin inserting the next bolt and washer already on into the next hole.

9.8.7.5.15 The trial shall be complete and the stopwatch shall be stopped when the torque wrench clicks on the bottom hole.

9.8.7.5.16 If bolts, nuts, or wrenches are dropped onto the test surface, the test subject shall pick them up. If washers are dropped onto the test surface, the test facilitator shall pick them up and hand them to the test subject. If bolts, nuts, wrenches, or washers are dropped onto the floor, then the trial shall be stopped and the full trial shall be repeated.

9.8.7.5.17 The time to fill all holes for each trial shall be measured for each test subject and shall be known as the dexterity test time.

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

9.8.7.5.19 The test subject shall perform at least three test trials by following the steps in 9.8.7.5 without gloves until the coefficient of variation (COV) of the baseline times that of the person’s last three repetitions does not exceed 8 percent. The COV shall be calculated as described in 9.8.7.5.21.

9.8.7.5.20 The test subject shall then perform three test trials by following the steps in 9.8.7.5 wearing gloves on each hand until the COV of the dexterity times that of the person’s fastest three repetitions does not exceed 8 percent. The test subject shall perform all three trials using only one pair of gloves. Each test subject shall receive their own pair of gloves for the test. The COV shall be calculated as described in 9.8.7.5.21.

9.8.7.5.21 The COV shall be calculated by dividing the standard deviation by the average of three repetitions and multiplying by 100.

9.8.7.5.22 The average of the last three repetitions without gloves where the COV did not exceed 8 percent shall be used as the baseline dexterity test time (DTT_b).

9.8.7.5.23 The average of the three fastest repetitions wearing gloves where the COV did not exceed 8 percent shall be the dexterity test time with gloves (DTT_g).

9.8.7.5.24 The dexterity test times with gloves shall be compared with the baseline dexterity test time for each test subject. The percentage of bare-handed control shall be calculated as follows:

[9.8.7.5.24]

$$\text{Percent of bare-handed control } = \left(DTT_g / DTT_b\right) \times 100$$

where:
DTT_g = average dexterity time with gloves (sec)
DTT_b = average baseline dexterity test time (sec)

9.8.7.6 Report.

9.8.7.6.1 The average percentage of bare-handed control shall be recorded and reported for each test subject.

9.8.7.6.2 The average percentage of bare-handed control for all test subjects shall be recorded and reported for each size.

9.8.7.7 Interpretation.

9.8.7.7.1 The average percentage of bare-handed control for size 70W (wide) and size 76W (wide) shall be used to determine pass or fail performance.

9.8.7.7.2 Failure of either size shall constitute failure of the test.

9.8.8 Footwear Ladder Shank Bend Resistance Test.

9.8.8.1 Application. This test shall apply to protective footwear.

9.8.8.2 Samples.

9.8.8.2.1 Samples for conditioning shall be whole footwear,

9.8.8.2.2 Ladder shanks or whole sole equivalents shall be conditioned as specified in 9.1.3.

9.8.8.3 Specimens. A minimum of three footwear ladder shank specimens, or whole sole equivalent specimens, shall be tested.

9.8.8.4 Apparatus. The apparatus shall consist of a tensile-testing machine that challenges a specimen with a simulated ladder rung. A 32 mm diameter × 50 mm long (1¼ in. diameter × 2 in. long) noncompressible probe shall be mounted on the movable arm. The specimen support assembly shall consist of two 50 mm × 25 mm × 25 mm (2 in. × 1 in. × 1 in.) noncompressible blocks placed 50 mm (2 in.) apart as shown in Figure 9.8.8.4.

9.8.8.5 Procedure. The specimen of the ladder shank or whole sole equivalent shall be placed on mounting blocks as it would be oriented toward the ladder, where the shank or whole sole equivalent is affixed into the protective footwear and subjected to force on its center with the test probe operated at 50 mm/min (2 in./min).

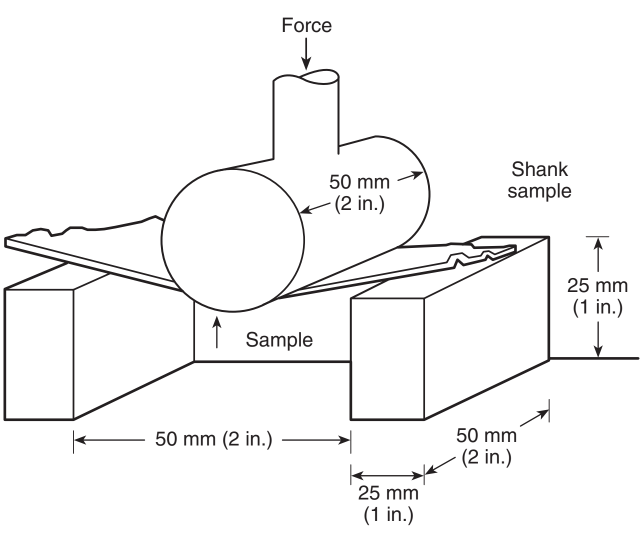


FIGURE 9.8.8.4 Shank Bend Test Setup.

9.8.8.6 Report.

9.8.8.6.1 Deflection at 182 kg (400 lb) shall be recorded and reported to the nearest 1 mm (0.05 in.).

9.8.8.6.2 The average deflection shall be calculated, recorded, and reported to the nearest 1 mm (0.05 in.).

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

9.8.9 Footwear Slip Resistance Test.

9.8.9.1 Application. This test method shall apply to footwear.

9.8.9.2 Sample Preparation.

9.8.9.2.1 Samples shall be the whole footwear items in men's size 9D.

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

9.8.9.3 Specimens.

9.8.9.3.1 Specimens shall be the whole footwear in men's size 9D.

9.8.9.3.2 At least three specimens shall be tested.

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

(1) Footwear shall be tested both in the forepart and heel positions.
(2) Footwear shall be tested in the wet condition.
(3) Footwear shall be tested on a quarry tile surface that meets the specifications of ASTM F2913 and shall be calibrated in accordance with ASTM F2913. The calibration frequency of 10 tests specified in ASTM F2913 shall be equivalent to 50 test runs.

9.8.9.5 Report.

9.8.9.5.1 The coefficient of friction of each specimen shall be reported.

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

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

9.8.10 Hood Opening Size Retention Test.

9.8.10.1 Application.

9.8.10.1.1 This test shall apply to the face openings or SCBA facepiece interface openings of protective hoods.

9.8.10.1.2 Protective hoods with either elastic face openings or manually adjustable face openings shall be tested by the procedure specified in 9.8.10.4.

9.8.10.1.3 Protective hoods designed for interface with a SCBA facepiece(s) shall be tested by the procedure specified in 9.8.10.5.

9.8.10.2 Samples.

9.8.10.2.1 Samples for conditioning shall be whole hoods.

9.8.10.2.2 Samples shall be conditioned as specified in 9.1.3.

9.8.10.3 Specimens. A minimum of three whole hoods shall be tested.

9.8.10.4 Procedure for Hoods with Elastic or Manually Adjustable Face Openings.

9.8.10.4.1 Specimen face openings shall be placed over a hood measuring device as shown in Figure 9.2.4.16.4. Specimen face openings in the relaxed state shall slide freely over the top half of the device where the circumference measures 45.6 cm ± 0.6 cm (18.0 in. ± 0.25 in.). Specimen face openings shall then be placed around the lower half of the device where the circumference measures 54.5 cm ± 0.6 cm (21.5 in. ±0.25 in.). Specimens shall then be visually inspected for gaps between the hood and the measuring device surface.

9.8.10.4.2 Upper and lower half drum mounting fixtures shown in Figure 9.8.10.4.2 shall be mounted on a tensile testing machine.

9.8.10.4.3 A 115 mm (2⅛ in.) gauge length separation shall be set between half drum fixtures on the tensile testing machine.

9.8.10.4.4 Place the hood specimen on the half drum fixtures such that the face opening expands around the upper and lower drums and the bottom of the hood drapes downward as shown in Figure 9.8.10.4.4. The opening shall be placed beyond the lips on the edge of the half drum fixtures to keep it in position during the testing.

9.8.10.4.5 The elongation of the tensile testing machine shall be started at an elongation of 508 mm/min (20 in./min).

9.8.10.4.6 The crosshead movement of the hood specimen on the drum fixtures shall be stopped after a total movement of 89 mm (6.5 in.) and returned to the zero position of 115 mm (2 ⅛ in.) gauge separation.

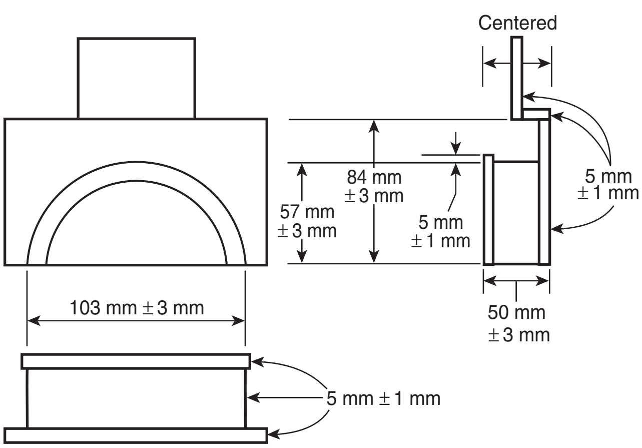


FIGURE 9.8.10.4.2 Upper and Lower Half Drum Mounting Fixtures.

FIGURE 9.8.10.4.4 Hood Face Opening Gauge.

9.8.10.4.7 The hood specimen shall be elongated and returned to the zero position a total of 50 times.

9.8.10.4.8 Following the 50 cycles, the hood shall be removed from the headform, and the hood shall be allowed to relax for 1 minute.

9.8.10.4.9 Specimens shall be examined as described in 9.8.10.4.1.

9.8.10.5 Procedure for Hoods with SCBA Facepiece Interface Openings.

9.8.10.5.1 The SCBA facepiece that the hood is designed to interface with shall be properly mounted, according to the SCBA manufacturer's instructions, on an ISO size J headform specified in Figure 9.3.6.4.1.

9.8.10.5.2 The hood shall then be donned on the headform, placing it over the SCBA facepiece.

9.8.10.5.3 The contact surface of the hood face opening with the SCBA facepiece shall be measured at a minimum of eight separate locations around the entire perimeter of the face opening contact area. The locations of measurement shall be marked on the hood.

9.8.10.5.4 Upper and lower half drum mounting fixtures shown in Figure 9.8.10.4.2 shall be mounted on a tensile testing machine.

9.8.10.5.5 A 115 mm (2⅛ in.) gauge length separation shall be set between half drum fixtures on the tensile testing machine.

9.8.10.5.6 Place the hood specimen on the half drum fixtures such that the face opening expands around the upper and lower drums and the bottom of the hood drapes downward as shown in Figure 9.8.10.4.4. The opening shall be placed beyond the lips on the edge of the half drum fixtures to keep it in position during the testing. Where the hood is designed to be manually adjustable around the hood face opening/SCBA facepiece interface area, the manual adjustment shall be made prior to commencing the elongation.

9.8.10.5.7 The elongation of the tensile testing machine shall be started at an elongation of 508 mm/min (20 in./min).

9.8.10.5.8 The crosshead movement of the hood specimen on the drum fixtures shall be stopped after a total movement of 89 mm (6.5 in.) and returned to a to the zero position of 115 mm (2⅛ in.) gauge separation.

9.8.10.5.9 The hood specimen shall be elongated and returned to the zero position a total of 50 times. Where the hood is designed to be manually adjustable around the hood face opening/SCBA facepiece interface area, the manual adjustment shall be opened and secured between each cycle.

9.8.10.5.10 Following the 50 cycles, the hood shall be removed from the headform, and the hood shall be allowed to relax for 1 minute.

9.8.10.5.11 The hood shall then be donned on the headform, placing it over the SCBA facepiece.

9.8.10.5.12 The contact surface of the hood face opening with the SCBA facepiece shall be measured at the same locations marked around the entire perimeter of the face opening contact area specified in 9.8.10.5.3.

9.8.10.5.13 The amount of overlap shall be measured.

9.8.10.6 Report for Hoods with Elastic or Manually Adjustable Face Openings.

9.8.10.6.1 Observations shall be recorded and reported of the ability of the face opening to slide freely over the top half of the hood measuring device and of gaps between the hood face opening and the bottom half of the hood measuring device before and after donning and doffing.

9.8.10.7 Report for Hoods with SCBA Facepiece Interface Openings.

9.8.10.7.1 The amount of overlap shall be recorded and reported for each location.

9.8.10.7.2 The average amount of overlap shall be recorded and reported for each specimen.

9.8.10.7.3 A photograph shall be provided to show the amount of overlap for any sample where an insufficient amount of overlap is reported.

9.8.10.8 Interpretation for Hoods with Elastic or Manually Adjustable Face Openings.

9.8.10.8.1 Pass or fail performance shall be based on the individual face openings being able to slide freely in the relaxed state over the top half of the hood measuring device and any observations of gaps between the hood face opening and the hood measuring device before and after donning and doffing.

9.8.10.9 Interpretation for Hoods with SCBA Facepiece Interface Openings. Pass or fail performance shall be based on the average amount of overlap for each specimen. One or more hood specimens failing this test shall constitute failing performance.

9.8.11 Drag Rescue Device (DRD) Function Test.

9.8.11.1 Application. This test shall apply to DRD installed in protective coats and protective coverall elements.

9.8.11.2 Samples.

9.8.11.2.1 Samples shall consist of complete protective coats or protective coveralls with DRD installed.

9.8.11.2.2 Samples shall be conditioned as specified in 9.1.3.

9.8.11.3 Specimens.

9.8.11.3.1 Specimens for testing shall be complete coat or complete coverall garment elements with DRD.

9.8.11.3.2 A minimum of three specimens shall be tested for each garment element type.

9.8.11.3.3 Each specimen shall have all garment layers in place.

9.8.11.4 Apparatus.

9.8.11.4.1 One pair of protective gloves for use by the test technician shall be provided.

9.8.11.4.1.1 The gloves shall be certified as compliant with this standard and be sized to fit the test technician.

9.8.11.4.1.2 For structural firefighting ensembles, the protective gloves shall be cow leather, gauntlet style structural firefighting gloves.

9.8.11.4.1.3 For proximity firefighting ensembles, the protective gloves shall be aluminized, gauntlet style proximity firefighting gloves.

9.8.11.4.2 One IAFF "Rescue Randy" Model 1475 manikin or equivalent shall be provided as the test manikin.

9.8.11.4.3 One 4500 psi open-circuit SCBA shall be provided.

9.8.11.4.3.1 The SCBA shall be certified as compliant with Chapters 15 through 19.

9.8.11.4.3.2 The SCBA shall be equipped with an empty 60-minute-rated breathing air cylinder.

9.8.11.4.3.3* The SCBA facepiece shall be sized to fit the test technician and be obscured according to the following:

(1) An adhesive vinyl shall be adhered to the external side of the viewing area of the facepiece.
(2) The vinyl shall be hazed so that there is a maximum of 71 percent blackout and a minimum of 50 percent blackout.
(3) The vinyl shall cover enough of the viewing area so that the test technician cannot perform the test without looking through the blackout area.

9.8.11.4.4 One particulate-blocking hood certified as compliant with this standard shall be provided.

9.8.11.5 Procedure.

9.8.11.5.1 The DRD shall be inspected to ensure correct installation within the garment element in accordance with the manufacturer's instructions.

9.8.11.5.2 The DRD shall be in the secured, nondeployed position.

9.8.11.5.3 The size of the specimen shall fit the manikin by conforming to the dimensions of the manikin chest circumference in accordance with the manufacturer's sizing system.

9.8.11.5.4 The test specimen shall be donned on the test manikin in accordance with the manufacturer's instructions for wearing and be tested with the SCBA harness and cylinder, hood, and helmet as specified in 9.8.11.4.

9.8.11.5.5 The items specified in 9.8.11.5.4 shall be donned on the test manikin, in accordance with the SCBA manufacturer's instructions, over the specimen.

9.8.11.5.6 The test manikin shall be placed on its side on a concrete surface.

9.8.11.5.7 With the test manikin in position, the test technician shall don the gloves specified in 9.8.11.4.1 and the SCBA facepiece specified in 9.8.11.4.3. The regulator port shall remain uncovered to allow air to enter the facepiece.

9.8.11.5.8 Deployment time shall be measured beginning when the test technician touches the manikin and stopping when the dragging motion begins.

9.8.11.5.9 The test technician shall drag the manikin in a straight line using the DRD, in accordance with the manufacturer's instructions, for a distance of 2.5 m, +0.5/−0 m (8 ft, +1½/−0 ft).

9.8.11.5.10 The deployment of the DRD and the dragging of the manikin shall be observed to determine if the SCBA is dislodged from the "as donned position."

9.8.11.6 Report.

9.8.11.6.1 The deployment time of the DRD shall be recorded and reported.

9.8.11.6.2 The ability to drag the manikin the required distance shall be recorded and reported.

9.8.11.6.3 Change in the position of the SCBA during either the deployment of the DRD or the dragging of the manikin shall be recorded and reported.

9.8.11.7 Interpretation.

9.8.11.7.1 The inability to deploy the device in 10 seconds or less, or the inability to drag the manikin 2.5 m (8 ft) shall constitute failing performance.

9.8.11.7.2 Failure of one or more specimens shall constitute failing performance.

9.8.12 Label Durability and Legibility Test 1.

9.8.12.1 Application.

9.8.12.1.1 This test method shall apply to labels and nonvisual/machine-readable tags on protective garments, hoods, gloves, and boots.

9.8.12.1.2 Modifications to this test method for testing garment labels shall be as specified in 9.8.12.7.

9.8.12.1.3 Modifications to this test method for testing hood labels shall be as specified in 9.8.12.8.

9.8.12.1.4 Modifications to this test method for testing glove labels shall be as specified in 9.8.12.9.

9.8.12.1.5 Modifications to this test method for testing footwear labels shall be as specified in 9.8.12.10.

9.8.12.1.6 Modifications to this test method for testing machine nonvisual/machine-readable tags shall be as specified in 9.8.12.11.

9.8.12.2 Samples. Samples shall be conditioned as specified in 9.1.3.

9.8.12.3 Specimens.

9.8.12.3.1 A minimum of three specimens of each type of label for each element shall be tested in each test.

9.8.12.3.2 Where labels have areas of "write-in" information, two additional specimens shall be tested that include those areas with sample information written in.

9.8.12.4 Procedures.

9.8.12.4.1 Laundering Durability Test.

9.8.12.4.1.1 Specimens shall be subjected to ten cycles of laundering and drying using Machine Cycle 1, Wash Temperature V, and Drying Procedure Ai of AATCC LP1, *Home Laundering: Machine Washing*.

9.8.12.4.1.2 A 1.8 kg ± 0.1 kg (4.0 lb ± 0.2 lb) load shall be used. A laundry bag shall not be used.

9.8.12.4.1.3 Specimens shall be examined for legibility to the unaided eye by a person with 20/20 vision, or vision corrected to 20/20, at a nominal distance of 305 mm (12 in.) in a well-illuminated area.

9.8.12.4.2 Abrasion Durability Test.

9.8.12.4.2.1 Specimens shall be subjected to abrasion in accordance with ASTM D4966, *Standard Test Method for Abrasion Resistance of Textile Fabrics (Martindale Abrasion Test Method)*, with the following modifications:

(1) The standard abrasive fabric and the felt-backing fabric shall be soaked for 24 hours or agitated in distilled water so that they are thoroughly wet.
(2) Specimens shall be subjected to 200 cycles, 3200 revolutions, of the test apparatus.
(3) Standard abrasive fabric shall only be used for 200 cycles.

9.8.12.4.2.2 Specimens shall be examined for legibility to the unaided eye by a person with 20/20 vision, or vision corrected to 20/20, at a nominal distance of 305 mm (12 in.) in a well-illuminated area.

9.8.12.4.3 Heat Durability Test.

9.8.12.4.3.1 Specimens shall be subjected to convective heat as specified in 9.1.5.

9.8.12.4.3.2 Specimens shall be examined for legibility to the unaided eye by a person with 20/20 vision, or vision corrected to 20/20, at a nominal distance of 305 mm (12 in.) in a well-illuminated area.

9.8.12.5 Report.

9.8.12.5.1 The legibility for each specimen shall be recorded and reported as acceptable or unacceptable.

9.8.12.5.2 A photograph or photographs shall be provided as part of the report if differences are observed between new labels and labels subjected to the applicable test procedures.

9.8.12.6 Interpretation. One or more label specimens failing this test shall constitute failing performance.

9.8.12.7 Specific Requirements for Testing Garment Labels.

9.8.12.7.1 For testing label legibility after laundering, specimens shall include individual labels sewn onto a 1 m (1 yd) square of ballast material no closer than 51 mm (2 in.) apart in parallel strips. The ballast material shall be a material that meets the outer shell requirements of this standard.

9.8.12.7.2 For testing label legibility after abrasion, specimens shall be individual labels.

9.8.12.7.3 For testing label legibility after convective heat exposure, specimens shall include individual labels sewn onto a separate 380 mm ± 13 mm (15 in. ± ½ in.) square of material that meets the outer shell requirements of Chapters 4 through 9 of this standard.

9.8.12.7.4 Sample conditioning shall be the same conditioning as specified for the respective tests.

9.8.12.7.5 Specimens shall be tested separately for legibility after laundering, abrasion, and heat durability tests as specified in 9.8.12.4.1, 9.8.12.4.2, and 9.8.12.4.3, respectively.

9.8.12.8 Specific Requirements for Testing Hood Labels.

9.8.12.8.1 For testing label legibility after laundering, specimens shall include complete hoods with labels attached.

9.8.12.8.2 For testing label legibility after abrasion, specimens shall be individual labels.

9.8.12.8.3 For testing label legibility after convective heat exposure, specimens shall include individual labels sewn onto a separate 380 mm ± 13 mm (15 in. ± ½ in.) square of hood material that meets the hood material requirements of this standard.

9.8.12.8.4 Sample conditioning shall be the same conditioning as specified for the respective tests.

9.8.12.8.5 Specimens shall be tested separately for legibility after laundering, abrasion, and heat durability tests as specified in 9.8.12.4.1, 9.8.12.4.2, and 9.8.12.4.3, respectively.

9.8.12.9 Specific Requirements for Testing Glove Labels.

9.8.12.9.1 For testing label legibility after laundering and convective heat exposure, specimens shall include complete gloves with labels attached.

9.8.12.9.2 For testing label legibility after abrasion, specimens shall be individual labels.

9.8.12.9.3 Sample conditioning shall be the same conditioning as specified for the respective tests.

9.8.12.9.4 Specimens shall be tested separately for legibility after laundering, abrasion, and heat durability tests as specified in 9.8.12.4.1, 9.8.12.4.2, and 9.8.12.4.3, respectively.

9.8.12.9.5 For the drying cycles of the laundering durability test specified in 9.8.12.4.1.1, gloves shall be tumble dried for 60 minutes and shall be removed immediately at the end of the drying cycle. At the conclusion of the final drying cycle, the gloves shall be direct dried on a forced-air, non-tumble-drying mechanism operated at 10°C ± 5°C (18°F ± 9°F) above current room temperature until dry but not less than 8 hours.

9.8.12.10 Specific Requirements for Testing Footwear Labels.

9.8.12.10.1 For testing label legibility after convective heat exposure, specimens shall include complete footwear items with the labels attached or representative sections of the footwear with labels attached.

9.8.12.10.2 For testing label legibility after abrasion, specimens shall be individual labels.

9.8.12.10.3 Sample conditioning shall be the same conditioning as specified for the respective tests.

9.8.12.10.4 Specimens shall be tested separately for legibility after abrasion and heat durability tests as specified in 9.8.12.4.2 and 9.8.12.4.3, respectively.

9.8.12.11 Specific Requirements for Testing Nonvisual/Machine-Readable Tags.

9.8.12.11.1 Garment, hood, and glove nonvisual/machine-readable tags shall be tested to 9.8.12.4.1 and 9.8.12.4.3 only.

9.8.12.11.1.1 Footwear nonvisual/machine-readable tags shall be tested to 9.8.12.4.3 only.

9.8.12.11.2 For testing after laundering, garment specimens shall include tags attached to a 1 m^2 (1 yd^2) square of ballast material no closer than 51 mm (2 in.) apart in parallel strips. The ballast material shall be a material that meets the outer shell requirements of this standard.

9.8.12.11.2.1 For testing after laundering, hood specimens shall include complete hoods with tags attached.

9.8.12.11.2.2 For testing after laundering, glove specimens shall include complete gloves with tags attached.

(A) For the drying cycles of the laundering durability test specified in 9.8.12.4.1.1, gloves shall be tumble dried for 60 minutes and removed immediately at the end of the drying cycle.

(B) At the conclusion of the final drying cycle, the gloves shall be direct dried on a forced-air, non-tumble-drying mechanism operated at 10°C ± 5°C (18°F ± 9°F) above current room temperature for at least 8 hours and until dry.

9.8.12.11.3 For testing after convective heat exposure, garment specimens shall include tags attached to a separate 380 mm ± 13 mm (15 in . ± ½ in.) square of material that meets the outer shell requirements of this standard.

9.8.12.11.3.1 For testing after convective heat exposure, hood specimens shall include tags attached to a separate 380 mm ± 13 mm (15 in. ± ½ in.) square of hood material that meets the hood material requirements of this standard.

9.8.12.11.3.2 For testing after convective heat exposure, glove specimens shall include complete gloves with tags attached.

9.8.12.11.3.3 For testing after convective heat exposure, footwear specimens shall include complete footwear items with tags attached or representative sections of the footwear with tags attached.

9.8.12.11.4 Sample conditioning shall be the same conditioning as specified for the respective tests.

9.8.12.11.5 Garment, hood, and glove specimens shall be tested separately for functionality after laundering and heat durability tests as specified in 9.8.12.4.1 and 9.8.12.4.3, respectively.

9.8.12.11.5.1 Footwear specimens shall be tested separately for functionality after the heat durability test as specified in 9.8.12.4.3 only.

9.8.12.11.6 Specimens shall be tested for functionality within 15 minutes of removal of the respective conditioning.

9.8.13 Label Durability and Legibility Test 2.

9.8.13.1 Application. This test method shall apply to labels and, where provided, nonvisual/machine-readable tags on helmets.

9.8.13.2 Samples.

9.8.13.2.1 Samples for conditioning shall be whole helmets with the labels and tags attached, where provided.

9.8.13.2.2 Samples shall be conditioned as specified in 9.1.3, 9.1.4, 9.1.6, and 9.1.7 for labels.

9.8.13.2.3 Samples shall be conditioned as specified in 9.1.5 for tags, where provided.

9.8.13.3 Specimens. A minimum of three labels and tags, where provided, for each condition specified shall be tested.

9.8.13.4 Procedure.

9.8.13.4.1 Label specimens shall be examined for legibility by a person with 20/20 vision, or vision corrected to 20/20, at a nominal distance of 305 mm (12 in.) in a well-illuminated area.

9.8.13.4.2 Tag specimens shall be tested for functionality within 15 minutes of removal from the conditioning.

9.8.13.5 Report.

9.8.13.5.1 The legibility for each label specimen shall be recorded and reported as acceptable or unacceptable.

9.8.13.5.2 A diagram or photograph shall be provided as part of the report if differences are observed between new labels and labels subjected to the applicable test procedures.

9.8.13.6 Interpretation. One or more label specimens failing this test shall constitute failing performance.

9.9 Cleaning and Care-Related Properties.

9.9.1 Cleaning Shrinkage Resistance Test.

9.9.1.1 Application.

9.9.1.1.1 This test method shall apply to the protective garment outer shell, moisture barrier, thermal barrier, winter liner, wristlet, bootie material where present, and protective hoods.

9.9.1.1.2 Modifications to this test method for testing woven textile materials shall be as specified in 9.9.1.7.

9.9.1.1.3 Modifications to this test method for testing knit and stretch woven materials shall be as specified in 9.9.1.8.

9.9.1.1.4 Modifications to this test method for testing hoods shall be as specified in 9.9.1.9.

9.9.1.2 Samples. Samples shall be conditioned as specified in 9.1.3.

9.9.1.3 Specimens. Cleaning shrinkage resistance testing shall be conducted on three specimens of each material, and each separable layer of a composite material shall be tested separately.

9.9.1.4 Procedure.

9.9.1.4.1 Specimens shall be tested using five cycles of the laundering procedure in 9.1.2.

9.9.1.4.2 A 1.8 kg ± 0.1 kg (4.0 lb ± 0.2 lb) load shall be used. A laundry bag shall not be used.

9.9.1.4.3 Laundry water hardness shall not exceed 25 ppm.

9.9.1.4.4 Specimen marking and measurements shall be conducted in accordance with the procedure specified in AATCC TM135, *Test Method for Dimensional Changes of Fabrics After Home Laundering*.

9.9.1.4.5 Knit specimens shall be pulled to original dimensions and shall be allowed to relax for 1 minute prior to measurement.

9.9.1.5 Report.

9.9.1.5.1 The percent change in the width and length dimensions of each specimen shall be calculated.

9.9.1.5.2 Results shall be recorded and reported as the average of all three specimens in each dimension.

9.9.1.6 Interpretation.

9.9.1.6.1 The average percent change in both dimensions shall be used to determine pass or fail performance.

9.9.1.6.2 Failure of either dimension shall constitute failure for the entire sample.

9.9.1.7 Specific Requirements for Testing Woven Textile Materials.

9.9.1.7.1 Each specimen shall be 380 mm × 380 mm ± 13 mm (15 in. × 15 in. ± ½ in.), and shall be cut from the fabric to be utilized in the construction of the clothing item.

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

9.9.1.7.3 Testing shall be performed as specified in 9.9.1.2 through 9.9.1.6.

9.9.1.8 Specific Requirements for Testing Knit and Stretch Woven Textile Materials.

9.9.1.8.1 Other than for wristlets, the dimensions of each specimen shall be 380 mm × 380 mm ± 13 mm (15 in. × 15 in. ± ½ in.), and shall be cut from the fabric to be utilized in the construction of the clothing item.

9.9.1.8.2 The dimensions of wristlet specimens shall be 113 mm × 113 mm ± 13 mm (4½ in. × 4½ in. ± ½ in.), and shall be cut from the wristlet fabric.

9.9.1.8.3 Samples for conditioning shall include material that is at least 50 mm (2 in.) larger in each of the two required specimen dimensions.

9.9.1.8.4 Testing shall be performed as specified in 9.9.1.2 through 9.9.1.6.

9.9.1.9 Specific Requirements for Testing Hoods.

9.9.1.9.1 Samples for conditioning shall include complete hoods with labels.

9.9.1.9.2 Specimens for testing shall be complete hoods with labels. A total of three specimens shall be tested.

9.9.1.9.3 Specimens shall be donned on a nonconductive test headform specified in Figure 9.2.4.12.3. Measurements shall be made at the back and both sides of the hood from the top of the hood to the basic plane. The location of the basic plane on the hood shall be marked at each location.

9.9.1.9.4 Specimen face openings with elastic or manually adjustable face openings shall be placed over a hood measuring device as shown in Figure 9.2.4.16.4. Specimen face openings in the relaxed state shall slide freely over the top half of the device where the circumference measures 45.6 cm ± 0.6 cm (18.0 in. ± 0.25 in.). Specimen face openings shall then be placed around the lower half of the device where the circumference measures 54.5 cm ± 0.6 cm (21.5 in. ± 0.25 in.). Specimens shall then be visually inspected for gaps between the hood and the measuring device surface.

9.9.1.9.4.1 Specimen hoods with SCBA facepiece interface openings shall be measured as specified in 9.8.10.5.3.

9.9.1.9.5 After washing, each elastic or manually adjustable face opening shall be placed over a hood measuring device as shown in Figure 9.2.4.16.4. Specimen face openings in the relaxed state shall slide freely over the top half of the device where the circumference measures 45.6 cm ± 0.6 cm (18.0 in. ± 0.25 in.). Specimen face openings shall then be placed around the lower half of the device where the circumference measures 54.5 cm ± 0.6 cm (21.5 in. ± 0.25 in.). Specimens shall then be visually inspected for gaps between the hood and the measuring device surface.

9.9.1.9.5.1 After washing, each hood with SCBA facepiece interface openings shall be measured as specified in 9.8.10.5.3.

9.9.1.9.5.2 After washing, all specimens shall then be donned on a nonconductive test headform specified in Figure 9.2.4.12.3. Knit specimens shall be pulled to original dimensions and shall be allowed to relax for 1 minute prior to measurement. Measurements shall be made from the top of the hood to the marks at the back and both sides of the hood.

9.9.1.9.6 Observations shall be recorded and reported of the ability of the elastic and manually adjustable face openings to slide freely over the top half of the hood measuring device as well as gaps between the hood face opening and the bottom half of the hood measuring device before and after laundering. The average percent shrinkage of the SCBA facepiece openings for each hood shall be recorded and reported.

9.9.1.9.7 Each of the three dimensions from the top of the hood to the marks along the basic plane before and after laundering shall be recorded and reported.

9.9.1.9.8 The percentage of shrinkage of each of the three dimensions from the top of the hood to the marks along the basic plane shall be individually calculated, recorded, and reported.

9.9.1.9.9* The average percentage of shrinkage of the three dimensions from the top of the hood to the marks along the basic plane for all specimens shall be calculated, recorded, and reported.

9.9.1.9.10* Pass or fail performance shall be based on the average percent shrinkage of the three dimensions from the top of the hood to the marks along the basic plane for each specimen.

9.9.1.9.11 Pass or fail performance shall also be based on the elastic or manually adjustable face opening being able to slide freely in the relaxed state over the top half of the hood measuring device and any observations of gaps between the hood face opening and the hood measuring device. One or more hood specimens failing this test shall constitute failing performance.

9.9.1.9.12 Pass or fail performance shall also be based on the average percent shrinkage of the SCBA facepiece openings.

9.9.2 Helmet Soft Goods Ease of Removal and Reinstallation Test.

9.9.2.1 Application. This test method shall apply to protective helmets used for structural firefighting.

9.9.2.2 Samples.

9.9.2.2.1 Samples for conditioning shall be whole helmets with all required components for compliance with this standard that include, but are not limited to, ear covers; sweatbands; chin straps; nape straps, if provided; and other textile-based soft goods not including suspension soft goods that come in contact with the wearer's head when the helmet is worn.

9.9.2.2.2 Samples shall be conditioned as specified in 9.1.3.

9.9.2.3 Specimens.

9.9.2.3.1 A minimum of 3 complete helmets shall be tested.

9.9.2.3.2 Each unique means for different ear covers; sweatbands; chins straps; nape straps, if provided; and any other textile-based soft goods not including suspension soft goods, where different, shall be tested.

9.9.2.4 Procedure.

9.9.2.4.1 A different test operator shall perform each separate test.

9.9.2.4.2 Each test operator shall be provided the manufacturer instructions for the removal of the ear covers; sweatbands; chins straps; nape straps, if provided; and any other textile-based soft goods not including suspension soft goods, any required tools dictated by the manufacturer, and a flat table with chair.

9.9.2.4.3 The test operators shall be permitted to acquaint themselves with the manufacturer instructions and practice in the removal and reattachment of all the textile-based soft goods, including, but not limited to, the ear covers; sweatbands; chin straps; nape straps, if provided; and any other textile-based soft goods not including suspension soft goods, until they believe they are competence in performing this action.

9.9.2.4.4 After the test operator has met the condition specified in 9.9.2.4.3, a completely assembled helmet with all provided textile-based soft goods not including suspension soft goods shall be provided to the test operator and the test operator shall be timed for the length that is needed to fully remove all of the soft goods completely from the helmet and then reinstall the same items back onto the helmet after all items have been removed.

9.9.2.5 Report. The individual ear covers; sweatbands; chins straps; nape straps, if provided; and any other textile-based soft goods not including suspension soft goods, removal times shall be reported and recorded. An average ear covers; sweatbands; chins straps; nape straps, if provided; and any other textile-based soft goods not including suspension soft goods, removal time shall be calculated.

9.9.2.6 Interpretation. Pass/fail performance shall be based on the average ear covers; sweatbands; chins straps; nape straps, if provided; and any other textile-based soft goods not including suspension soft goods, removal time.

9.9.3 Contamination Removal Efficiency Tests.

9.9.3.1 Application. This test method shall apply to the following materials from each of the respective elements:

(1) Garments elements: outer shell, moisture barrier, and thermal barrier materials
(2) Helmet elements: ear cover, suspension system, and retention system materials that come in contact with the wearer's head or neck when worn without a protective hood
(3) Hood interface components: composites that include all layers

9.9.3.2 Sample Preparation. Garment, helmet, and hood samples shall be subject to five cycles of laundering conditioning as specified in 9.1.2.

9.9.3.3 Specimens. Specimens shall be prepared in accordance with the applicable requirements for semivolatile organic compounds and heavy metals as specified in Section 12.4 of NFPA 1851 with the following modifications:

(1) The specimens shall be the actual materials to be tested.
(2) Specimens shall be prepared as specified in 9.9.3.2, not as specified in 12.4.3.2 of NFPA 1851.
(3) If webbing materials are evaluated for helmets, the specimen size shall be adjusted to have the same area requirements as specified in 12.4.3.2 of NFPA 1851.
(4) For hoods, the specimens shall be whole hoods with specific target contaminations and evaluation areas that are marked on the products through stitching or other means to remain in place following the laundering but not compromise the results of the testing.

9.9.3.4 Procedure. Specimens shall be evaluated for cleaning efficiency in removing semivolatile organic compounds and for cleaning efficiency in removing heavy metals in accordance with Sections 12.6 and 12.7, respectively, of NFPA 1851 with the following modifications:

(1) For garment and helmet material specimens, the subject material shall be contaminated on the normal exterior side of the respective material.
(2) For hood composites, the subject composite specimen shall be contaminated on the exterior side of the composite of the whole hood specimen.
(3) For garment materials, specimens shall be placed in the surrogate garment for carrying out advanced cleaning as specified in Section 12.9 of NFPA 1851.
(4) Ballast material as specified in Section 12.4.4.3 of NFPA 1851 shall conform only to Panel F specifications that measure 229 mm × 750 mm (9 in. × 29.5 in.)
(5) For helmet materials and hood composite specimens, specimens shall be attached by a safety pin or similar device to individual ballast material panels.
(6) Garment outer shell, garment moisture barrier, garment thermal barrier, hood composite, and helmet specimens shall be subject to one cycle of washing and drying as specified in 9.1.12 with the following modifications:
    (a) If ballast is needed to reach load capacity, ballast as specified in 12.4.4.3 of NFPA 1851 shall be used.
    (b) High efficiency (HE) standard reference liquid detergent without optical brighteners at a ratio of 38 mL per 3.8 L ± 1 percent of water shall be used.
    (c) Air drying and forced-air drying as specified in 9.1.12.5 shall not be permitted.
    (d) Specimens shall be washed and dried for a total of one cycle.

9.9.3.5 Report.

9.9.3.5.1 The results of testing for semivolatile organic compound cleaning efficiency shall be reported in accordance with Section 12.6 of NFPA 1851.

9.9.3.5.2 The results of testing for heavy metals cleaning efficiency shall be reported in accordance with Section 12.7 of NFPA 1851.

9.9.4 Flame Resistance Following Fuel Exposure and Cleaning Test.

9.9.4.1 Application. This test shall apply to garment outer shells.

9.9.4.2 Sample Preparation.

9.9.4.2.1 Samples shall measure at least 1 m^2 (1 yd^2).

9.9.4.2.2 Samples shall be conditioned as specified in 9.1.2 using 10 laundering cycles followed by conditioning as specified in 9.1.3.

9.9.4.3 Specimens.

9.9.4.3.1 Specimens shall be sized 235 mm × 360 mm (9.4 in. × 14.1 in.).

9.9.4.3.2 A test specimen smaller in the width direction across the test apparatus trough than specified in 9.9.4.3.1 shall be permitted if it can be demonstrated that the flow of liquid down the specimen stays on the specimen during the application of the liquid exposure.

9.9.4.3.3 A minimum of six specimens shall be tested, with three specimens in each material direction for both conditions in Table 9.9.4.3.3: post-fuel contamination (Condition 1) and post-fuel contamination followed by cleaning (Condition 2)..

9.9.4.4 Apparatus. The exposure test apparatus and related equipment specified in ISO 6530, *Protective clothing – Protection against liquid chemicals – Test method for resistance of materials to penetration by liquids*, shall be used.

9.9.4.5 Procedure.

9.9.4.5.1 Specimens for both Condition 1 and Condition 2 in Table 9.9.4.3.3 shall be tested as specified in ISO 6530, *Protective clothing – Protection against liquid chemicals – Test method for resistance of materials to penetration by liquids*, against Grade No. 2-D S15 diesel fuel as specified in ASTM D975, *Standard Specification for Diesel Fuel*, with the measurement of the index of repellency, index of penetration, and index of absorption.

9.9.4.5.2 For Condition 2 in Table 9.9.4.3.3, within 24 hours, +2/−0 hours, of the testing procedures in 9.9.4.5.1, diesel-fuel-

Table 9.9.4.3.3 Testing Procedures

Reference	Condition 1	Condition 2
9.9.4.5.1	Fuel contamination	Fuel contamination
9.9.4.5.2	N/A	Cleaning *(within 24 hours of 9.9.4.5.1)*
9.9.4.5.3.1 9.9.4.5.3.1.1	N/A	Flame resistance test 1 *(within 24 hours of 9.9.4.5.2)*
9.9.4.5.3.2 9.9.4.5.3.2.1	Flame resistance test 1 *(within 4 hours of 9.9.4.5.1)*	N/A

contaminated specimens shall be subject to one cycle of washing and drying as specified in 9.1.12 with the following modifications:

(1) If ballast is needed to reach load capacity, ballast as specified in 12.4.4.3 of NFPA 1851 shall be used.
(2) AATCC High Efficiency (HE) Standard Reference Liquid Detergent WOB (without optical brighteners), at a ratio of 38 mL/3.8L ±1% water shall be used.
(3) Air drying and forced-air drying as specified in 9.1.12.5 shall not be permitted.
(4) Specimens shall be washed and dried for a total of 1 cycle.

9.9.4.5.3 Contaminated specimens shall be tested as specified in either 9.9.4.5.3.1 for Condition 1 in Table 9.9.4.3.3 or 9.9.4.5.3.2 for Condition 2 in Table 9.9.4.3.3.

9.9.4.5.3.1 Within 24 hours, +2/−0 hours, of the completion of the cleaning procedures as specified in 9.9.4.5.2, a 75 mm × 305 mm (3 in. × 12 in.) specimen shall be removed from each cleaned, contaminated specimen such that the new specimen's bottom edge coincides with the drip edge of the diesel exposure.

9.9.4.5.3.1.1 Within 24 hours, +2/−0 hours, of the cleaning procedures described in 9.9.4.5.2, each specimen shall be subjected to flame resistance testing as specified in 9.2.1.

9.9.4.5.3.2 Within 4 hours, +15/−0 minutes, of the testing as described in 9.9.4.5.1, a 75 mm × 305 mm (3 in. × 12 in.) specimen shall be removed from each contaminated specimen, such that the new specimen's bottom edge coincides with the drip edge of the diesel exposure.

9.9.4.5.3.2.1 Within 4 hours, +15/−0 minutes, of the testing as described in 9.9.4.5.1, each specimen shall be subjected to flame resistance testing as specified in 9.2.1.

9.9.4.6 Report.

9.9.4.6.1 The indices of repellency, penetration, and absorption shall be reported for each specimen as well as the average indices for each material directionfor each condition in Table 9.9.4.3.3.

9.9.4.6.2 The flame resistance results as specified in 9.2.1 shall be reported for each specimen with the average afterflame time and char length calculated for each material direction for each condition in Table 9.9.4.3.3.

9.9.4.6.3 For comparison purposes, the ordinary flame resistance results for the respective outer shell material shall be provided alongside the test results described in 9.9.4.6.2.

9.10 PPE-Based Hazardous Substances Requirements.

9.10.1 Tests for Acceptable Levels of Specific Restricted Substances.

9.10.1.1* Specified components of specified protective elements shall be evaluated for each listed restricted substance or category of restricted substances and not exceed the maximum concentration as specified in Table 9.10.1.1.

9.10.1.2 Alternative test methods shall be permitted if the test method can demonstrate it is capable of providing a lower limit of quantification that is at the specified limit or below established for the respective substance in Table 8.21(a),unless otherwise stated in Table 9.10.1.1, and that provides an 80 percent or better recovery of the respective substance from the tested material or component.

9.10.1.3 The report for this testing shall include the identification of the recognized component, the specific restricted substances evaluated, and the measured level for each restricted substance against the limits established in Section 8.21.

9.10.2 Test for Total Fluorine.

9.10.2.1 Application. This test method shall apply to any protective element for which the manufacturer is making the claim that is permitted in 6.1.7.5.

9.10.2.2 Selection of Samples for Evaluation.

9.10.2.2.1 Protective garment samples shall include outer shells, moisture barriers, thermal barriers, and wristlet/garment-glove interface components.

9.10.2.2.2 Protective helmet samples shall include ear cover fabric material layers, textile-based suspension materials, and textile-based retention system materials.

9.10.2.2.3 Protective glove samples shall include glove principal textile-based fabric materials, including shells, moisture barriers, linings, wristlets, and any nontextile moisture barrier materials.

9.10.2.2.4 Protective footwear samples shall include all footwear upper principal textile-based fabric material layers, including any exterior layer(s), barrier layers(s), lining(s), and any nontextile barrier layers.

9.10.2.2.5 Protective hood interface component samples shall include all hood fabric materials, including the outer layer, inner layers (where different), and particulate-blocking layers, as applicable.

9.10.2.3 Samples.

9.10.2.3.1 The size of the respective samples from the applicable material or component shall be as specified in the specific procedure applied.

9.10.2.3.2 A minimum default sample size of 5 g (0.18 oz) shall be used if specimen size or weight is not specified in the selected procedure.

9.10.2.3.3 The selected samples shall include all specific nonseparable parts, layers, or attributes of the applicable material or component.

Table 9.10.1.1 Test Methods for Evaluating Protective Element Components for Specific Restrictive Substances

Chemical Class or Group	Restricted Substance(s)	Test Method
Acetophenone and 2-Phenyl-2-propanol	Acetophenone and 2-Phenyl-2-propanol	Extraction in acetone or methanol, sonification for 30 minutes at 60°C (140°F); analysis by GC/MS
Acidity and alkaline substances	Measured by reporting pH	Textiles and artificial leather: ISO 3071 using KCl solution
Akyl phenols and ethoxylates	4-tert Butylphenol, nonylphenol, octylphenol, heptaphenol, and pentylphenol	Textiles: ISO 21084 Polymers and other materials: 1 g sample/20 mL THF, sonification for 60 min at 70°C (158°F) with analysis in accordance with ISO 21084
	Nonylphenolethoxylates and octylphenol-ethoxylates	All materials: ISO 18254-1 with analysis using LC/MS or LC/MS/MS
Azo-amines and aryl amine salts	See Table 8.21(b)	All materials: ISO 14362-1 For p-aminoazobenzene: All materials: ISO 14362-3
Bisphenol	Bisphenol A, Bisphenol B, and Bisphenol S	All materials, extraction: 1 g sample/20 ml THF, sonication for 60 minutes at 60°C (140°F), analysis with LC/MS
Chlorinated benzenes and toluenes	See Table 8.21(c)	All materials: EN 17137
Chlorinated paraffins	Short chain and medium chain chlorinated paraffins	ISO 22818
Chlorinated phenols	Pentachlorophenol Tetrachlorophenols Trichlorophenols Dichlorophenols Monochlorophenols	All materials: EN 17134-2
Dyes	See Table 8.21(d) Navy Blue: Component 1: $C_{39}H_{23}ClCrN_7O_{12}S.2Na$; and Component 2: $C_{46}H_{30}CrN_{10}O_{20}S_2.3Na$	All materials: DIN 54231 All materials: DIN 54231
Flame retardants	See Table 8.21(e)	All materials: ISO 17881-1 and ISO 17881-2
Formaldehyde	Free and partially releasable	All materials: ISO 14184-1
Heavy metals, extractable	Antimony, arsenic, barium, cadmium, chromium, cobalt, copper, lead, mercury, nickel, and selenium	All materials: EN 16711-2
	Chromium VI	Textiles: EN 16711-2 with ISO 17075-1 if chromium is detected
Heavy metals, total content	Arsenic, cadmium, and mercury Lead	All materials: EN 16711-2 All materials: CPSC-CH-E1002-08.3
Monomers	Styrene, free	Extraction in methanol; GC/MS, sonication at 60°C (140°F) for 60 minutes
	Vinyl chloride	All materials: ISO 6401
Nitrosamines	See Table 8.21(f)	All materials: ISO 19577
Organotin compounds	Tributyltin (TBT), triphenyltin (TPhT), and chemicals in Table 8.21(g)	All materials: ISO/TS 16179
Ortho-phenylphenol	Ortho-phenylphenol	All materials: DIN 50009

(continues)

Table 9.10.1.1 ***Continued***

Chemical Class or Group	Restricted Substance(s)	Test Method
Perfluorinated and polyfluorinated compounds	Total fluorine Individual chemicals in accordance with Table 8.21(j)	All materials: EN 14582 or ASTM D7359 All materials: ISO 23702-1 or EN 17681-1 and EN 17681-2
Phthalates	See Table 8.21(h)	Sample preparation for all materials: CPSC-CH-C1001-09.4 Measurement: Textiles: GC/MS, ISO 14389 All materials except textiles: GC/MS
Polycyclic aromatic hydrocarbons (PAH)	See Table 8.21(i)	All materials: AFPS GS 2019:01
Quinoline	Quinoline	All materials: DIN 54231 with methanol extraction at 70°C (158°F)
Solvent residues	Dimethylformamide, and N-methyl-2-pyrrolidone	Textiles: EN 17131 All other materials: ISO/TS 16189
UV stabilizers	2-Benzotriazol-2-yl-4,6-di-tert-butylphenol (UV 320), 2,4-Di-tert-butyl-6-(5-chlorobenzotriazol-2-yl) phenol (UV 327), 2-(2H-Benzotriazol-2-yl)-4,6-di-tert-penthylphenol (UV 328), and 2-(2H-Benzotriazol-2-yl)-4-(tert-butyl)-6-(sec-butyl)phenol (UV 350)	EN 62321-6; extraction in THF, analysis by GC/MS)
Volatile organic compounds (VOCs)	See Table 8.21(k)	GC/MS headspace for 45 minutes at 120°C (248°F)

9.10.2.3.4 The selected samples shall be taken in the same way from each source material or component so that they are as identical as possible in representing the specific material or component.

9.10.2.4 Specimens.

9.10.2.4.1 A minimum of three specimens taken from separate unique lots for each applicable material or component shall be evaluated.

9.10.2.4.2 Each specimen shall represent all parts, layers, or attributes of the applicable material or component being tested.

9.10.2.5* Procedure. Total fluorine shall be measured in accordance with ASTM D7359, *Standard Test Method for Total Fluorine, Chlorine, and Sulfur in Aromatic Hydrocarbons and Their Mixtures by Oxidative Pyrohydrolytic Combustion followed by Ion Chromatography Detection (Combustion Ion Chromatography–CIC)*, or an equivalent method for total fluorine by ion chromatography, with the following modifications:

(1) Only total fluorine shall be measured.
(2) The total fluorine measurement shall be reported in ppm.

9.10.2.6 Report.

9.10.2.6.1 The total fluorine measurements for each specimen of each tested material and component shall be reported.

9.10.2.6.2 The average total fluorine measurement of all specimens shall be reported.

9.10.2.6.3 A separate laboratory report shall be prepared on the total fluorine results of all applicable materials and components specific to the protective element for which the product label claim in 6.1.7.5 is being made.

9.10.2.6.4 The laboratory report shall include the following information:

(1) The name and address of the laboratory.
(2) The specific procedures used for the measurement of total fluorine.
(3) The specific laboratory quality control procedures used in the measurement of total fluorine.
(4) The individual specimen and average total fluorine results for each evaluated material and component of the subject protective element.
(5) An indication of the material or component that has the highest reported average total fluorine measurement.

9.10.2.7 Interpretation. The total fluorine concentration to be used as the basis of permitting the optional product label claim in 6.1.7.5 shall be the highest reported average total fluorine measurement of any materials or components that are evaluated for the respective protective element.

9.11* Liquid Barrier Performance Test.

9.11.1 Application. This test method shall apply to garment moisture barrier materials and moisture barrier seams and bootie moisture barrier materials and moisture barrier seams, where present.

9.11.2 Samples.

9.11.2.1 Samples for conditioning shall be at least 380 mm (15 in.) square and shall consist of a composite constructed using a layer of 7.5 oz/yd^2 woven 93 percent meta-aramid, 5 percent para-aramid, 2 percent antistat fiber with a nonfluorinated finish, the moisture barrier, and a layer of 7.8 oz/yd^2 ± 0.3 oz/yd^2 thermal barrier consisting of a woven plain weave face cloth quilted to two layers of aramid nonwoven. Where the sample includes the seam, the moisture barrier layer shall be constructed with a straight center seam that extends across the entire 380 mm (15 in.) width of the specimen. The three-layer composite shall be stitched around the entire periphery.

9.11.2.2 A minimum of six samples for each moisture barrier material and a minimum of six samples for each moisture barrier seam shall be prepared.

9.11.2.3 Moisture barrier material and moisture barrier seam specimens shall be tested after being twice subjected to the following conditioning process:

(1) Specimens shall be subjected to the procedure specified in 9.1.2.
(2) Specimens shall be conditioned as specified in 9.1.3.
(3) Specimens shall be conditioned as specified in 9.1.5.
(4) Specimens shall be conditioned at a temperature of 21°C ± 3°C (70°F ± 5°F) and at a relative humidity of 65 percent ± 5 percent for at least 4 hours.

9.11.2.4 The moisture barrier material layer or moisture barrier seam layer shall be removed from the sample after the conditioning and used for creating the specimen evaluated in each specified evaluation technique in this test method.

9.11.3 Specimens.

9.11.3.1 A minimum of three specimens shall be tested for each moisture barrier material and for each evaluation technique, including hydrostatic pressure water resistance and impact penetration water resistance.

9.11.3.2 A minimum of three specimens shall be tested for each moisture barrier seam and for each evaluation type, including hydrostatic pressure water resistance and impact penetration water resistance.

9.11.4 Procedure. Hydrostatic penetration water resistance and impact penetration water resistance shall be measured according to the test procedures found in Section 5 of AAMI PB70, *Liquid barrier performance and classification of protective apparel and drapes intended for use in health care facilities*, with the following modifications:

(1) The specified sampling plan shall not be followed.
(2) Three specimens shall be tested for each evaluation technique and each type of sample.
(3) AATCC TM42, *Test Method for Water Resistance: Impact Penetration Test*, shall be used.
(4) AATCC TM127, *Test Method for Water Resistance: Hydrostatic Pressure Test*, shall be used.

9.11.5 Report.

9.11.5.1 The impact penetration water resistance test result for each specimen shall be recorded and reported.

9.11.5.2 The failing hydrostatic pressure test result for each specimen shall be recorded and reported.

9.11.6 Interpretation.

9.11.6.1 The pass or fail performance of the material or seam sample for impact penetration water resistance shall be based on the highest test result relative to the Level 3 acceptance criteria in AAMI PB70, *Liquid barrier performance and classification of protective apparel and drapes intended for use in health care facilities.*

9.11.6.2 The pass or fail performance of the material or seam sample for hydrostatic pressure water resistance shall be based on the lowest test result relative to the Level 3 acceptance criteria in AAMI PB70, *Liquid barrier performance and classification of protective apparel and drapes intended for use in health care facilities.*

9.11.6.3 Moisture barriers and moisture barrier seams shall only meet the Level 3 acceptance criteria in AAMI PB70, *Liquid barrier performance and classification of protective apparel and drapes intended for use in health care facilities*, when the results of both material and seams meet the passing requirements of both evaluation techniques.

Chapter 10 Certification (NFPA 1975)

10.1 Administration.

10.1.1 Scope.

10.1.1.1 Chapters 10 through 14 of this standard shall specify requirements for the design, performance, testing, and certification of nonprimary protective work apparel and the individual garments comprising work apparel.

10.1.1.2* Work apparel garments shall not include socks, dress uniforms, and specific types of undergarments including briefs, boxer shorts, boxer briefs, and bras.

10.1.1.3 Chapters 10 through 14 of this standard shall also specify requirements for the thermal stability of textiles used in the construction of work apparel.

10.1.1.4* Chapters 10 through 14 of this standard shall also specify optional requirements for flame resistance, water resistance, and insect repellency where such options are specified or claimed to be used in construction of work apparel.

10.1.1.5* Chapters 10 through 14 of this standard shall not specify requirements for clothing that is intended to provide primary protection from given hazard exposures.

10.1.1.6* Certification of work apparel to the requirements of this standard shall not preclude certification to additional applicable standards for primary protective clothing where the clothing meets all requirements of each standard.

10.1.1.7 Chapters 10 through 14 of this standard shall not be construed as addressing all of the safety concerns associated with the use of compliant work apparel garments for their personnel. It shall be the responsibility of the persons and organizations that use compliant work apparel garments to establish safety and health practices and determine the applicability of regulatory limitations prior to use.

10.1.1.8 Chapters 10 through 14 of this standard shall not be construed as addressing all of the safety concerns, if any, associated with the use of Chapters 10 through 14 by testing facilities. It shall be the responsibility of the persons and organizations that use Chapters 10 through 14 to conduct testing of work apparel garments to establish safety and health practices and determine the applicability of regulatory limitations prior to using this standard for any designing, manufacturing, and testing.

10.1.1.9* Chapters 10 through 14 of this standard shall not specify requirements for any accessories that could be attached to the certified product but are not necessary for the certified product to meet the requirements of Chapters 10 through 14.

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

10.1.2 Purpose.

10.1.2.1 The purpose of Chapters 10 through 14 of this standard shall be to provide emergency services personnel with work apparel that will not contribute to burn injury severity.

10.1.2.1.1 To achieve this purpose, Chapters 10 through 14 of this standard shall establish minimum requirements for thermally stable textiles that will not rapidly deteriorate, melt, shrink, or adhere to the wearer's skin, causing greater, more severe burn injuries.

10.1.2.1.2 Chapters 10 through 14 of this standard shall also provide optional flame resistance requirements and tests to verify the flame resistance of textiles where the authority having jurisdiction specifies the use of flame resistance textiles for the construction of work apparel, or where the manufacturer represents work apparel textiles as flame resistant.

10.1.2.1.3 Chapters 10 through 14 of this standard shall also provide optional liquid resistance requirements and tests to verify the liquid resistance of textiles where the authority having jurisdiction specifies the use of liquid-resistant textiles for the construction of work apparel, or where the manufacturer represents work apparel textiles as having liquid-resistant properties.

10.1.2.1.4 Chapters 10 through 14 of this standard shall also provide optional insect repellency requirements and tests to verify the insect repellency of textiles where the authority having jurisdiction specifies the use of insect-repellent textiles for the construction of work apparel, or where the manufacturer represents work apparel textiles as having insect-repellent properties.

10.1.2.2* Controlled laboratory tests used to determine compliance with the performance requirements of Chapters 10 through 14 of this standard shall not be deemed as establishing performance levels for all situations to which emergency services personnel might be exposed.

10.1.2.3* Chapters 10 through 14 of this standard shall not be intended to serve as a detailed manufacturing or purchasing specification but shall be permitted to be referenced in purchase specifications as minimum requirements.

10.1.3 Application.

10.1.3.1 Chapters 10 through 14 of this standard shall apply to the designing, manufacturing, testing, and certification of new work apparel and the individual garments comprising work apparel.

10.1.3.2 Chapters 10 through 14 of this standard shall apply to nonprimary protective garments that comprise work apparel.

10.1.3.3 Chapters 10 through 14 of this standard alone shall not apply to clothing that is intended to provide primary protection from given hazard exposures. *(See A.10.1.1.5.)*

10.1.3.4 This edition of NFPA 1970 shall not apply to any work apparel manufactured to previous editions of NFPA 1975.

10.1.3.5 Chapters 10 through 14 of this standard shall not apply to any work apparel manufactured to the requirements of any other organization's standards.

10.1.3.6* Chapters 10 through 14 of this standard shall not apply to the use of work apparel.

10.1.3.7 Chapters 10 through 14 of this standard shall not apply to any accessories that could be attached to the certified product, before or after purchase, but are not necessary for the certified product to meet the requirements of Chapters 10 through 14. *(See A.10.1.1.9.)*

10.1.4 Units.

10.1.4.1 In Chapters 10 through 14 of this standard, values for measurement are followed by an equivalent in parentheses, but only the first stated value shall be regarded as the requirement.

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

10.2 General.

10.2.1 The process of certification for work apparel as being compliant with Chapters 10 through 14 of this standard shall meet the requirements of Sections 4.1 through 4.9.

10.2.2 All compliant work apparel garments that are labeled as being compliant with Chapters 10 through 14 of this standard shall meet or exceed all applicable requirements specified in Chapters 10 through 14 and shall be certified.

10.2.3 The certification organization shall not issue any new certifications based on the 2019 edition of NFPA 1975 after the NFPA effective date of the 2025 edition of NFPA 1970.

10.2.4 The certification organization shall not permit any manufacturer to continue to label any products that are certified as compliant with the 2019 edition of NFPA 1975 on the effective date of the 2025 edition of NFPA 1970, plus 12 months.

10.2.5 The certification organization shall require manufacturers to remove all certification labels and product labels indicating compliance with the 2019 edition of NFPA 1975 from all products that are under the control of the manufacturer on the effective date of the 2025 edition of NFPA 1970, plus 12 months, and the certification organization shall verify that this action is taken.

10.2.6 Where work apparel garments are manufactured with flame-resistant textiles, the entire garment shall be certified as compliant with the requirements of Section 13.2 in addition to all other requirements of Sections 4.1 through 4.9 and Chapters 10 through 14 of this standard.

10.2.6.1 Where work apparel is manufactured with water-resistant textiles, the entire garment shall be certified as compliant with the requirements of Section 13.3 in addition to all other requirements of Sections 4.1 through 4.9 and Chapters 10 through 14 of this standard.

10.2.6.2 Where work apparel is manufactured with insect repellent, the entire garment shall be certified as compliant with the requirements of Section 13.4 in addition to all other requirements of Sections 4.1 through 4.9 and Chapters 10 through 14 of this standard.

10.3 Inspection and Testing.

10.3.1 Testing to determine product compliance with the performance requirements specified in Chapter 13 shall be conducted by the certification organization in accordance with the specified testing requirements of Chapter 14.

10.3.1.1 Testing shall be performed on specimens representative of materials and components used in the actual construction of the protective ensemble and ensemble element.

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

10.3.2 The certification organization shall only accept from the manufacturer, for evaluation and testing for certification, product or product components that are the same in every respect as the actual final product or product component.

10.3.3 The certification organization shall not allow any modifications, pretreatment, conditioning, or other such special processes of the product or any product component prior to the product's submission for evaluation and testing by the certification organization.

10.3.4 The certification organization shall not allow the substitution, repair, or modification, other than as specifically permitted herein, of any product or any product component during testing.

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

10.3.6 The certification organization shall test ensemble elements with the specific ensemble(s) with which they are to be certified.

10.3.7 Any change in the design, construction, or material of a compliant product shall necessitate new inspection and testing to verify compliance to all applicable requirements of this standard that the certification organization determines can be affected by such change. This annual verification shall be conducted before labeling the modified product as being compliant with this standard.

10.3.8 The manufacturer shall maintain all design and performance inspection and test data from the certification organization used in the certification of the manufacturer's compliant product. The manufacturer shall provide such data, upon request, to the purchaser or authority having jurisdiction.

10.4 Annual verification.

10.4.1 The annual verification shall include the following:

(1) Inspection and evaluation to all design requirements as required by this standard on all manufacturer models and components
(2) Testing to all performance requirements as required by this standard on all manufacturer models and components with the following protocol:
    (a) Where a test method incorporates testing both before and after laundering preconditioning specified in 14.1.3 and 14.1.4 and the test generates quantitative results, annual verification testing shall be limited to the conditioning that yielded the worst-case test result during the initial certification for the model or component.
    (b) Where a test method incorporates testing both before and after laundering preconditioning specified in 14.1.3 and 14.1.4 and the test generates nonquantitative results such as pass/fail for melt/drip, annual verification shall be limited to a single conditioning procedure in any given year. Subsequent annual verifications shall cycle through the remaining conditioning procedures to ensure that all required conditionings are included over time.
    (c) Where a test method requires the testing of three specimens, a minimum of one specimen shall be tested for annual verification.
    (d) Where a test method requires the testing of five or more specimens, a minimum of two specimens shall be tested for annual verification.

10.4.2 Any change that affects the work apparel clothing item's performance under the design or performance requirements of this standard shall constitute a different model.

10.4.3 For this standard, models shall include each unique pattern, style, or design of the individual work apparel clothing item.

10.4.4 Samples of manufacturer models and components for annual verification shall be acquired as part of the follow-up program in accordance with 4.2.9 and shall be permitted to be used toward annual verification.

10.4.5 The manufacturer shall maintain all design and performance inspection and test data from the certification organization used in the annual verification of manufacturer models and components.

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

Chapter 11 Labeling and Information (NFPA 1975)

11.1 Product Labeling Requirements.

11.1.1 Work apparel shall have a product label or labels permanently and conspicuously attached to it. *(See A.6.1.1.)*

11.1.1.1 The required label shall be permitted to be printed directly on the compliant product.

11.1.1.2 Recognized components shall have identifiable markings either on the product itself, or on the smallest unit packaging.

11.1.2 Multiple label pieces shall be permitted if necessary to carry all statements and information required to be on the product label.

11.1.3 The certification organization's label, symbol, or identifying mark shall be permanently attached to the product label or shall be part of the product label.

11.1.3.1 Where the product is being labeled is a recognized component, the certification organization's label, symbol, or identifying mark shall be distinct from the certification organization's label, symbol, or identifying mark being used on compliant work apparel.

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

11.1.5 Where work apparel is certified as compliant with only the mandatory base requirements of this standard, the following statement shall be printed on the product label. All letters shall be at least 2.5 mm ($\frac{3}{32}$ in.) high.

THIS GARMENT MEETS THE BASE REQUIREMENTS OF NFPA 1975, INCORPORATED INTO THE 2025 EDITION OF NFPA 1970.

DO NOT REMOVE THIS LABEL.

11.1.6 Where work apparel is certified as compliant with the mandatory base requirements of this standard and certified as compliant with one or more of the optional requirements of this standard, the statement in 11.1.5 shall be printed on the product label. The label shall also indicate the applicable optional requirement(s) by either the symbol or statement as identified in Table 11.1.6. Where the symbol is used to identify compliance with the optional requirement(s), the statement shall be included in the user information to explain that symbol. All letters shall be at least 2.5 mm ($\frac{3}{32}$ in.) high.

11.1.7 The following information contained in Table 11.1.7 shall be printed on the product label or printed directly on the product, or product packaging, where permissible. All letters shall be at least 1.6 mm ($\frac{1}{16}$ in.) high.

11.1.8 Symbols and other pictorial graphic representations shall be permitted to be used in place of worded statements on the product labels where explanations for symbols and pictorial graphic representations are explained in the user information.

11.1.9 Additional Product Label Requirements for Work Apparel Containing Electrical Circuitry.

11.1.9.1* Nonincendive Equipment and Systems. The following additional compliance statement shall be printed on the product label for work apparel containing electrical circuitry that complies with 12.3.3. All product label letters and figures shall be at least 2.5 mm ($\frac{3}{32}$ in.) in height.

THIS GARMENT CONTAINS ELECTRICAL CIRCUITRY MEETING THE REQUIREMENTS OF UL 121201, 2017, FOR CLASS I & II, DIVISION 2, GROUPS C, D, F, G, AND CLASS III, (insert temperature class).

DO NOT REMOVE THIS LABEL.

11.1.9.2* Intrinsically Safe Apparatus and Systems. The following additional compliance statement shall be printed on the product label for work apparel containing electrical circui-

Table 11.1.6 Label Symbols for Work Apparel

Optional Requirement	Compliance Statement	Symbol
13.2 Optional Requirements for Flame-Resistant Work Apparel	THIS GARMENT MEETS THE OPTIONAL FLAME RESISTANCE REQUIREMENTS OF NFPA 1970 (1975), 2025.	$\boxed{\text{FR}}$
13.3 Optional Requirements for Water-Resistant Work Apparel	THIS GARMENT MEETS THE OPTIONAL WATER RESISTANCE REQUIREMENTS OF NFPA 1970 (1975), 2025.	$\boxed{\text{WR}}$
13.4 Optional Requirements for Insect-Repellent Work Apparel	THIS GARMENT MEETS THE OPTIONAL INSECT-REPELLENT REQUIREMENTS OF NFPA 1970 (1975), 2025.	$\boxed{\text{IR}}$

Table 11.1.7 Information Required to Be Present on Product Labeling

Labeling Item	Work Apparel	Components
(1) Manufacturer's name	X	X
(2) Manufacturer's garment or component identification number, lot number, or serial number	X	X
(3) Country of manufacture	X	X
(4) Model name, number, or design	X	X
(5) Date of manufacture	X	X
(6) Size	X	
(7) Cleaning and drying instructions, including applicable warnings regarding detergents, soaps, cleaning additives, and bleaches	X	
(8) Fiber content and composition or component material description	X	X

try that complies with 12.3.3. All product label letters and figures shall be at least 2.5 mm ($\frac{3}{32}$ in.) in height.

THIS GARMENT CONTAINS ELECTRICAL CIRCUITRY MEETING THE REQUIREMENTS OF UL 913, SIXTH EDITION, FOR CLASS I & II, DIVISION 1, GROUPS C, D, E, F, G, AND CLASS III, (insert temperature class).

DO NOT REMOVE THIS LABEL.

11.2 User Information.

11.2.1 The manufacturer shall provide user information including, but not limited to, warnings, information, and instructions with each work apparel garment.

11.2.2* The manufacturer shall attach the required user information, or packaging containing the user information, to the work apparel garment in such a manner that it is not possible to use the garment without being aware of the availability of the information.

11.2.3 The required user information, or packaging containing the user information, shall be attached to the work apparel garment so that a deliberate action is necessary to remove it.

11.2.4 The manufacturer shall provide notice that the user information is to be removed only by the end user.

11.2.5 Symbols and other pictorial graphic representations shall be permitted to be used to supplement worded statements or in place of worded statements in the user information where explanations for symbols and pictorial graphic representations are explained in the user information.

11.2.6 The manufacturer shall provide at least the following instructions and information with each work apparel garment:

(1) Pre-use information as follows:
   (a) Manufacturer's name and address
   (b) Safety considerations
   (c) Garment marking recommendations and restrictions
   (d) A statement that most performance properties of the garment cannot be tested by the user in the field
   (e) Warranty information

(2) Inspection frequency and details

(3)* Maintenance information as follows:
   (a) Cleaning instructions
   (b) Methods of repair where applicable
   (c) Decontamination procedures for both chemical and biological contamination

(4) Retirement and disposal criteria and consideration

Chapter 12 Design Requirements (NFPA 1975)

12.1 General.

12.1.1 Work apparel shall have at least the applicable design requirements specified in this section when inspected by the certification organization as specified in Section 4.3, Inspection and Testing.

12.1.2 All work apparel hardware shall be examined and shall be free of rough spots, burrs, or sharp edges.

12.1.3 Any metal findings of work apparel shall not come into direct contact with the wearer's body.

12.1.4 Where work apparel garments are constructed from flame-resistant textiles, the garments shall be stitched with thread of an inherently flame-resistant fiber.

12.1.5* Aftermarket products applied to apparel shall not be utilized to meet any performance requirements of this standard.

12.2 Configuration.

12.2.1 Work apparel designed for the upper torso shall be permitted to be configured as follows:

(1) Shirt, with collar, full-length front opening, either long sleeve or short sleeve
(2) Polo or golf-style shirt, with collar, pullover with partial front opening, either long sleeve or short sleeve
(3) Tee shirt, pullover without front opening, without collar, either long sleeve or short sleeve *(See A.10.1.1.2.)*
(4) Sweatshirt, pullover, with or without collar, either long sleeve or short sleeve
(5) Jacket, with or without collar, with full front opening and long sleeves

12.2.2 Work apparel garments designed for the lower torso shall be permitted to be configured as follows:

(1) Pants, extending from the waist to the ankles
(2) Shorts, extending from the waist to a point at or above the knee

12.3* Design Requirements for Electrical Circuitry.

12.3.1 General. Work apparel involving electrical circuitry shall only use circuitry that meets the requirements of this standard for one of the following types of explosion protection:

(1) Nonincendive equipment, stand-alone type (i.e., individual pieces of equipment separately certified for Class I and II, Division 2 and Class III applications, without any external electrical interconnection means, and intended for stand-alone use)
(2) Nonincendive equipment, electrically interconnected type (i.e., individual pieces of equipment separately certified for Class I and II, Division 2 and Class III applications, with external electrical interconnection means involving plugs and jacks, and intended for electrical interconnection to other separately certified nonincendive equipment, electrically interconnected types)
(3) Nonincendive system (i.e., multiple pieces of nonincendive equipment certified together for Class I and II, Division 2 and Class III applications, with electrical interconnection means, and intended for dedicated system use)
(4) Intrinsically safe apparatus, stand-alone type (i.e., individual pieces of apparatus separately certified for Class I and II, Division 1 and Class III applications, without any external electrical interconnection means, and intended for stand-alone use)
(5) Intrinsically safe system (i.e., multiple pieces of intrinsically safe apparatus certified together for Class I and II, Division 1 and Class III applications, with electrical interconnection means, and intended for dedicated system use)

12.3.1.1* Passive electrical circuitry that relies on a supplemental device to energize it shall be exempt from explosion protection if the requirement in 12.3.1.2 is met.

12.3.1.2 The instructions supplied with work apparel involving passive electrical circuitry shall indicate that the supplemental device used to energize the circuitry shall not be used or stored in a hazardous location.

12.3.2 Nonincendive Equipment and Systems.

12.3.2.1* General. Electrical circuitry contained within work apparel shall, at a minimum, be suitable for use in Class I, Division 2, Groups C and D; Class II, Division 2, Groups F and G; and Class III, Divisions 1 and 2 hazardous (classified) locations, with a temperature class within the range of T3 through T6 inclusive, in accordance with UL 121201, *Nonincendive Electrical Equipment for Use in Class I and II, Division 2 and Class III, Divisions 1 and 2 Hazardous (Classified) Locations*.

12.3.2.2 Interconnection of Nonincendive Equipment, Electrically Interconnected Types.

12.3.2.2.1 Interconnection of electrical circuits that are separately certified as nonincendive equipment, electrically interconnected types, shall occur by means of a plug and jack that comply with the device connector requirements specified in Section 6.10 of NFPA 1802.

12.3.2.2.2 The electrical parameters for interconnection shall comply with Table 12.3.2.2.2.

12.3.2.2.3 The instructions supplied with the work apparel shall identify the circuits as nonincendive equipment, electrically interconnected types, and indicate the ability to interconnect the circuitry with any other circuitry also identified as nonincendive equipment, electrically interconnected types, in accordance with this standard.

Table 12.3.2.2.2 Electrical Parameters for Interconnection of Separately Certified Nonincendive Equipment, Electrically Interconnected Types

Device Connector as Source	Required Relationship	Device Connector as Sink
$U_o \leq 8$ V	$U_o \leq U_i$	$U_i \geq 10$ V
$I_o \leq 500$ mA	$I_o \leq I_i$	$I_i \geq 1$ A
$C_o \geq 69$ μF	$C_o \geq C_i + C_{cable}$*	$C_i \leq 68$ μF
$L_o \geq 320$ μH	$L_o \geq L_i + L_{cable}$*	$L_i \leq 315$ μH

*Assumption for cable capacitance (Ccable) and cable inductance (Lcable): 200 pF/m and 1 μH/m.

12.3.2.3 Interconnection of Nonincendive Systems.

12.3.2.3.1 Electrical circuits that are certified as part of a nonincendive system shall only be interconnected with other electrical circuits also certified as part of the same nonincendive system.

12.3.2.3.2 The instructions supplied with the work apparel shall identify the circuits as part of a nonincendive system and indicate the other circuits that comprise the nonincendive system in accordance with this standard.

12.3.3 Intrinsically Safe Apparatus and Systems.

12.3.3.1* Electrical circuitry contained within work apparel shall be permitted to be certified at a minimum for use in Class I, Division 1, Groups C and D; Class II, Division 1, Groups E, F, and G; and Class III, Divisions 1 and 2 hazardous locations, with a temperature class within the range of T3 through T6 inclusive, in accordance with UL 913, *Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, and III, Division 1 Hazardous (Classified) Locations*.

12.3.3.2 Interconnection of Intrinsically Safe Systems.

12.3.3.2.1 Electrical circuits that are certified as part of an intrinsically safe system shall only be interconnected with other electrical circuits certified as part of the same intrinsically safe system.

12.3.3.2.2 The instructions supplied with the work apparel shall identify the circuits as part of an intrinsically safe system and indicate the other circuits that comprise the intrinsically safe system in accordance with this standard.

Chapter 13 Performance Requirements (NFPA 1975)

13.1 Base Requirements for Work Apparel.

13.1.1 Heat and Thermal Shrinkage Resistance.

13.1.1.1 Textile fabrics, excluding interlinings, shall be tested individually for heat resistance as specified in Section 14.2, and shall not melt, drip, separate, or ignite, and shall not shrink more than 10 percent in any direction. Where the optional stretching frame is specified to be used for testing knits, fabrics shall be able to be stretched to their original dimensions and remain intact.

13.1.1.2 Findings and visibility markings — excluding labels and excluding emblems, collar stays, elastic, and hook-and-pile fasteners placed where they will not come into direct contact with the body — shall be tested individually for heat resistance as specified in Section 14.2, and shall not melt, drip, separate, or ignite.

13.1.2 Thermal Stability.

13.1.2.1 Textile fabrics, excluding interlinings, shall be tested individually for thermal stability as specified in Section 14.3, and shall not melt, ignite, or stick to the glass plates and shall have a rating of resistance to blocking of 1 or 2.

13.1.2.2 All thread utilized in work apparel shall be tested for heat resistance as specified in Section 14.7, and shall not melt at or below 260°C (500°F).

13.1.3 Seam Strength.

13.1.3.1 Garment major seams shall be tested for seam strength as specified in Section 14.4, and shall have a minimum breaking strength of 133 N (30 lb) for either thread or fabric.

13.1.3.2 Seam strength shall be considered acceptable where the fabric strength is less than the required seam strength specified in 13.1.3.1, provided the fabric fails without seam failure below the applicable forces specified in 13.1.3.1.

13.1.4 Product Label Printing Durability. Product labels shall be tested for printing durability as specified in Section 14.5, and shall be legible.

13.2* Optional Requirements for Flame-Resistant Work Apparel.

13.2.1 Where work apparel is represented as being flame resistant, it shall also meet the requirements of Section 13.1.

13.2.2 Where work apparel is represented as being flame resistant, textile fabrics and visibility markings excluding interlinings, emblems, labels, elastic, hook and pile fasteners, and closure tape, shall be tested individually for flame resistance as specified in Section 14.6, and shall have an average char length of not more than 150 mm (6 in.), shall have an average afterflame of not more than 2 seconds, and shall not melt or drip. *(See Section C.5.)*

13.2.3 Where work apparel is represented as being flame resistant, visibility markings and small textile items, excluding interlinings, emblems, labels, elastic, hook and pile fasteners, and closure tape, that are not large enough to meet the specimen requirements specified in 14.6.3.1 shall be tested for flame resistance as specified in Section 14.6, and shall not be totally consumed, shall not have afterflame of more than 2 seconds, and shall not melt or drip.

13.3* Optional Requirements for Water-Resistant Work Apparel.

13.3.1 Where work apparel is represented as being water resistant it shall also meet the requirements of Section 13.1.

13.3.2 Where work apparel is represented as being water resistant, textile fabrics, excluding visibility markings, emblems, labels, elastic, hook and pile fasteners, and closure tape, shall be tested as specified in Section 14.8, and shall have a water absorption of 15 percent or less.

13.4* Optional Requirements for Insect-Repellent Work Apparel.

13.4.1 Where work apparel is represented as being insect repellent it shall also meet the requirements of Section 13.1.

13.4.2 Where work apparel is represented as having insect-repellent properties, textile fabrics, excluding interlinings and reinforcements, shall be tested for insect repellency as specified in Section 14.9 and shall have a permethrin level of 25 ppm to 135 ppm (0.025 mg/cm^2 to 0.135 mg/cm^2).

13.4.3 Where work apparel is represented as having insect-repellent properties as specified in Section 13.4 and is also represented as having flame-resistant properties as specified in Section 13.2, textile fabrics, excluding interlinings, emblems, labels, elastic, hook and pile fasteners, and closure tape, shall be individually retested after treatment for insect repellency for flame resistance as specified in Section 14.6 and shall have an average char length of not more than 150 mm (6 in.), shall have an average afterflame time of not more than 2 seconds, and shall not melt or drip.

Chapter 14 Test Methods (NFPA 1975)

14.1 Sample Preparation Procedures.

14.1.1 Application.

14.1.1.1 The sample preparation procedures contained in Section 14.1 shall apply to each test method in this chapter, as specifically referenced in the sample preparation section of each test method.

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

14.1.2 Room Temperature Conditioning Procedure.

14.1.2.1 Specimens shall be conditioned at a temperature of 21°C, ±3°C (70°F, ±5°F) and a relative humidity of 65 percent, ±5 percent, until equilibrium is reached, as determined in accordance with ASTM D1776/D1776M, *Standard Practice for Conditioning and Testing Textiles*, or for at least 24 hours, whichever is shortest.

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

14.1.3 Washing and Drying Procedure.

14.1.3.1 Specimens shall be subjected to 25 cycles of washing and drying in accordance with the procedure specified in AATCC LP1, *Home Laundering: Machine Washing*, using Machine Cycle 1, Wash Temperature V, and Drying Procedure Ai.

14.1.3.2 Flame-resistant textiles being tested to the Flame Resistance Test as specified in Section 14.6 shall be subjected to 100 cycles of washing and drying in accordance with the procedure specified in AATCC LP1, *Home Laundering: Machine Washing*, using Machine Cycle 1, Wash Temperature V, and Drying Procedure Ai.

14.1.3.3 A 1.8 kg, ±0.1 kg (4 lb, ±0.2 lb) load shall be used.

14.1.3.4 A laundry bag shall not be used.

14.1.4 Commercial Dry-Cleaning Procedure.

14.1.4.1 Specimens shall be subjected to 25 cycles of dry cleaning as specified in the procedures of Sections 9.2 and 9.3 of AATCC TM158, *Test Method for Dimensional Changes on Drycleaning in Perchloroethylene: Machine Method.*

14.1.4.2 Flame-resistant textiles being tested to the Flame Resistance Test as specified in Section 14.6 shall be subjected to 100 cycles of dry cleaning as specified in the procedures of Sections 9.2 and 9.3 of AATCC TM158, *Test Method for Dimensional Changes on Drycleaning in Perchloroethylene: Machine Method.*

14.2 Heat and Thermal Shrinkage Resistance Test.

14.2.1 Application.

14.2.1.1 This test method shall apply to textiles, visibility markings, and findings.

14.2.1.2 Modifications to this test method for testing woven and nonwoven textiles shall be as specified in 14.2.8.

14.2.1.3 Modifications to this test method for visibility markings and findings shall be as specified in 14.2.9.

14.2.1.4 Modifications to this test method for testing knits shall be as specified in 14.2.10.

14.2.2 Samples.

14.2.2.1 Samples for preconditioning shall be a 1 m (1 yd) square of textile.

14.2.2.2 If the manufacturer designates that the garments are to be washed, separate samples shall be preconditioned according to 14.1.3.1.

14.2.2.3 If the manufacturer designates that the garments are to be dry cleaned, separate samples shall be preconditioned according to 14.1.4.1.

14.2.3 Specimens.

14.2.3.1 Heat resistance testing shall be conducted on a minimum of three specimens according to 14.2.9.

14.2.3.2 Thermal shrinkage resistance testing shall be conducted on a minimum of three specimens for textile fabrics according to 14.2.8 or 14.2.10, as applicable.

14.2.3.3 Specimens shall be tested both before and after the preconditioning specified in either 14.2.2.2 or 14.2.2.3.

14.2.3.4 All specimens shall be conditioned as specified in 14.1.2 prior to testing.

14.2.4 Apparatus. The test oven shall be as specified in ASTM F2894, *Standard Test Method for Evaluation of Materials, Protective Clothing, and Equipment for Heat Resistance Using a Hot Air Circulating Oven.*

14.2.5 Procedure. Testing shall be performed in accordance with ASTM F2894, *Standard Test Method for Evaluation of Materials, Protective Clothing, and Equipment for Heat Resistance Using a Hot Air Circulating Oven*, using the following parameters:

(1) The test temperature shall be 260°C, +6/−0°C (500°F, +10/−0°F).
(2) The optional stretching frame shall be used, as specified in 14.2.10.5 and 14.2.10.6, to evaluate knit materials, where specified by the fabric manufacturer.

14.2.6 Report.

14.2.6.1 Observations of ignition, melting, dripping, or separation for each specimen shall be recorded and reported.

14.2.6.2 The percent change in the width and length dimensions of each textile specimen shall be calculated and recorded.

14.2.6.3 Results shall be reported as the average of all three specimens in each direction.

14.2.7 Interpretation.

14.2.7.1 Any evidence of ignition, melting, dripping, or separation on any specimen shall constitute failing performance.

14.2.7.2 The average percent shrinkage change in each direction shall be used to determine pass/fail.

14.2.7.3 Failure in any one direction shall constitute failure for the entire sample.

14.2.8 Specific Requirements for Thermal Shrinkage Testing of Woven and Nonwoven Textiles.

14.2.8.1 Each specimen shall be 380 mm × 380 mm, ±13 mm (15 in. × 15 in., ±½ in.).

14.2.8.2 Testing shall be performed as specified in 14.2.2 through 14.2.7.

14.2.8.3 Observations of ignition, melting, dripping, or separation shall be recorded and reported.

14.2.8.4 Five minutes after the specified exposure, and prior to measuring shrinkage, woven and nonwoven textile specimens shall be restored to their original state by manually flattening any curling or rippling that resulted from the specified exposure.

14.2.9 Specific Requirements for Testing Findings and Visibility Markings.

14.2.9.1 Findings and visibility marking specimens shall be in the center of 150 mm × 150 mm, ±13 mm (6 in. × 6 in., ±½ in.) pieces of the garment textile.

14.2.9.1.1 Hardware shall be affixed in a fashion representative of their use in the finished product.

14.2.9.2 Testing shall be performed as specified in 14.2.2 through 14.2.7.

14.2.9.3 Thermal shrinkage shall not be measured.

14.2.10 Specific Requirements for Testing of Knits.

14.2.10.1 Each specimen shall be 380 mm × 380 mm ±13 mm, (15 in. × 15 in., ±½ in).

14.2.10.2 Testing shall be performed as specified in 14.2.2 through 14.2.7.

14.2.10.3 Observations of ignition, melting, dripping, or separation for each specimen shall be recorded and reported.

14.2.10.4 Any evidence of ignition, melting, dripping, or separation for each specimen shall be recorded and reported.

14.2.10.5 Where the use of the optional stretching frame is specified by the fabric manufacturer, 5 minutes after the specified exposure, knit textiles shall be pulled in such a way as to return the benchmarks to their original dimensions and held for 10 minutes, followed by a 10-minute relaxation prior to measuring shrinkage.

14.2.10.5.1 The surface for specimen relaxation shall be a smooth, flat, horizontal surface that is free from imperfections that could snag the specimen or impede relaxation.

14.2.10.6 Where the optional stretching frame is specified to be used, and fabrics exhibit breaking or inability to be stretched to the original dimensions, this result shall constitute failure.

14.3 Thermal Stability Test.

14.3.1 Application. This test method shall apply to textiles.

14.3.2 Samples.

14.3.2.1 Samples for preconditioning shall be a 1 m (1 yd) square of textile.

14.3.2.1.1 Where a 1 m square of textile cannot be obtained, the samples for preconditioning shall be a minimum of the size to be tested.

14.3.2.2 If the manufacturer designates that the garments are to be washed, separate samples shall be preconditioned according to 14.1.3.1.

14.3.2.3 If the manufacturer designates that the garments are to be dry cleaned, separate samples shall be preconditioned according to 14.1.4.1.

14.3.3 Specimens.

14.3.3.1 Thermal stability testing shall be conducted on a minimum of three specimens for each textile.

14.3.3.2 Specimens shall be cut from the preconditioned sample.

14.3.3.3 Specimens shall be tested after the preconditioning specified in either 14.3.2.2 or 14.3.2.3.

14.3.3.4 All specimens shall be conditioned as specified in 14.1.2 prior to testing.

14.3.4 Apparatus.

14.3.4.1 The test oven shall be as specified in ASTM F2894, *Standard Test Method for Evaluation of Materials, Protective Clothing, and Equipment for Heat Resistance Using a Hot Air Circulating Oven.*

14.3.4.2 Clean borosilicate or soda lime glass plates measuring 100 mm × 100 mm × 3 mm (4 in. × 4 in. × ⅛ in.) shall be used.

14.3.5 Procedure. Specimens shall be tested according to ASTM D751, *Standard Test Methods for Coated Fabrics*, using the Procedures for Blocking Resistance at Elevated Temperatures, specified in Sections 84 through 88, with the following modifications:

(1) The glass plates specified in 14.3.4.2 shall be used.
(2) A test temperature of 265°C, +3/−0°C (510°F, +5/−0°F) shall be used.
(3) The 1.8 kg (4 lb) mass shall be removed from the glass plates within 5 minutes after removal of the glass plates from the oven.
(4) The specimens shall remain between the glass plates and cool for 18 hours, +1/−0 hours after removal of the glass plates from the oven.
(5) In removing specimens from the glass plates, the rating of resistance to blocking shall be determined and observations shall be made whether each specimen sticks to the glass plates or shows evidence of melting or ignition. The determination of a specimen sticking to the glass plates shall be made by placing the glass plates and specimen on a flat level surface and raising the top glass plate in a smooth continuous motion with the plate parallel to the surface and observing if the material separates from either of the glass plates. If the tested fabric separates from the lower glass plate but clings to the upper glass plate, invert the upper glass, lay it on a flat surface, and raise the fabric with a smooth continuous motion. If the fabric does not separate cleanly from either of the glass plates, or if it lifts the glass plate completely off the surface, then it shall be judged as sticking.
(6) Where the specimen size is such that a 102 mm × 102 mm (4 in. × 4 in.) square cannot be achieved, three specimens shall be tested folded face to face, and three specimens shall be tested folded back to back.

14.3.6 Report.

14.3.6.1 The condition of each specimen shall be recorded and reported.

14.3.6.2 Where specimens show no damage, the condition shall be recorded and reported as "no damage."

14.3.6.3 Where specimens stick to the glass plates or show evidence of melting or ignition, the applicable condition shall be recorded and reported. The rating of resistance to blocking shall also be recorded and reported.

14.3.7 Interpretation.

14.3.7.1 Observations of any sticking to the glass plate, melting, or ignition for any specimen shall constitute failure for the textile being tested.

14.3.7.2 A rating of resistance to blocking other than 1 or 2 shall also constitute failing performance.

14.4 Seam Breaking Strength Test.

14.4.1 Application.

14.4.1.1 This test method shall apply to seam assemblies for garments.

14.4.1.2* This test method shall apply to major seams.

14.4.2 Samples.

14.4.2.1 Samples shall be a straight seam cut from a finished garment or shall be prepared by joining two pieces of the garment textile.

14.4.2.2 Where the sample is prepared by joining two pieces of woven textile, the textile shall be joined as specified in 9.2.1.2 of ASTM D1683/D1683M, *Standard Test Method for Failure in Sewn Seams of Woven Fabrics.*

14.4.2.3 Where the sample is prepared by joining two pieces of knit or woven stretch textiles, the textiles shall be joined as specified in ASTM D6797, *Standard Test Method for Bursting Strength of Fabrics Constant-Rate-of-Extension (CRE) Ball Burst Test.*

14.4.3 Specimens.

14.4.3.1 A minimum of five seam specimens representative of the type of major seam in the garment shall be tested.

14.4.3.2 Specimens to be tested shall be the same thread, seam type, and stitch type used in the finished garment.

14.4.3.3 All specimens shall be conditioned as specified in 14.1.2 prior to testing.

14.4.4 Procedure.

14.4.4.1 All woven seam assemblies shall be tested in accordance with ASTM D1683/D1683M, *Standard Test Method for Failure in Sewn Seams of Woven Fabrics.* The test machine shall be operated at a rate of 305 mm/min (12 in./min).

14.4.4.2 All knit seam assemblies shall be tested in accordance with ASTM D6797, *Standard Test Method for Bursting Strength of Fabrics Constant-Rate-of-Extension (CRE) Ball Burst Test.* Padding of the clamps shall be permitted to prevent fabric slippage due to the thickness of the seam. The seam allowance shall be placed facing away from the penetrating ball.

14.4.5 Report.

14.4.5.1 The seam breaking strength for each seam specimen shall be recorded and reported.

14.4.5.2 The average seam breaking strength for each seam type shall also be recorded and reported.

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

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

14.5 Label Print Durability Test.

14.5.1 Application. This test method shall apply to garment labels.

14.5.2 Samples.

14.5.2.1 Samples for preconditioning shall be specimens of labels attached in the center of a 1 m (1 yd) square of garment textile.

14.5.2.2 Samples shall be preconditioned according to 14.1.3 where the manufacturer designates that the garments are to be washed.

14.5.2.3 Samples shall be preconditioned according to 14.1.4 where the manufacturer designates that the garments are to be dry cleaned.

14.5.3 Specimens.

14.5.3.1 A minimum of three different specimens shall be tested.

14.5.3.2 Specimens of product labels shall be attached to garment textile.

14.5.3.3 Specimens shall be tested after the preconditioning specified in either 14.5.2.2 or 14.5.2.3.

14.5.3.4 All specimens shall be conditioned as specified in 14.1.2 prior to testing.

14.5.4 Procedure. Specimens shall be examined at a distance of 305 mm (12 in.) by the unaided eye with 20/20 vision or vision corrected to 20/20.

14.5.5 Report. The legibility of each specimen shall be recorded and reported as pass or fail.

14.5.6 Interpretation. Any one specimen failing the test shall constitute failing performance for the test.

14.6 Flame Resistance Test.

14.6.1 Application.

14.6.1.1 This test method shall apply to flame-resistant textiles and visibility markings.

14.6.1.2 Modifications to this test method for testing woven textile materials shall be as specified in 14.6.8.

14.6.1.3 Modifications to this test method for testing knit textile materials shall be as specified in 14.6.9.

14.6.1.4 Modifications to this test method for testing nonwoven textile materials shall be as specified in 14.6.10.

14.6.1.5 Modifications to this test method for testing small textile items not meeting the specimen size requirements of 14.6.3.1 shall be as specified in 14.6.11.

14.6.1.5.1 Modifications to this test method for testing visibility markings shall be as specified in 14.6.12

14.6.1.6 Modifications to this test method for testing textile materials that are represented as being flame resistant and insect repellent shall be as specified in 14.6.13.

14.6.2 Samples.

14.6.2.1 Samples for preconditioning shall be 1 m (1 yd) square of each textile material.

14.6.2.2 If the manufacturer designates that the garments are to be washed, separate samples shall be preconditioned according to 14.1.3.2.

14.6.2.3 If the manufacturer designates that the garments are to be dry cleaned, separate samples shall be preconditioned according to 14.1.4.2.

14.6.3 Specimens.

14.6.3.1 Specimens shall consist of a 75 mm × 305 mm (3 in. × 12 in.) rectangle with the long dimension parallel to either the warp or filling, the wale or course, or machine or cross-machine direction of the material.

14.6.3.2 Each individual layer of multilayer material systems or composites shall be separately tested.

14.6.3.3 Specimens shall be tested after the preconditioning specified in either 14.6.2.2 or 14.6.2.3.

14.6.3.4 All specimens shall be conditioned as specified in 14.1.2 prior to testing.

14.6.4 Apparatus. The test apparatus specified in ASTM D6413/D6413M, *Standard Test Method for Flame Resistance of Textiles (Vertical Test)*, shall be used.

14.6.5 Procedure.

14.6.5.1 Flame resistance testing shall be performed in accordance with ASTM D6413/D6413M, *Standard Test Method for Flame Resistance of Textiles (Vertical Test)*.

14.6.5.2 Each specimen shall be examined for evidence of melting or dripping.

14.6.6 Report.

14.6.6.1 Afterflame time and char length shall be recorded and reported for each specimen.

14.6.6.2 The afterflame time shall be recorded and reported to the nearest 0.2 second.

14.6.6.3 The char length shall be recorded and reported to the nearest 3 mm (⅛ in.).

14.6.6.4 The average afterflame time and char length for each material shall be calculated, recorded, and reported.

14.6.6.5 Observations of melting or dripping for each specimen shall be recorded and reported.

14.6.7 Interpretation.

14.6.7.1 Pass or fail performance shall be based on any observed melting or dripping, the average afterflame time, and the average char length.

14.6.7.2 Failure in either direction shall constitute failure of the material.

14.6.8 Specific Requirements for Testing Woven Textile Materials.

14.6.8.1 Five specimens from each of the warp and filling directions shall be tested.

14.6.8.2 No two warp specimens shall contain the same warp yarns, and no two filling specimens shall contain the same filling yarns.

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

14.6.8.4 Testing shall be performed as specified in 14.6.2 through 14.6.7.

14.6.9 Specific Requirements for Testing Knit Textile Materials.

14.6.9.1 Five specimens from each of the two directions shall be tested.

14.6.9.2 Samples for conditioning shall include material that is a minimum of 75 mm × 305 mm (3 in. × 12 in.).

14.6.9.3 Testing shall be performed as specified in 14.6.2 through 14.6.7.

14.6.10 Specific Requirements for Testing Nonwoven Textile Materials.

14.6.10.1 Five specimens from each of the machine and cross machine directions shall be tested.

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

14.6.10.3 Testing shall be performed as specified in 14.6.2 through 14.6.7.

14.6.11 Specific Requirements for Testing Small Textile Materials.

14.6.11.1 Five specimens attached to the textile layer as used in the station/work garments shall be tested.

14.6.11.2 The specimens shall be attached to the textile layer such that the bottom exposure edge of the item coincides with the bottom exposure edge of the textile support layer.

14.6.11.3 Samples for conditioning shall be a 1 m (1 yd) square of the textile layer on which the small specimens are attached.

14.6.11.4 Testing shall be performed as specified in 14.6.2 through 14.6.7; however, char length shall not be measured.

14.6.12 Specific Requirements for Testing Visibility Markings.

14.6.12.1 Samples for preconditioning shall be attached to a textile layer measuring 1 m (1 yd) square.

14.6.12.2 Where the visibility markings do not meet the specimen size requirements, the markings shall be attached to a textile layer meeting the specimen size requirements so that the bottom exposure edge of the item coincides with the bottom exposure edge of the textile support layer.

14.6.12.3 Testing shall be performed as specified in 14.6.2 through 14.6.7 with the exception that testing shall be limited to only the length direction of the visibility marking material and the char length shall not be measured.

14.6.13 Specific Requirements for Testing Insect-Repellent Materials.

14.6.13.1 Textile fabrics that are represented as being both insect repellent and flame resistant shall be tested in both the pre- and post-insect-repellent treatment configurations.

14.6.13.2 Pretreated Textile Materials.

14.6.13.2.1 Woven pre-insect-repellent treatment textile materials shall be tested in accordance with 14.6.8.

14.6.13.2.2 Knit pre-insect-repellent treatment textile materials shall be tested in accordance with 14.6.9.

14.6.13.3 Woven Post-Treated Textile Materials.

14.6.13.3.1 Five specimens from each of the warp and filling directions shall be tested.

14.6.13.3.2 No two warp specimens shall contain the same warp yarns, and no two filling specimens shall contain the same filling yarns.

14.6.13.3.3 Samples shall be permitted to be obtained from yardage or finished garments.

14.6.13.3.4 Testing shall be performed as specified in 14.6.2 through 14.6.7.

14.6.13.4 Knit Post-Treated Textile Materials.

14.6.13.4.1 Five specimens from each of the two directions shall be tested.

14.6.13.4.2 Samples for conditioning shall include material that is a minimum of 75 mm × 305 mm (3 in. × 12 in.).

14.6.13.4.3 Samples shall be permitted to be obtained from yardage or finished garments.

14.6.13.4.4 Testing shall be performed as specified in 14.6.2 through 14.6.7.

14.7 Thread Heat Resistance Test.

14.7.1 Application. This test method shall apply to each type of thread used in the construction of work apparel.

14.7.2 Procedure. Specimens shall be tested to a temperature of 260°C (500°F) in accordance with ASTM D7138, *Standard Test Method to Determine Melting Temperature of Synthetic Fibers*.

14.7.2.1 Where garments are certified to meet only the base requirements of this standard, the thread shall be tested using either Method 1 or Method 2 as specified by the garment manufacturer.

14.7.2.2 Where garments are certified to meet the optional flame resistance requirements of this standard, the thread shall be tested using Method 1.

14.7.3 Report.

14.7.3.1 The melting point of the sample unit shall be the average of the results obtained from the specimens tested and shall be recorded and reported to the nearest degree C.

14.7.3.2 The pass or fail results for each specimen tested shall be recorded and reported.

14.7.4 Interpretation. One or more thread specimens failing this test shall constitute failing performance for the thread type.

14.8 Water Absorption Resistance Test.

14.8.1 Application.

14.8.1.1 This test method shall apply to water-resistant textiles.

14.8.2 Samples.

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

14.8.2.2 If the manufacturer designates that the garments are to be washed, separate samples shall be preconditioned according to 14.1.3.1.

14.8.2.3 If the manufacturer designates that the garments are to be dry cleaned, separate samples shall be preconditioned according to 14.1.4.2.

14.8.3 Specimens.

14.8.3.1 Specimens shall be 200 mm × 200 mm (8 in. × 8 in.).

14.8.3.2 At least three specimens shall be tested.

14.8.3.3 Specimens shall be tested after the preconditioning specified in 14.8.2.2 or 14.8.2.3.

14.8.3.4 All specimens shall be conditioned as specified in 14.1.2 prior to testing.

14.8.4 Apparatus. The test apparatus shall be as specified in AATCC TM42, *Test Method for Water Resistance: Impact Penetration Test*, with the following modifications:

(1) A metal roller 113 mm ±6 mm (4½ in. ±¼ in.) long and weighing 1 kg (2¼ lb) shall be used.
(2) Embroidery hoops measuring 150 mm to 180 mm (6 in. to 7 in.) in diameter shall be used for mounting the specimen.

14.8.5 Procedure.

14.8.5.1 The conditioned specimen shall be securely mounted in the embroidery hoops with sufficient tension to ensure a uniformly smooth surface.

14.8.5.2 The direction of the flow of water down the specimen shall coincide with the warpwise direction of the specimen as placed on the stand.

14.8.5.3 The mounted specimen shall be placed on the block with the center of the specimen directly beneath the center of the nozzle and the plane of the surface of the specimen at a 45-degree angle with the horizontal.

14.8.5.4 A 500 mL (17 oz) volume of distilled water at a temperature of 27°C ±1°C (80°F ±2°F) shall be poured quickly into the funnel and allowed to spray onto the specimen.

14.8.5.5 The following operations shall then be executed as rapidly as possible:

(1) The specimen shall be removed from the hoops and placed between sheets of blotting paper on a flat horizontal surface.
(2) The metal roller shall be rolled quickly forward and back one time over the paper without application of any pressure other than the weight of the roller.
(3) A square 100 mm × 100 mm (4 in. × 4 in.) shall be cut out of the center of the wet portion of the specimen and weighed to the nearest 0.05 g. This weight shall be designated the "wet weight." Not more than 30 seconds shall

elapse between the time the water has ceased flowing through the spray nozzle and the start of the weighing.

(4) The same 100 mm (4 in.) square shall be conditioned as specified in 14.1.2 until it has dried and reached moisture equilibrium with the surrounding standard atmosphere for textiles.

(5) Following the conditioning in 14.8.5.5, the square shall be reweighed, and this weight designated as the "dry weight."

14.8.5.6 The percent water absorption shall be calculated using the following equation: Percent water absorption = [(wet weight − dry weight)/(dry weight)] × 100

14.8.6 Report.

14.8.6.1 The percent water absorption for each specimen shall be recorded and reported.

14.8.6.2 The average percent water absorption for all tested specimens shall be calculated and reported.

14.8.7 Interpretation. The average percent water absorption shall be used to determine pass/performance.

14.9 Insect Repellency Test.

14.9.1 Application. This test method shall apply to textile materials identified as insect repellent.

14.9.2 Samples. Samples shall be as specified in section 4.5.1 of Department of Defense GL/PD 07-13C, *Purchase Description Coat, Army Combat Uniform.*

14.9.3 Procedure. Testing and conditioning shall be as specified in section 4.5.1 of Department of Defense GL/PD 07-13C, *Purchase Description Coat, Army Combat Uniform.*

14.9.4 Report. The individual concentration for each specimen in milligrams per square centimeter permethrin to the nearest 0.001 mg shall be reported.

14.9.5 Interpretation. Failure of an individual specimen shall constitute failure of the material.

Chapter 15 Scope and Certification Requirements (NFPA 1981)

15.1 Administration.

15.1.1 Scope.

15.1.1.1* Chapters 15 through 19 of this standard shall specify the minimum requirements for the design, performance, testing, and certification of new compressed breathing air open-circuit self-contained breathing apparatus (SCBA) and compressed breathing air combination open-circuit self-contained breathing apparatus and supplied air respirators (SCBA/SARs) and for the replacement parts, components, and accessories for these respirators.

15.1.1.2 This edition of NFPA 1970 (NFPA 1981) shall also specify the minimum requirements for the design, performance and testing of replacement parts, components, and add-on accessories for SCBA and combination SCBA/SARs certified as compliant to earlier editions of NFPA 1981.

15.1.1.3 Chapters 15 through 19 of this standard shall not specify requirements for other types of SCBA.

15.1.1.4* Chapters 15 through 19 of this standard shall not specify requirements for any accessories that could be attached to the certified product that are not certified by the National Institute for Occupational Safety and Health (NIOSH).

15.1.1.5 Chapters 15 through 19 of this standard shall not establish criteria for SCBA for water or underwater operations.

15.1.1.6 Chapters 15 through 19 of this standard shall not establish criteria for protection from ionizing radiation.

15.1.1.7 Chapters 15 through 19 of this standard shall not be construed as addressing all of the safety concerns associated with the use of compliant SCBA and combination SCBA/SARs. It shall be the responsibility of the persons and organizations that use compliant SCBA and combination SCBA/SARs to establish safety and health practices and to determine the applicability of regulatory limitations prior to use.

15.1.1.8 Chapters 15 through 19 of this standard shall not be construed as addressing all of the safety concerns, if any, associated with the use of this standard by testing facilities. It shall be the responsibility of the persons and organizations that use this standard to conduct testing of SCBA and combination SCBA/SARs to establish safety and health practices and to determine the applicability of regulatory limitations prior to using this standard for any designing, manufacturing, and testing.

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

15.1.2 Purpose.

15.1.2.1 The purpose of Chapters 15 through 19 of this standard shall be to establish minimum levels of protection for emergency services personnel from atmospheres that are categorized as immediately dangerous to life and health (IDLH).

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

15.1.2.3* Chapters 15 through 19 of this standard shall not be interpreted or used as a detailed manufacturing or purchase specification but shall be permitted to be referenced in purchase specifications as minimum requirements.

15.1.3 Application.

15.1.3.1 Chapters 15 through 19 of this standard shall apply to all open-circuit SCBA and combination SCBA/SARs used by emergency services organizations for respiratory protection of its personnel during firefighting, rescue, hazardous materials, terrorist incident, and similar operations where products of combustion, oxygen deficiency, particulates, toxic products, or other IDLH atmospheres exist or could exist at the incident scene.

15.1.3.1.1* If the SCBA is equipped with an UEBSS, the UEBSS performance requirements set forth in Chapters 15 through 19 of this standard shall apply only to open-circuit SCBA and combination SCBA/SARs used by the fire service for respiratory protection of its personnel during the applications listed in 15.1.3.1.

15.1.3.2 This edition of NFPA 1970 (NFPA 1981) shall apply to the design, manufacturing, and certification of new open-circuit SCBA and combination SCBA/SARs and shall apply to replacement parts, components, and add-on accessories for such respirators certified as compliant to earlier editions of NFPA 1981.

15.1.3.3 Chapters 15 through 19 of this standard shall apply to accessories attached to the SCBA that are certified by NIOSH for use with that specific SCBA or combination SCBA/SARs.

15.1.3.4 Chapters 15 through 19 of this standard shall not apply to open-circuit SCBA and combination SCBA/SARs manufactured according to previous editions of NFPA 1981; however, organizations shall be permitted to have open-circuit SCBA and combination SCBA/SARs that are certified as compliant with previous editions of NFPA 1981 and modified to become compliant with this edition of NFPA 1970 (NFPA 1981).

15.1.3.5 Chapters 15 through 19 of this standard shall not apply to closed-circuit SCBA.

15.1.3.6 Chapters 15 through 19 of this standard shall not apply to accessories that can be attached to an open-circuit SCBA and combination SCBA/SARs but are not certified by NIOSH for use with that specific SCBA or combination SCBA/SARs.

15.1.3.7 Chapters 15 through 19 of this standard shall not apply to the use of SCBA and combination SCBA/SARs; those requirements are specified in NFPA 1550.

15.1.4 Units.

15.1.4.1 In Chapters 15 through 19 of this standard, values for measurement are followed by an equivalent in parentheses, but only the first stated value shall be regarded as the requirement.

15.1.4.2 Equivalent values in parentheses shall not be considered as the requirement because those values might be approximate.

15.2 General.

15.2.1 The process for certification of SCBA as being compliant with NFPA 1970 (NFPA 1981) shall meet the requirements of Sections 4.1 through 4.9.

15.2.2 Prior to certification of SCBA to the requirements of Chapters 15 through 19 of this standard, SCBA shall be NIOSH certified.

15.2.2.1 SCBA shall have NIOSH certification as positive pressure.

15.2.2.2* SCBA shall have a NIOSH-certified rated service time of at least 30 minutes.

15.2.2.3 SCBA that are NIOSH certified as positive pressure but capable of supplying air to the user in a negative pressure demand-type mode shall NOT be certified to this standard.

15.2.3 SCBA and accessories that are certified as compliant with NFPA 1970 (NFPA 1981) shall also be certified by NIOSH as compliant with the *Statement of Standard for NIOSH CBRN SCBA Testing*.

15.2.4 All SCBA that are labeled as being compliant with this standard shall meet or exceed all applicable requirements specified in Chapters 15 through 19 of this standard and shall be certified. This certification shall be in addition to, and shall not be construed to be the same as, the NIOSH certification as specifically defined in 3.3.121.

15.2.5 The certification organization shall not issue any new certifications based on the 2019 edition of NFPA 1981 after the NFPA effective date of the 2025 edition of NFPA 1970.

15.2.6 The certification organization shall not permit any manufacturer to continue to label any products that are certified as compliant with the 2019 edition of NFPA 1981 on the effective date of the 2025 edition of NFPA 1970, plus 18 months.

15.2.7 The certification organization shall require manufacturers to remove all certification labels and product labels indicating compliance with the 2019 edition of NFPA 1981 from all products that are under the control of the manufacturer on the effective date of the 2025 edition of NFPA 1970, plus 18 months, and the certification organization shall verify that this action is taken.

15.2.8 The certification organization shall not permit any manufacturer to label any SCBA as compliant with this standard according to 15.2.6 except when replacement labels or replacement components that bear the certification organization's label are required.

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

15.2.9.1 The certification organization and the manufacturer shall evaluate replacement parts, components, and software to determine any changes affecting the form, fit, or function of SCBAs certified to earlier editions of this standard to permit incorporation of replacement parts, components, or software, leading to certification of devices to this edition of the standard.

15.2.9.2* Replacement parts, components, and add-on accessories for SCBAs certified to the 2013 edition or the 2018 edition of NFPA 1981 shall be approved by NIOSH in accordance with 42 CFR 84, "Respiratory Protective Devices, Tests for Permissibility."

15.3 Inspection and Testing.

15.3.1 Inspection and evaluation by the certification organization for determining compliance with the design requirements specified in Chapter 16 shall be performed on whole or complete products.

15.3.2 SCBA and SCBA components shall be subjected to the tests specified in Table 15.3.2 for each series.

15.3.3 SCBA shall be initially tested for certification and shall meet the performance requirements of three separate test series of Categories A, B, C, D, E, and F, as specified in Table 15.3.2. All tests within Categories A, B, C, D, E, and F shall be conducted in the order specified and are designed as cumulative damage tests.

15.3.4 SCBA fabric, thread, and lens components shall be initially tested for certification and shall meet the performance requirements of one test series of Category G, as specified in Table 15.3.2. SCBA component testing in Category G shall be conducted on test specimens as specified in each respective test method.

15.3.5 SCBA shall be initially tested for certification and shall meet the performance requirements of one test series for Category H, as specified in Table 15.3.2 for each EOSTI identified by the product manufacturer. Additional SCBA shall be permitted to be used, where necessary, to conduct all the Category H tests.

15.3.6 After certification, compliant SCBA and components of compliant SCBA shall be tested annually within 12 months of previous tests and shall meet the performance requirements of one test series of Categories A, B, C, D, E, F, G, and H, as specified in Table 15.3.2.

15.3.7 A minimum of seven identical SCBA that are to be certified to this standard shall be selected from the manufacturer's production.

15.3.8 The first SCBA shall be subjected to the tests listed in Category A, the second SCBA shall be subjected to the tests listed in Category B, the third SCBA shall be subjected to the tests in Category C, the fourth SCBA shall be subjected to the tests in Category D, the fifth SCBA shall be subjected to the tests in Category E, the sixth SCBA shall be subjected to the tests in Category F, and the seventh SCBA, at a minimum, shall be subjected to the tests in Category H, as shown in Table 15.3.2. Additional SCBA shall be permitted to be used, where necessary, to conduct all the Category H tests.

15.3.9 Components from SCBA that are to be certified to this standard shall be subjected to the tests specified in Category G of Table 15.3.2. SCBA component testing in Category F shall be conducted on test specimens as specified in each respective test method.

15.3.10 The requirement specified in 15.3.6 shall be waived every fifth year when the testing required by 15.3.11 is conducted.

Table 15.3.2 Test Series

Test Order	Category A (SCBA #1)	Category B (SCBA #2)	Category C (SCBA #3)	Category D (SCBA #4)	Category E (SCBA #5)	Category F (SCBA #6)	Category G (Component Tests)	Category H (Additional SCBA as required)
1	Airflow *(Section 19.1)*	Airflow *(Section 19.1)*	Airflow *(Section 19.1)*	Airflow *(Section 19.1)*	HUD visibility performance *(Sections 19.17 through 19.19)*	Low power capacity test *(Section 19.26)*	Fabric flame tests *(Section 19.4)*	EOSTI independent activation *(Section 19.13)*
2	Facepiece carbon dioxide content *(Section 19.12)*	Breathing air cylinder and valve assembly retention test *(Section 19.22)*	Vibration resistance *(Section 19.3)*	Heat and flame resistance *(Section 19.11)*	HUD low power source visual alert signal test *(Section 19.16)*	Heat and immersion leakage tests *(Section 19.24)*	Fabric heat tests *(Section 19.5)*	EOSTI recognition performance *(Section 19.14)*
3	Nonelectronic communications test *(Section 19.10)*	Cylinder connections and accessibility test *(Section 19.23)*	—	—	Wiring connection strength *(Section 19.15)*	—	Thread heat test *(Section 19.6)*	Elevated temperature heat and flame resistance test *(Section 19.29)*
4	Supplementary voice communications system performance test *(Section 19.25)*	RIC UAC cylinder refill breathing performance *(Section 19.20)*	—	—	Lens radiant heat *(Section 19.28)*	—	Facepiece lens abrasion resistance *(Section 19.9)*	—
5	Environmental temperature *(Section 19.2)*	RIC UAC system fill rate performance *(Section 19.21)*	—	—	—	—	—	—
6	UEBSS cold temp. performance test* *(Section 19.27)*	UEBSS cold temp. performance test* *(Section 19.27)*	—	—	—	—	—	—
7	Particulate test *(Section 19.8)*	Accelerated corrosion test *(Section 19.7)*	—	—	—	—	—	—
8	—	Strength of connection test *(Section 19.30)*	—	—	—	—	—	—

*To be tested together.

15.3.11 Compliant SCBA shall be tested and shall meet the performance requirements of three separate test series of Categories A, B, C, D, E, and F, as specified in Table 15.3.2, every fifth year from the date of the initial certification testing specified in 15.3.4.

15.3.12 SCBA fabric, thread, and lens components shall be tested and shall meet the performance requirements of one test series of Category G, as specified in Table 15.3.2, every fifth year from the date of the initial certification testing specified in 15.3.2. SCBA component testing in Category G shall be conducted on test specimens as specified in each respective test method.

15.3.13 Compliant SCBA shall be tested and shall meet the performance requirements of one test series for Category H, as specified in Table 15.3.2, for each EOSTI identified by the product manufacturer, every fifth year from the date of the initial certification testing specified in 15.3.5. Additional SCBA shall be permitted to be used, where necessary, to conduct all the Category H tests.

15.3.14 The certification organization shall not allow any modifications, pretreatment, conditioning, or other such special processes of the product or any product component prior to the product's submission for evaluation and testing by the certification organization.

15.3.14.1 The certification organization shall accept from the manufacturer for evaluation and testing for certification only product or product components that are the same in every respect to the actual final product or product component.

15.3.14.2 The certification organization shall not allow the substitution, repair, or modification, other than as specifically permitted herein, of any product or any product component during testing.

15.3.15 No adjustment, repair, or replacement of parts shall be permitted to any SCBA being tested in accordance with this standard; however, breathing air cylinders shall be permitted to be filled as required.

15.3.16 Where SCBA are provided with an accessory or accessories that are certified by NIOSH in accordance with 42 CFR 84 for that specific SCBA, the SCBA with accessories installed shall be tested to all of the performance requirements specified in Chapter 18, and the accessories shall not cause degradation of the performance of the SCBA. The accessories themselves shall not be required to pass the performance testing unless specifically specified herein.

15.3.17 After completion of these tests for a specific model SCBA or its variant, only those tests on other similar SCBA models or variants shall be required where, in the determination of the certification organization, the SCBA's test results can be affected by any components or NIOSH-certified accessories that are different from those on the original SCBA tested.

15.3.18 Any modifications made to an SCBA or to any NIOSH-certified accessories provided for an SCBA by the SCBA manufacturer after certification shall require the retesting and meeting of the performance requirements of all those individual tests that the certification organization determines could be affected by such changes. This retesting shall be conducted before the modified SCBA is certified as being compliant with this standard.

15.3.19 The manufacturer shall maintain all design and performance inspection and test data from the certification organization used in the certification of the manufacturer's compliant product. The manufacturer shall provide such data, upon request, to the purchaser or authority having jurisdiction.

15.4 Annual Verification.

15.4.1 Annual verification shall include inspection and evaluation to all design requirements and testing to all performance requirements as required by 15.3.1 and 15.3.6 on all manufacturer models and components.

15.4.2 The manufacturer shall maintain all design and performance inspection and test data from the certification organization used in the annual verification of manufacturer models and components and shall provide such data, upon request, to the purchaser or authority having jurisdiction.

15.5 Hazards Involving Compliant Product.

15.5.1 In addition to the requirements outlined in Section 4.7, the requirements in 15.5.1.1 and 15.5.1.2 must also be met.

15.5.1.1 Where the report of a hazard involved with a compliant product certified to NFPA 1970 (NFPA 1981), the certification organization shall contact NIOSH National Personal Protective Technology Laboratory (NPPTL), and the validity of the report shall be investigated following the procedures established by NIOSH/NPPTL.

15.5.1.2 Where it is established that a hazard is involved with a compliant product, the certification organization will coordinate any additional actions outlined in Section 4.7 with NIOSH/NPPTL for products certified to NFPA 1970 (NFPA 1981).

15.6 Manufacturers' Investigation of Complaints and Returns. In addition to the requirements in Section 4.8, the manufacturer shall also immediately contact NIOSH/NPPTL and provide all information about their review to assist NIOSH/NPPTL with their investigation.

15.7 Manufacturers' Safety Alert and Product Recall Systems. In addition to the requirements in Section 4.9, the manufacturers' safety alert and product recall system shall provide a method of notifying all dealers, distributors, purchasers, users, and the NFPA about the safety alert or product recall that can be initiated within a one-week period, after the manufacturer has been directed by NIOSH/NPPTL to issue a safety alert or conduct a product recall.

Chapter 16 Labeling and Information (NFPA 1981)

16.1 Product Label Requirements.

16.1.1 In addition to the NIOSH certification label, each SCBA shall have an SCBA product label, which shall be permanently and conspicuously attached to the SCBA.

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

16.1.3 The certification organization's label, symbol, or identifying mark shall be attached to both the NIOSH certification label and the SCBA product label or be part of the product labels and shall be placed in a conspicuous location. All letters shall be at least 2.5 mm (3⁄32 in.) in height, and the label, symbol, or identifying mark shall be at least 6 mm (15⁄64 in.) in height.

16.1.4 All worded portions of both required product labels shall be at least in English.

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

16.1.6 The SCBA product label shall bear the following compliance statement printed, and all letters and numbers shall be at least 2 mm (5⁄64 in.) in height:

THIS SCBA MEETS THE REQUIREMENTS OF

NFPA 1970 (1981), 2025 EDITION.

DO NOT REMOVE THIS LABEL.

16.1.7 SCBA components, as listed on the NIOSH certification labels, shall be marked directly on the component with the lot number, the serial number, or the year and month of manufacture.

16.2 User Information.

16.2.1 The SCBA manufacturer shall provide with each SCBA at least the training material and user instructions specified within this section.

16.2.2 Upon request at the time of purchase, the SCBA manufacturer shall provide to the purchaser an information sheet with each SCBA that documents at least the following:

(1) Manufacturing performance tests conducted at time of manufacture and the results
(2) Date of manufacture
(3) Model number
(4) Serial number
(5) Lot number, if applicable
(6) Hydrostatic test dates and results, if applicable

16.2.3 Information or training materials regarding pre-use shall be provided at least on the following areas:

(1) Safety considerations
(2) Limitations of use
(3) Charging breathing air cylinders
(4) Breathing air quality in accordance with NFPA 1989
(5) Marking recommendations and restrictions
(6) Warranty information
(7) Recommended storage practices
(8) Mounting on/in vehicles or fire apparatus

16.2.4 Information or training materials regarding periodic inspections shall be provided at least on inspection frequency and details.

16.2.5 Information or training materials regarding donning and doffing shall be provided at least on the following areas:

(1) Donning and doffing procedures
(2) Adjustment procedures
(3) Interface issues

16.2.6 Information or training materials regarding use shall be provided at least on the following areas:

(1) Pre-use checks
(2) For fire departments or fire department–based emergency services, proper use consistent with NFPA 1550
(3) Recharging breathing air cylinders
(4) Emergency procedures to be followed in the event of damage, malfunction, or failure of the breathing apparatus
(5) Emergency procedures to be followed in the event of an out-of-air situation
(6) Instructions for UEBSS operation utilizing the following wording: "Immediately after the UEBSS connection has been completed, the cylinder valve of the receiving SCBA shall be closed."

16.2.7* Information or training materials regarding periodic maintenance and cleaning shall be provided at least on the following areas:

(1) Cleaning instructions and precautions
(2) Disinfecting procedures
(3) Maintenance frequency and details
(4) Methods of repair, where applicable
(5) Low power source signals and power source replacement, where applicable
(6) Complete instructions for reporting to the manufacturer, certification authority, and NIOSH/NPPTL all returned equipment or complaints of damage, malfunction, or failure of the breathing apparatus that might present a hazard to the user

16.2.7.1 Cleaning instructions and precautions shall include procedures and pertinent information for the preliminary exposure reduction, advanced cleaning, and decontamination of SCBA that includes the following minimum information:

(1) Information for when and how SCBA is subjected to preliminary exposure reduction after being contaminated
(2) A statement that SCBA subject to exposure to products of combustion on the fireground usually warrants advanced cleaning
(3) The specific technique(s) that can be applied for cleaning, including hand washing, machine washing, or other processes that the manufacturer indicates as safe for the SCBA
(4) The identification of any SCBA components that should be removed for separate cleaning
(5) Any specific detergents for cleaning the SCBA or specific SCBA components, or a list of acceptable parameters for a detergent such as pH, chemical constituents that are acceptable, and chemical constituents to be excluded
(6)* Warnings against the use of any specific substances
(7)* Characteristics of any tools or equipment

(8)* Specifications of any other cleaning parameters
(9) Specific procedures for carrying out advanced cleaning, including drying of SCBA
(10)* Specific precautions related to decontamination where SCBA are exposed to hazardous substances, including where SCBA exposure to certain hazardous substances requires specialized cleaning, replacement of components, or disposal
(11) A requirement for the organization or end user to inspect the SCBA following preliminary exposure reduction, advanced cleaning, or decontamination
(12) A reference to NFPA 1852 for additional cleaning and care requirements

16.2.7.2 Information provided on disinfecting procedures shall include the following minimum information:

(1) A list of considerations for when SCBA or SCBA components are to be subject to disinfection
(2) A warning that sharing of SCBA facepieces and other SCBA components require disinfection and advanced cleaning between individuals
(3) The identification of specific sanitizers or disinfectants that are suitable for SCBA, and if these disinfectants have been registered with the US Environmental Protection Agency for disinfection of specific infectious diseases
(4) Specific procedures for the application of the disinfectant, including the concentration, manner of application, dwell time, and any subsequent requirement for rinsing, drying, or advanced cleaning.
(5) A reference to NFPA 1852 for additional disinfection requirements

16.2.8 Information or training materials regarding retirement in accordance with NFPA 1852 shall be provided.

16.2.9 The SCBA manufacturer shall provide the manufacturer's specified component service life for composite breathing air cylinders and for all elastomeric components of the SCBA. This information shall be included at least in the maintenance information provided to the users.

16.2.10 Equipment certified for use in hazardous locations shall be provided with at least the following information in user instructions or training materials:

(1) For SCBA and SCBA accessories that are certified as nonincendive equipment, electrically interconnected types, the following:
    (a) Identification as nonincendive equipment, electrically interconnected types
    (b) Indication of the ability to interconnect with any other SCBA and SCBA accessories also certified and identified as nonincendive equipment, electrically interconnected types, in accordance with this standard
(2) For SCBA that is part of a nonincendive system, indication of the SCBA accessories that comprise the nonincendive system in accordance with this standard
(3) For SCBA that is part of an intrinsically safe system, indication of the SCBA accessories that comprise the intrinsically safe system in accordance with this standard

Chapter 17 Design Requirements (NFPA 1981)

17.1 General Design Requirements.

17.1.1 SCBA shall meet the applicable design requirements specified in this chapter where inspected and evaluated by the certification organization as specified in Section 15.3, Inspections and Testing.

17.1.2 Prior to certification of SCBA to the requirements of this standard, SCBA shall be NIOSH certified in accordance with 42 CFR 84.

17.1.2.1 SCBA shall have NIOSH certification as pressure demand (positive pressure).

17.1.2.2* SCBA shall have a NIOSH-certified rated service time of at least 30 minutes.

17.1.2.3 SCBA that are NIOSH certified as pressure demand but capable of supplying air to the user in a negative pressure demand-type mode shall NOT be certified to this standard.

17.1.3 SCBA that are certified as compliant with Chapters 15 through 19 of this standard shall also be certified by NIOSH as compliant with the *Statement of Standard for NIOSH CBRN SCBA Testing*.

17.1.4 SCBA shall consist of all the components necessary for NIOSH certification in accordance with 42 CFR 84, at least two independent end-of-service-time indicators (EOSTI), heads-up display (HUD), voice communications system, and a rapid intervention crew/company universal air connection (RIC UAC).

17.1.5 In addition to the HUD and cylinder-mounted breathing air pressure gauge, all SCBA shall have another independently operating breathing air pressure gauge that shall be capable of being viewed by the wearer when the SCBA is worn in accordance with the SCBA manufacturer's instructions.

17.1.5.1 The design of this independently operating breathing air pressure gauge shall be such that the failure of one breathing air pressure gauge shall not affect the activation and operation of other breathing air pressure gauge.

17.1.5.2 A failure mode and effects analysis shall be provided to the certification organization for each independently operating breathing air pressure gauge.

17.1.5.3 The failure mode and effects analysis shall identify each potential failure mode for each component necessary for the independently operating breathing air pressure gauge to function.

17.1.5.4 The failure mode and effects analysis shall demonstrate that the activation and operation of the independently operating breathing air pressure gauge specified in 17.1.5 is not affected by any of the potential failure modes, as identified in accordance with 17.1.5.3, of all other breathing air pressure gauges.

17.1.6 The pressure gauge provided as part of the SCBA manufacturer's breathing air cylinder and valve assembly shall be readable by a person other than the wearer of the SCBA when the SCBA is worn in accordance with the SCBA manufacturer's instructions and with the breathing air cylinder securely retained in the SCBA backframe.

17.1.7 All SCBA shall be equipped with a full facepiece that covers, at a minimum, the wearer's eyes, nose, and mouth.

17.1.8* Hazardous Location Requirements.

17.1.8.1 General. SCBA and SCBA accessories involving electrical circuitry shall only use circuitry that meets the requirements of this standard for one of the following types of explosion protection:

(1) Nonincendive equipment, stand-alone type (i.e., individual pieces of equipment separately certified for Class I and II, Division 2 and Class III applications, without any external electrical interconnection means, and intended for stand-alone use)
(2) Nonincendive equipment, electrically interconnected type (i.e., individual pieces of equipment separately certified for Class I and II, Division 2 and Class III applications, with external electrical interconnection means involving plugs and jacks, and intended for electrical interconnection to other separately certified nonincendive equipment, electrically interconnected types)
(3) Nonincendive system (i.e., multiple pieces of nonincendive equipment certified together for Class I and II, Division 2 and Class III applications, with electrical interconnection means, and intended for dedicated system use)
(4) Intrinsically safe apparatus, stand-alone type (i.e., individual pieces of apparatus separately certified for Class I and II, Division 1 and Class III applications, without any external electrical interconnection means, and intended for stand-alone use)
(5) Intrinsically safe system (i.e., multiple pieces of intrinsically safe apparatus certified together for Class I and II, Division 1 and Class III applications, with electrical interconnection means, and intended for dedicated system use)

17.1.8.2 Nonincendive Equipment and Systems.

17.1.8.2.1* General. SCBA and SCBA accessories involving electrical circuitry shall, at a minimum, be suitable for use in Class I, Division 2, Groups C and D; Class II, Division 2, Groups F and G; and Class III, Divisions 1 and 2 hazardous (classified) locations, with a temperature class within the range of T3 through T6 inclusive, in accordance with UL 121201, *Nonincendive Electrical Equipment for Use in Class I and II, Division 2 and Class III, Divisions 1 and 2 Hazardous (Classified) Locations.*

17.1.8.2.2 Interconnection of Nonincendive Equipment, Electrically Interconnected Types. The electrical parameters for this interconnection shall comply with Table 17.1.8.2.2.

Table 17.1.8.2.2 Electrical Parameters for Interconnection of Separately Certified Nonincendive Equipment, Electrically Interconnected Types

Device Connector as Source	Required Relationship	Device Connector as Sink
Uo ≤ 8 V	Uo ≤ Ui	Ui ≥ 10 V
Io ≤ 500 mA	Io ≤ Ii	Ii ≥ 1 A
Co ≥ 69 μF	Co ≥ Ci + Ccable*	Ci ≤ 68 μF
Lo ≥ 320 μH	Lo ≥ Li +Lcable*	Li ≤ 315 μH

*Assumption for cable capacitance (Ccable) and cable inductance (Lcable): 200 pF/m and 1 μH/m.

17.1.8.2.3 Interconnection of Nonincendive Systems. SCBA that are certified as part of a nonincendive system shall only be interconnected with SCBA accessories also certified as part of the same nonincendive system.

17.1.8.3 Intrinsically Safe Apparatus and Systems.

17.1.8.3.1* SCBA and SCBA accessories involving electrical circuitry shall, at a minimum, be permitted to be certified at a minimum for use in Class I, Division 1, Groups C and D; Class II, Division 1, Groups E, F, and G, Class III, Division 1 and Division 2 hazardous (classified) locations, with a temperature class within the range of T3 through T6 inclusive, in accordance with UL 913, *Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, and III, Division1 Hazardous (Classified) Locations*.

17.1.8.3.2 SCBA that are certified as part of an intrinsically safe system shall only be interconnected with SCBA accessories also certified as part of the same intrinsically safe system.

17.1.9 All hardware, brackets, and snaps or other fasteners of SCBA or any NIOSH-certified accessories shall be free of rough spots, burrs, and sharp edges.

17.1.10 All SCBA shall have a voice communications system that, at a minimum, shall consist of a nonelectronic transmission system.

17.1.10.1 The voice communications system shall be designed to project sound without other persons needing a receiver to hear the voice communications.

17.1.10.2 If the SCBA incorporates an optional electronic Supplementary Voice Communications System, the Supplementary Voice Communications System design shall incorporate an indicator that the system is "on." This indicator shall be permitted to be positioned outside the user's field of vision with the SCBA facepiece properly donned.

17.1.10.3 The optional Supplementary Voice Communications System's power source shall display a visual alert signal indicating low power capacity.

17.1.10.4 The optional Supplementary Voice Communications System shall be designed to be switched off and on manually without the performance of the SCBA being affected.

17.1.10.5 Where the optional Supplementary Voice Communications System is automatically activated, the operation of the on/off control shall override the auto activation of the Supplementary Voice Communications System without affecting the performance of the SCBA.

17.1.10.6 The optional Supplementary Voice Communications System shall be permitted to be equipped with an adjustable volume (gain) control.

17.1.11 If the SCBA incorporates a removable regulator, two distinct actions for disconnection shall be required prior to withdrawal of the regulator from the facepiece.

17.1.11.1 Withdrawal of the regulator shall not be considered one of the two distinct actions.

17.1.11.2 Where a double-release mechanism is utilized, actuation of a single-release mechanism shall not cause disconnection of the regulator.

17.1.12* The SCBA shall incorporate data logging in nonvolatile memory and, at a minimum, the following events and data points shall be identified and recorded with the data log and shall also have a date and time stamp for each event and data point in the data log:

(1) Initial activation pressure
(2) Pressure when the HUD deactivates
(3) SCBA pressure on the high pressure side of the first stage pressure reducer
(4) Transmission of visual information signals for breathing air cylinder content specified in 17.3.9.6.1

17.1.12.1 After initial activation, the SCBA shall record pressure as specified in 17.1.12(3) at data logging intervals of no more than 30 seconds.

17.1.12.2 The SCBA data logging shall incorporate a pressure resolution of no more than 0.7 bar (10 psi) increments.

17.1.12.3 The SCBA shall retain a minimum of 36 hours of data collection before data points are overwritten.

17.1.12.4 SCBA data logging shall be permitted to cease when the HUD deactivates.

17.1.12.5 The data logging information shall be downloadable by the emergency services organization.

17.1.12.6 The SCBA wearer's breathing rate in liters per minute (L/min) shall be reported by the data logging software at least every 30 seconds with a minimum of 5 L/min resolution.

17.1.12.7 The SCBA manufacturer shall provide data logging software that shall be capable of creating and exporting a CSV file format that provides, at a minimum, the data points specified in 17.1.12(1) through 17.1.12(4).

17.1.13 If the SCBA incorporates an optional wired interface for connection to NFPA 1802-compliant RF devices or NFPA 1802-compliant remote speaker devices/microphones (RSD/RSM), the SCBA shall include an RF device connector (RFDC) that complies with the requirements for compatible devices as specified in Section 6.10 of NFPA 1802.

17.1.14 If the SCBA incorporates wireless interfaces for connection to non-NFPA 1802-compliant SCBA accessories, the SCBA shall indicate the connection status for each wireless connection.

17.1.14.1 Wireless interface connection status indication shall be permitted to be located on the HUD or other SCBA components.

17.1.14.2 Wireless interface connection status indication shall be detectable by the user when the SCBA and facepiece are donned.

17.1.14.3 The SCBA shall indicate wireless interface connection status when connected to paired SCBA accessories.

17.1.14.4 The SCBA shall indicate wireless interface connection status when connection is lost with paired SCBA accessories.

17.1.15 SCBA shall be designed to permit the removal of all porous, textile-based components mounted on the backframe, including, but not limited to, the harness system, shoulder straps, waist straps, chest straps, and padding by the end user.

17.2 End-of-Service-Time Indicator (EOSTI) Design Requirements.

17.2.1 All SCBA shall be equipped with a minimum of two independent EOSTI.

17.2.2 Each EOSTI shall be activated with no additional procedures than those required to activate the SCBA breathing system.

17.2.3 Each EOSTI shall meet the activation requirements of NIOSH certification as specified in 42 CFR 84.

17.2.4 Each EOSTI shall consist of at least the following:

(1) A sensing mechanism
(2) A signaling device

17.2.4.1 At least one of the two required EOSTI shall be independent of any other EOSTI.

17.2.4.2 The EOSTI sensing mechanism shall activate the signaling device(s).

17.2.4.3 The EOSTI signaling devices shall provide notification to the SCBA user of the activation of the EOSTI by stimulating one or more human senses.

17.2.4.4 Each EOSTI shall be permitted to have more than one signaling device, and each signaling device shall be permitted to stimulate more than one human sense.

17.2.4.5 Where one EOSTI signaling device stimulates only one human sense, the other EOSTI shall stimulate at least one different human sense.

17.2.5 The design of EOSTI shall be such that the failure of one EOSTI shall not affect the activation and operation of other EOSTI.

17.2.5.1 A failure mode and effects analysis shall be provided to the certification organization for each EOSTI.

17.2.5.1.1 The failure mode and effects analysis shall identify each potential failure mode for each component necessary for the EOSTI to function.

17.2.5.1.2 The failure mode and effects analysis shall demonstrate that the activation and operation of both EOSTI specified in 17.2.1 are not affected by any of the potential failure modes, as identified in accordance with 17.2.5.1.1, of all other EOSTI.

17.2.5.2 For purposes of the failure mode and effects analysis, power sources other than the air from the SCBA breathing air cylinder shall be considered as part of the EOSTI.

17.2.6 The EOSTI alarm shall activate at the percentage of rated service pressure specified in Table 17.2.6.

17.3 Heads-Up Display (HUD) Design Requirements.

17.3.1* All SCBA shall be equipped with at least one heads-up display.

17.3.2 The HUD shall be activated with no additional procedures than those required to activate the SCBA breathing system.

17.3.3 Each time the SCBA breathing system is activated with a breathing air cylinder pressure of 20 bar (290 psi) or greater, a HUD shall provide a visual indication of activation for a minimum of 20 consecutive seconds.

17.3.4 Where HUD is provided with an external wiring disconnect, the wiring disconnect shall be designed to prevent accidental disconnection and shall not be capable of being connected in such a manner as to prevent the pneumatic system and the HUD from operating simultaneously.

17.3.5 HUD shall provide at least visual displays of alert signals and information.

17.3.6 All HUD visual displays shall be visible to the SCBA wearer with the SCBA and facepiece properly donned and regardless of the wearer's head movement.

17.3.7 HUD shall not use color as the only means of differentiating between alert signal displays and informational displays.

17.3.8 Visual Alert Signals.

17.3.8.1 HUD shall display visual alert signals for remaining rated cylinder volume specified in 17.3.8.5, and for power source condition specified in 17.3.8.6.

17.3.8.2 In addition to the mandatory visual alert signals specified in 17.3.8.5 and 17.3.8.6, additional visual alert signals to indicate when other status or conditions have occurred shall be permitted.

17.3.8.3 All visual alert signals shall be visible for a minimum of 20 consecutive seconds.

17.3.8.4 Each visual alert signal shall be identifiable, by the SCBA wearer, from any other visual alert signals or other informational displays provided on HUD or on the SCBA.

17.3.8.5 HUD shall display a visual alert signal to indicate 50 percent remaining rated cylinder volume at the percentage of rated service pressure specified in Table 17.3.8.5. This visual alert signal shall visibly flash at a frequency of not less than one per second.

17.3.8.6 Where a power source is used for HUD to comply with the requirements of this standard, HUD shall display a visual alert signal for low power.

Table 17.2.6 EOSTI Activation Based on SCBA Rated Service Pressure

	2216 psig SCBA	3000 psig SCBA	4500 psig SCBA	5500 psig SCBA	6000 psig SCBA
EOSTI Activation	34% ±2% rated service pressure	33% ±2% rated service pressure	31% ±2% rated service pressure	29% ±2% rated service pressure	28% ±2% rated service pressure

Table 17.3.8.5 HUD Indication of Remaining Rated Cylinder Volume Based on SCBA Rated Service Pressure

		2216 psig SCBA	3000 psig SCBA	4500 psig SCBA	5500 psig SCBA	6000 psig SCBA
HUD Visual Alert Signals and Visual Information Displays	100% remaining volume indication	100% +0/−5% rated service pressure	100% +0/−5% rated service pressure	100% +0/−5% rated service pressure	100% +0/−5% rated service pressure	100% +0/−5% rated service pressure
	75% remaining volume indication	74% ±5% rated service pressure	73% ±5% rated service pressure	70% ±5% rated service pressure	67% ±5% rated service pressure	66% ±5% rated service pressure
	50% remaining volume indication	49% ±5% rated service pressure	48% ±5% rated service pressure	45% ±5% rated service pressure	42% ±5% rated service pressure	41% ±5% rated service pressure
	35% remaining volume indication	34% ±2% rated service pressure	33% ±2% rated service pressure	31% ±2% rated service pressure	29% ±2% rated service pressure	28% ±2% rated service pressure

17.3.8.6.1 The low power source visual alert signal shall be independent from and physically distinguishable from the breathing air cylinder content visual alert signal display.

17.3.8.6.2 The low power source visual alert signal shall be displayed at all times when the power source condition is below the level specified in 17.3.8.6 while the HUD is activated.

17.3.8.7 If the SCBA incorporates an optional wireless interface for connection to NFPA 1802-compliant RF devices or NFPA 1802-compliant remote speaker devices/microphones(RSD/RSM), the HUD shall display a visual alert signal when the SCBA loses connection with a paired NFPA 1802-compliant device.

17.3.8.7.1 The wireless interface connection visual alert signal shall be independent from and physically distinguishable from the breathing air cylinder content visual alert signal display.

17.3.9 Visual Informational Displays.

17.3.9.1 HUD shall display visual informational signals for at least breathing air cylinder content as specified in 17.3.9.6.1.

17.3.9.2 In addition to the mandatory visual informational signal specified in 17.3.9.6.1, additional visual informational signals to indicate when other status or conditions have occurred shall be permitted.

17.3.9.3 All visual displays of information shall be permitted to flash at a frequency of not less than one per second for a minimum of 10 consecutive seconds every 60 seconds.

17.3.9.4 Where the visual display is not constantly visible or is not visible for at least 10 consecutive seconds every 60 seconds, the HUD shall be provided with a manual activation of the display. The manual activation shall cause the display to be visible for at least 5 consecutive seconds for each activation.

17.3.9.5 Each visual informational signal shall be identifiable, by the SCBA wearer, from any other informational displays or visual alert signals provided on HUD or on the SCBA.

17.3.9.6 HUD shall display a visual informational signal for breathing air cylinder volume in at least four increments of the cylinder's total rated service volume.

17.3.9.6.1 HUD visual information signals for breathing air cylinder volume shall indicate 100 percent, 75 percent, 50 percent, and 35 percent remaining rated cylinder volume at the percentage of rated service pressure specified in Table 17.3.8.5.

17.3.9.6.2 Where an analog visual display is used, the gauge shall visually indicate the reserve air zone with a red background.

17.3.9.6.3 Where an electronic visual display is used, the gauge shall visually indicate that reserve air is being utilized with a flash at a frequency of not less than one per second for the remaining duration of the cylinder.

17.3.9.7 A display only in units of pressure shall not be permitted.

17.3.9.8 If the SCBA incorporates an optional wireless interface for connection to NFPA 1802-compliant RF devices or NFPA 1802-compliant remote speaker devices/microphones(RSD/RSM), the HUD shall display a visual informational signal to indicate when the SCBA is connected to a paired NFPA 1802-compliant device.

17.4* Rapid Intervention Crew/Company Universal Air Connection (RIC UAC) Design Requirements.

17.4.1 Each SCBA shall be equipped with an RIC UAC male fitting to allow replenishment of breathing air to the SCBA breathing air cylinder.

17.4.2 The RIC UAC male fitting shall meet the requirements specified in 17.4.5, and shall be located on each SCBA in a permanently fixed position.

17.4.3 The distance between the leading edge of the CGA fitting at the outlet of the SCBA cylinder valve and the leading edge of the RIC UAC male fitting shall be a maximum of 100 mm (4 in.).

17.4.4 A separate self-resetting relief valve shall be installed on the SCBA to protect the SCBA against overpressurization.

17.4.5 RIC UAC Male Fitting.

17.4.5.1 The RIC UAC male fitting shall be designed as specified in Figure 17.4.5.1.

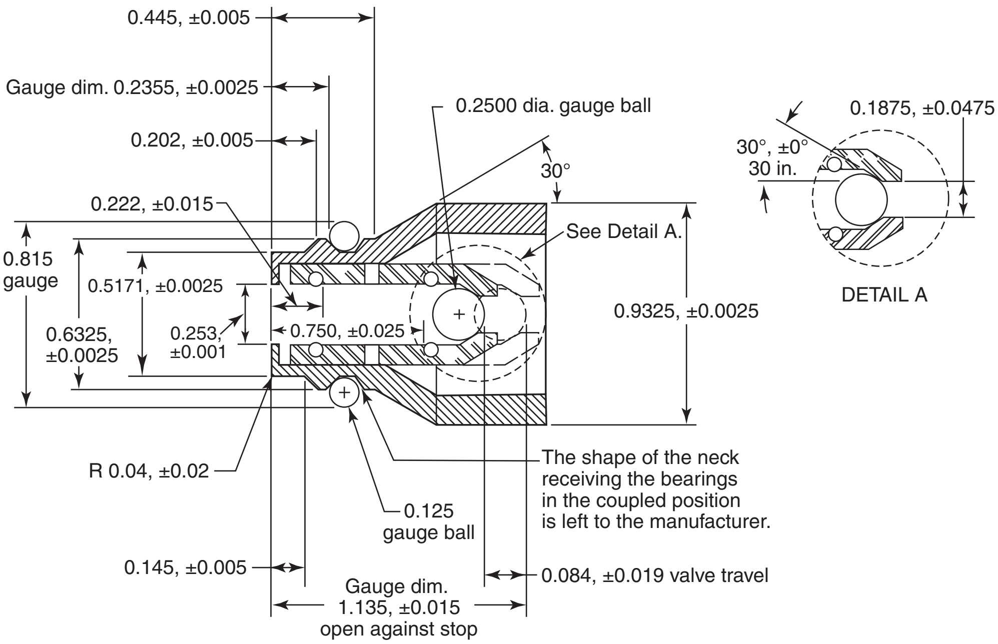


FIGURE 17.4.5.1 RIC UAC Male Fitting (all measurements in inches).

17.4.5.2 The RIC UAC male fitting shall be capable of connecting to any RIC UAC female fitting.

17.4.5.3 The RIC UAC male fitting shall not interfere with any other operation of the SCBA.

17.4.5.4 RIC UAC male fittings shall be equipped with a dust cap or sealing plug to prevent dust, dirt, and debris from entering the fitting and to serve as a leakproof seal.

17.4.6 RIC UAC Female Fitting.

17.4.6.1 The RIC UAC female fitting shall be designed as specified in Figure 17.4.6.1.

17.4.6.2 The RIC UAC female fitting shall be capable of connecting to all RIC UAC male fittings.

17.4.6.3 RIC UAC female fittings shall be equipped with a dust cap or sealing plug to prevent dust, dirt, and debris from entering the fitting and to serve as a leakproof seal.

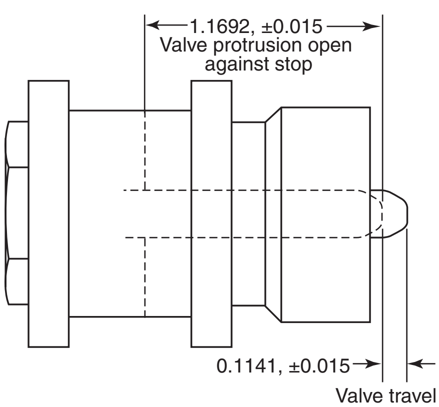


FIGURE 17.4.6.1 RIC UAC Female Fitting (all measurements in inches).

17.4.7 RIC UAC Filling Hose Assembly.

17.4.7.1 Each SCBA manufacturer shall make available an RIC UAC filling hose assembly that consists of a filling hose and a RIC UAC female fitting.

17.4.7.2 The RIC UAC filling hose assembly shall be a high-pressure, 310 bar (4500 psi) assembly designed to replenish breathing air to an SCBA breathing air cylinder.

17.4.7.3 The filling hose shall have an RIC UAC female fitting that meets the requirements specified in 17.4.6, attached to the delivery end.

17.4.8 RIC UAC Coupling.

17.4.8.1 The complete RIC UAC male and female fittings shall constitute the RIC UAC coupling.

17.4.8.2 The RIC UAC coupling shall be capable of connection and disconnection with one hand while subjected to maximum operation pressure.

17.4.8.3 The RIC UAC coupling shall have an operating pressure of at least 310 bar (4500 psi).

17.5 Power Source Design Requirements.

17.5.1 The power source for electronics that are part of the SCBA shall be either a single dedicated source for one device, or shall be a common power source for multiple devices.

17.5.2 Where all electronic devices that are part of the SCBA share a common power source, a single low power source visual alert signal shall be provided and shall be part of the HUD display.

17.5.3 Where multiple but not all electronic devices that are part of the SCBA share a common power source, a low power source visual alert signal shall be located on each of those electronic devices supplied by the common power source, and positioned on each of those electronic devices where it will be seen with the electronic device mounted in its permanent position on the SCBA.

17.5.4 Where an electronic device uses a single, dedicated power source, the low power source visual alert signal shall be located on the electronic device and positioned where it will be seen with the electronic device mounted in its permanent position on the SCBA.

17.5.5 With the exception of HUD displays of low power source visual alert signals specified in 17.5.2, the low power source visual alert signals shall be permitted to be positioned outside of the user's field of vision with the SCBA facepiece properly donned.

17.6 Emergency Breathing Safety System (UEBSS) Design Requirements.

17.6.1 If an SCBA is equipped with an UEBSS, it shall meet the performance requirements of Sections 18.20 and 19.27.

17.6.2 Each UEBSS shall operate off the pressure after the first stage pressure reducer of the SCBA.

17.6.3 The UEBSS shall have an operating pressure range between 5.5 bar (80 psi) and 10.3 bar (150 psi).

17.6.4 The UEBSS shall have bi-directional male and female connections with a check valve feature to prevent inward contaminants.

17.6.4.1 The UEBSS male fitting shall be designed as specified in Figure 17.6.4.1, or equivalent.

17.6.4.2 The UEBSS female fitting shall be designed as specified in Figure 17.6.4.1, or equivalent.

17.6.5 The UEBSS pressure hose shall have a minimum length of 0.51 m (20 in.).

17.6.6 The UEBSS shall be removable from storage by the wearer using a single hand in a one-directional pull.

17.6.7 The UEBSS shall require only one action for connection of the donor's fitting to the receiving SCBA's fitting.

17.6.8 The UEBSS shall require two distinctive actions to disconnect the fitting between the donor SCBA and receiving SCBA.

17.6.9 The UEBSS fitting(s) shall be equipped with a dust cap or sealing plug to prevent dust, dirt, and debris from entering the fitting(s).

17.6.10 The connection of two UEBSS shall be independent of the facepieces.

17.6.11 The UEBSS access location shall be readily visible to an assisting firefighter.

17.6.11.1 The UEBSS access location shall be marked UEBSS in letters that contrast with its background.

17.6.11.1.1 The letters shall be at least 25 mm (1 in.) in height.

17.7 Accessories Design Requirements.

17.7.1 Items attached to or integrated with SCBA that are not required for the SCBA to meet the requirements of this standard shall be considered as accessories.

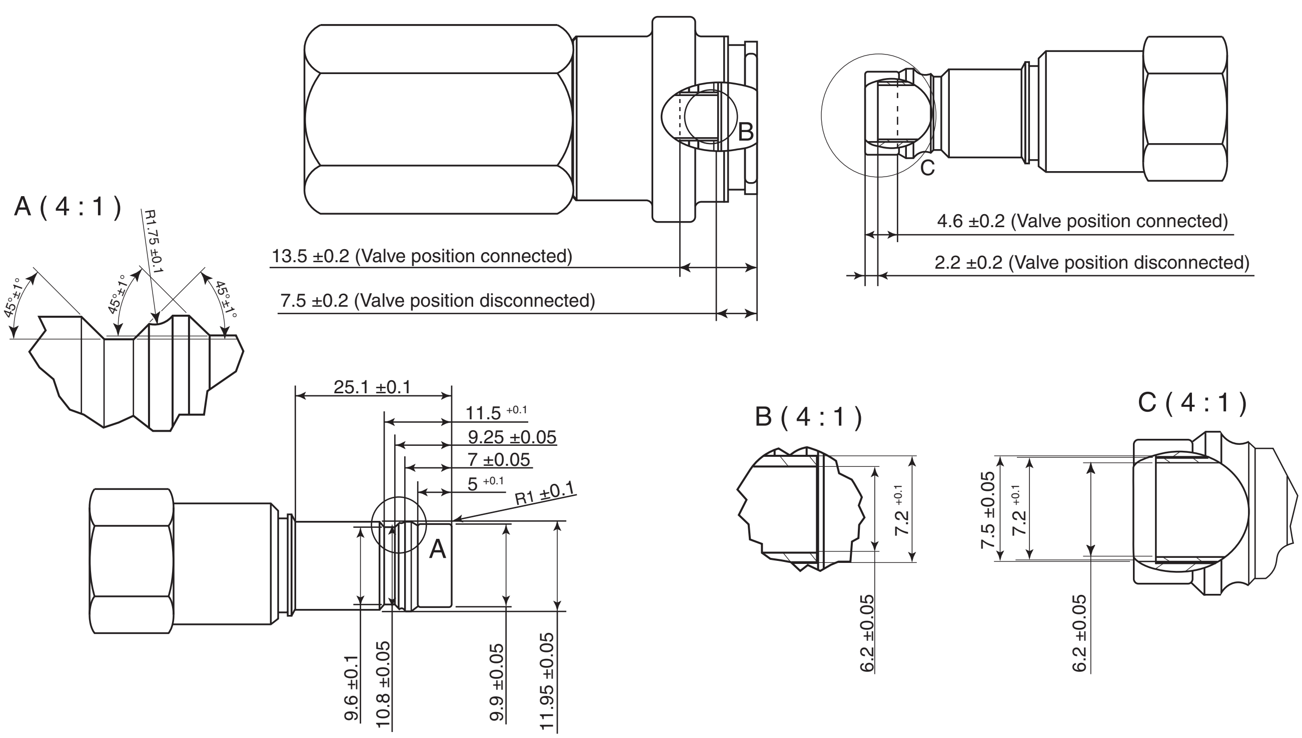


FIGURE 17.6.4.1 UEBSS Male and Female Fitting.

17.7.2 All accessories attached to or integrated with SCBA shall be certified by NIOSH in accordance with 42 CFR 84 for use with that specific SCBA.

17.7.3 Any accessories attached to SCBA shall not interfere with the function of the SCBA or with the function of any of the SCBA's component parts.

17.7.4 Where SCBA are provided with an accessory or accessories that are attached to or integrated with the SCBA, the SCBA, with accessories installed, shall meet all of the design and performance requirements of this standard.

17.7.5 In all cases, such accessories shall not degrade the performance of the SCBA.

Chapter 18 Performance Requirements (NFPA 1981)

18.1* Airflow Performance.

18.1.1 SCBA shall be tested for airflow performance as specified in Section 19.1, Airflow Performance Test, and the SCBA facepiece pressure shall not be less than 0.0 mm (0.0 in.) water column and shall not be greater than 89 mm (3½ in.) water column above ambient pressure from the time the test begins until the time the test is concluded.

18.1.2 SCBA shall be tested for activation of EOSTI during the airflow performance testing specified in Section 19.1, Airflow Performance Test, and each EOSTI shall activate as specified in 17.2.2 and shall continue to operate throughout the remainder of the airflow performance test.

18.1.3 The SCBA shall be tested for proper functioning of the HUD breathing air cylinder content informational display and visual alert signals during the airflow performance testing specified in Section 19.1, Airflow Performance Test, and the HUD shall display the visual information for the breathing air cylinder content as specified in 17.3.9.6 and shall display the visual alert signal as specified in 17.3.8.5.

18.2 Environmental Temperature Performance.

18.2.1 SCBA shall be tested for environmental temperature performance as specified in Section 19.2, Environmental Temperature Tests.

18.2.1.1 SCBA shall be tested for cold environment as specified in 19.2.5.5, Test 1, and the SCBA facepiece pressure shall not be less than 0.0 mm (0.0 in.) water column from the time the test begins until the time the test is concluded, the SCBA facepiece pressure shall not be greater than 89 mm (3½ in.) water column above ambient pressure from the time the test begins until the time the test is concluded, and the data logging functions specified in 17.1.12(1) through 17.1.12(4) shall be operating properly.

18.2.1.2 SCBA shall be tested for hot environment as specified in 19.2.5.6, Test 2, and the SCBA facepiece pressure shall not be less than 0.0 mm (0.0 in.) water column from the time the test begins until the time the test is concluded, the SCBA facepiece pressure shall not be greater than 89 mm (3½ in.) water column above ambient pressure from the time the test begins until the time the test is concluded, and the data logging functions specified in 17.1.12(1) through 17.1.12(4) shall be operating properly.

18.2.1.3 SCBA shall be tested for hot-to-cold environment as specified in 19.2.5.7, Test 3, and the SCBA facepiece pressure shall not be less than 0.0 mm (0.0 in.) water column from the time the test begins until the time the test is concluded, the SCBA facepiece pressure shall not be greater than 89 mm (3½ in.) water column above ambient pressure from the time the test begins until the time the test is concluded, and the data logging functions specified in 17.1.12(1) through 17.1.12(4) shall be operating properly.

18.2.1.4 SCBA shall be tested for cold-to-hot environment as specified in 19.2.5.8, Test 4, and the SCBA facepiece pressure shall not be less than 0.0 mm (0.0 in.) water column from the time the test begins until the time the test is concluded, the SCBA facepiece pressure shall not be greater than 89 mm (3½ in.) water column above ambient pressure from the time the test begins until the time the test is concluded, and the data logging functions specified in 17.1.12(1) through 17.1.12(4) shall be operating properly.

18.2.2 SCBA shall be tested for activation of EOSTI during the environmental temperature performance as specified in Section 19.2, Environmental Temperature Tests.

18.2.2.1 SCBA shall be tested for cold environment as specified in 19.2.5.5, Test 1, and each EOSTI shall activate as specified in 17.2.2 and shall continue to operate throughout the remainder of the airflow performance test.

18.2.2.2 SCBA shall be tested for hot environment as specified in 19.2.5.6, Test 2, and each EOSTI shall activate as specified in 17.2.2 and shall continue to operate throughout the remainder of the airflow performance test.

18.2.2.3 SCBA shall be tested for hot-to-cold environment as specified in 19.2.5.7, Test 3, and each EOSTI shall activate as specified in 17.2.2 and shall continue to operate throughout the remainder of the airflow performance test.

18.2.2.4 SCBA shall be tested for cold-to-hot environment as specified in 19.2.5.8, Test 4, and each EOSTI shall activate as specified in 17.2.2 and shall continue to operate throughout the remainder of the airflow performance test.

18.2.3 SCBA shall be tested for the proper functioning of the HUD breathing air cylinder content informational display and the visual alert signal during the environmental temperature performance as specified in Section 19.2, Environmental Temperature Tests.

18.2.3.1 SCBA shall be tested for cold environment as specified in 19.2.5.5, Test 1, and the HUD shall display the visual information for the breathing air cylinder content as specified in 17.3.9.6 and shall display the visual alert signal as specified in 17.3.8.5.

18.2.3.2 SCBA shall be tested for hot environment as specified in 19.2.5.6, Test 2, and the HUD shall display the visual information for the breathing air cylinder content as specified in 17.3.9.6 and shall display the visual alert signal as specified in 17.3.8.5.

18.2.3.3 SCBA shall be tested for hot-to-cold environment as specified in 19.2.5.7, Test 3, and the HUD shall display the visual information for the breathing air cylinder content as specified in 17.3.9.6 and shall display the visual alert signal as specified in 17.3.8.5.

18.2.3.4 SCBA shall be tested for cold-to-hot environment as specified in 19.2.5.8, Test 4, and the HUD shall display the visual information for the breathing air cylinder content as specified in 17.3.9.6 and shall display the visual alert signals as specified in 17.3.8.5.

18.3 Vibration Resistance Performance.

18.3.1 SCBA shall be tested for vibration resistance as specified in Section 19.3, Vibration Test, and the SCBA facepiece pressure shall not be less than 0.0 mm (0.0 in.) water column from the time the test begins until the time the test is concluded, the SCBA facepiece pressure shall not be greater than 89 mm (3½ in.) water column above ambient pressure from the time the test begins until the test is concluded, the SCBA shall not have movement of the CGA fittings causing a break of any width in the line, and the data logging functions specified in 17.1.12(1) through 17.1.12(4) shall be operating properly.

18.3.2 SCBA shall be tested for activation of EOSTI during the vibration testing specified in Section 19.3, Vibration Test, and each EOSTI shall activate as specified in 17.2.2 and shall continue to operate throughout the remainder of the airflow performance test.

18.3.3 The SCBA shall be tested for proper functioning of the HUD breathing air cylinder content informational display and visual alert signals during the vibration testing specified in Section 19.3, Vibration Test, and the HUD shall display the visual information for the breathing air cylinder content as specified in 17.3.9.6 and shall display the visual alert signal as specified in 17.3.8.5.

18.4 Fabric Flame Resistance Performance. All fabric components of SCBA that are used to secure the SCBA to the wearer shall be tested for flame resistance as specified in Section 19.4, Fabric Flame Tests, and shall have an average char length of not more than 100 mm (4 in.), shall have an average afterflame of not more than 2.0 seconds, and shall not melt or drip.

18.5 Fabric Heat Resistance Performance. All fabric components of SCBA that are used to secure the SCBA to the wearer shall be tested for heat resistance as specified in Section 19.5, Fabric Heat Tests, and shall not melt or ignite.

18.6 Thread Heat Resistance Performance. All thread used in SCBA components shall be tested for heat resistance as specified in Section 19.6, Thread Heat Test, and shall not melt or ignite.

18.7 Corrosion Resistance Performance.

18.7.1 SCBA shall be tested for corrosion resistance as specified in Section 19.7, Accelerated Corrosion Test, and any corrosion shall not prohibit the proper use and function, as specified in the manufacturer's instructions, of any control or operating feature of the SCBA.

18.7.2 SCBA shall be tested for corrosion resistance as specified in Section 19.7, Accelerated Corrosion Test, and the SCBA facepiece pressure shall not be less than 0.0 mm (0.0 in.) water column from the time the test begins until the time the test is concluded, the SCBA facepiece pressure shall not be greater than 89 mm (3½ in.) water column above ambient pressure from the time the test begins until the time the test is concluded, and the data logging functions specified in 17.1.12(1) through 17.1.12(4) shall be operating properly.

18.7.3 SCBA shall be tested for activation of EOSTI during the corrosion resistance testing specified in Section 19.7, Accelerated Corrosion Test, and each EOSTI shall activate as specified in 17.2.2 and shall continue to operate throughout the remainder of the airflow performance test.

18.7.4 The SCBA shall be tested for proper functioning of the HUD breathing air cylinder content informational display and visual alert signals during the corrosion resistance testing specified in Section 19.7, Accelerated Corrosion Test, and the HUD shall display the visual information for the breathing air cylinder content as specified in 17.3.9.6 and shall display the visual alert signal as specified in 17.3.8.5.

18.8 Particulate Resistance Performance.

18.8.1 SCBA shall be tested for particulate resistance as specified in Section 19.8, Particulate Test, and the SCBA facepiece pressure shall not be less than 0.0 mm (0.0 in.) water column and shall not be greater than 89 mm (3½ in.) water column above ambient pressure from the time the test begins until the time the test is concluded.

18.8.2 SCBA shall be tested for activation of EOSTI during the particulate resistance testing specified in Section 19.8, Particulate Test, and the EOSTI shall activate as specified in 17.2.2 and shall continue to operate throughout the remainder of the airflow performance test.

18.8.3 SCBA shall be tested for proper functioning of the HUD breathing air cylinder content informational display and visual alert signals during the particulate resistance testing specified in Section 19.8, Particulate Test, and the HUD shall display the visual information for the breathing air cylinder content as specified in 17.3.9.6 and shall display the visual alert signal as specified in 17.3.8.5.

18.9* Facepiece Lens Abrasion Resistance Performance. SCBA facepiece lenses shall be tested for abrasion resistance as specified in Section 19.9, Facepiece Lens Abrasion Test, and the average value of the tested specimens shall not exhibit a delta haze greater than 14 percent.

18.10* Nonelectronic Communications Performance Requirements. The SCBA voice communications system shall be tested for communications performance as specified in Section 19.10, Nonelectronic Communications Test, and shall have a Speech Transmission Index (STI) average value of not less than 0.55.

18.11 Heat and Flame Resistance Performance.

18.11.1 SCBA shall be tested for heat and flame resistance as specified in Section 19.11, Heat and Flame Test, and the SCBA facepiece pressure shall not be less than 0.0 mm (0.0 in.) water column from the time the test begins until the time the test is concluded, the SCBA facepiece pressure shall not be greater than 89 mm (3½ in.) water column above ambient pressure from the time the test begins until the time the test is concluded, and the data logging functions specified in 17.1.12(1) through 17.1.12(4) shall be operating properly.

18.11.2 SCBA and SCBA accessories shall be tested for heat and flame resistance as specified in Section 19.11, Heat and Flame Test, and no components of the SCBA and no accessories shall have an afterflame of more than 2.2 seconds.

18.11.3 SCBA shall be tested for heat and flame resistance as specified in Section 19.11, Heat and Flame Test, and no component of the SCBA shall separate or fail in such a manner that would cause the SCBA to be worn and used in a position not specified by the manufacturer's instructions.

18.11.4 The SCBA facepiece shall be tested for heat and flame resistance as specified in Section 19.11, Heat and Flame Test, and the facepiece lens shall not obscure vision below the 20/100 vision criterion.

18.11.5 SCBA shall be tested for activation of EOSTI during the heat and flame resistance testing specified in Section 19.11, Heat and Flame Test, and each EOSTI shall activate as specified in 17.2.2 and shall continue to operate throughout the remainder of the airflow performance test.

18.11.6 SCBA shall be tested for functioning of the HUD breathing air cylinder content informational display and visual alert signals during the heat and flame resistance testing specified in Section 19.11, Heat and Flame Test, and the HUD shall display the visual information for the breathing air cylinder content as specified in 17.3.9.6 and shall display the visual alert signal as specified in 17.3.8.5.

18.12 Carbon Dioxide (CO_2) Content Performance. SCBA facepieces shall be tested for CO_2 content as specified in Section 19.12, Facepiece Carbon Dioxide Content Test, and the CO_2 content in the inhalation air shall not be greater than 1.0 percent by volume.

18.13 Additional SCBA EOSTI Performance.

18.13.1 EOSTI Independent Activation.

18.13.1.1 Each EOSTI shall be tested for independent activation as specified in Section 19.13, EOSTI Independent Activation Test, and the activation of the alarm of each EOSTI shall be independent of any other EOSTI.

18.13.1.2 After activation of the unblocked EOSTI, the alarm signal shall remain active at least until the cylinder pressure drops below 20 bar (290 psi).

18.13.2 EOSTI Alarm Recognition. Each EOSTI shall be tested for alarm recognition as specified in Section 19.14, EOSTI Recognition Test, and the EOSTI alarm signal shall be recognized in 10 seconds or less.

18.14 Additional SCBA HUD Performance.

18.14.1 Where HUD incorporates exposed wiring, the wire's entry into any associated components shall be tested for connection strength as specified in Section 19.15, HUD Wiring Connection Strength Test, and the HUD shall remain functional.

18.14.2 Where a power source is used for HUD to comply with the requirements of this standard, HUD shall be tested for functioning of visual alert signals and visual information displays as specified in Section 19.16, and HUD shall continue to function at maximum power consumption for a minimum of 1 hour following the activation of the HUD low power source visual alert signal and shall display the visual alert signals specified in 17.3.8.5 and 17.3.8.6 and shall display the visual information for the breathing air cylinder content as specified in 17.3.9.6.

18.14.3 HUD shall be tested for wearer visibility as specified in Section 19.17, HUD Visibility Test, and each informational display and visual alert signal shall be observable, distinct, and identifiable in both darkness and bright light.

18.14.4 Where the HUD displays are external to the facepiece and the gap between the HUD display and the facepiece lens is greater than 1 mm (1⁄32 in.), HUD displays shall be tested for wearer visibility while obscured as specified in Section 19.18, HUD Obscuration Test, and each informational display and visual alert signal shall be observable, distinct, and identifiable.

18.14.5 HUD shall be tested for disabling glare as specified in Section 19.19, HUD Disabling Glare Test, and the test subject shall be able to read at least 9 out of 10 selected letters when each visual alert signal is activated.

18.15 RIC UAC Performance Requirements.

18.15.1 SCBA shall be tested for cylinder refill breathing performance as specified in Section 19.20, Cylinder Refill Breathing Performance Test, and the SCBA facepiece pressure shall not be less than 0.0 mm (0.0 in.) water column and shall not be greater than 89 mm (3½ in.) water column above ambient pressure from the time the test begins until the time the test is concluded.

18.15.2 SCBA shall be tested for RIC UAC system fill rate performance as specified in Section 19.21, RIC UAC System Fill Rate Test, and the maximum allowable fill time shall be 3.0 minutes.

18.15.3 The RIC UAC system connection shall be tested for accessibility as specified in Section 19.23, Cylinder Connections and Accessibility Test, and the RIC UAC shall be connected in a maximum of 15 seconds and shall disconnect in a maximum of 15 seconds.

18.16 Breathing Air Cylinder Performance Requirements.

18.16.1 The SCBA backframe and cylinder retention device shall be tested for breathing air cylinder and valve assembly retention security as specified in Section 19.22, Breathing Air Cylinder and Valve Assembly Retention Test, and the cylinder and valve assembly shall not change position by more than 25 mm (1 in.).

18.16.2 The SCBA cylinder valve connection shall be tested for accessibility, attachment, and detachment as specified in Section 19.23, Cylinder Connections and Accessibility Test, and the cylinder and valve assembly shall fully attach to the SCBA in less than 30 seconds, and the cylinder and valve assemble shall fully detach from the SCBA in less than 30 seconds.

18.16.3 The SCBA RIC UAC connections shall be tested for accessibility, attachment, and detachment as specified in Section 19.23, Cylinder Connections and Accessibility Test, and the breathing air fill hose shall fully attach to the RIC UAC connection in less than 15 seconds, and the breathing air fill hose shall fully detach from the RIC UAC connection in less than 15 seconds.

18.17 Supplementary Voice Communications System Performance Requirements. The SCBA voice communications system, as identified by the SCBA manufacturer, shall be tested for communication performance as specified in Section 19.25, Supplementary Voice Communications System Performance Test, and shall have a Speech Transmission Index (STI) average value of not less than 0.60.

18.18 Heat and Immersion Leakage Performance Requirements. SCBA electronics shall be tested for resistance to heat and water ingress as specified in Section 19.24, Heat and Immersion Leakage Test, and the electronics shall function properly in accordance with the SCBA manufacturer's instructions for normal use, all power source compartments or enclosures shall remain dry, and the data logging functions specified in 17.1.12(1) through 17.1.12(4) shall be operating properly.

18.19 Low Power Capacity. Where power sources are used to comply with the requirements of this standard, electronic devices shall be tested for proper functioning during low power capacity as specified in Section 19.26, and shall continue to function at maximum power consumption for a minimum of 1 hour following the activation of the low power source visual alert signal.

18.20 Emergency Breathing Safety System Cold Temperature Performance Requirements.

18.20.1 The donor and receiving SCBA shall be tested independently for airflow performance as specified in Section 19.27, Emergency Breathing Safety System Cold

Temperature Performance Test, and the SCBA facepiece pressure shall not be less than 0.0 mm (0.0 in.) water column and shall not be greater than 89 mm (3½ in.) water column above ambient pressure from the time the test begins until the time the test is concluded.

18.20.2 Each SCBA shall be tested independently for activation of EOSTI during the airflow performance testing specified in Section 19.1, Airflow Performance Test, and each EOSTI shall activate as specified in 17.2.2 and shall continue to operate throughout the remainder of the airflow performance test.

18.20.3 Each SCBA shall be tested independently for proper functioning of the HUD breathing air cylinder content informational display and visual alert signals during the airflow performance testing specified in Section 19.1, Airflow Performance Test, and the HUD shall display the visual information for the breathing air cylinder content as specified in 17.3.9.6 and shall display the visual alert signal as specified in 17.3.8.5.

18.20.4 The SCBA classified as the donor shall start at full cylinder pressure, and the SCBA classified as the receiving SCBA shall have a pressure of 7 bar, +0.6 bar/–0 bar (100 psi, +10 psi/–0).

18.20.5 Both SCBA shall be connected through the UEBSS and shall be tested for cold environment as specified in Section 19.27, Emergency Breathing Safety System Cold Temperature Performance Test, and the SCBA facepiece pressure shall not be less than 0.0 mm (0.0 in.) water column and shall not be greater than 89 mm (3 ½ in.) water column above ambient pressure from the time the test begins until the time the test is concluded.

18.20.6 The donor SCBA shall be tested for activation of EOSTI during the environmental temperature performance as specified in Section 19.27, Emergency Breathing System Cold Temperature Performance Test.

18.20.7 The donor SCBA shall be tested for the proper functioning of the HUD breathing air cylinder content informational display and the visual alert signal during the environmental temperature performance as specified in Section 19.27, Emergency Breathing System Cold Temperature Performance Test.

18.21 Lens Radiant Heat Resistance Performance.

18.21.1 SCBA shall be tested for lens radiant heat resistance as specified in Section 19.28, Lens Radiant Heat Test. SCBA facepiece pressure shall not be less than 0.0 mm (0.0 in.) water column and shall not be greater than 89 mm (3 ½ in.) water column above ambient pressure from the time the test begins until the time the test is concluded.

18.21.2 The duration of the test as specified in Section 19.28, Lens Radiant Heat Test, shall not be less than 80 percent of the NIOSH-rated duration for the lowest volume cylinder offered for the SCBA.

18.22 Elevated Temperature Heat and Flame Resistance Performance.

18.22.1 SCBA shall be tested for lens heat and flame resistance as specified in Section 19.29, Elevated Temperature Heat and Flame Resistance Test. SCBA facepiece pressure shall not be less than 0.0 mm (0.0 in.) water column and shall not be greater than 89 mm (3 ½ in.) water column above ambient pressure from the time the test begins until the time the test is concluded.

18.22.2 The duration of the test as specified in Section 19.29, Elevated Temperature Heat and Flame Resistance Test, shall not be less than 80 percent of the NIOSH-rated duration for the lowest volume cylinder offered for the SCBA.

18.23* Strength of Interface Between Facepiece and Second Stage Regulator Performance.

18.23.1 The SCBA facepiece and second stage regulator shall be tested for strength of interface as specified in Section 19.30, Strength of Interface Between Facepiece and Second Stage Regulator Test, and all components, with the exception of wiring components, shall remain connected.

Chapter 19 Test Methods (NFPA 1981)

19.1 Airflow Performance Test.

19.1.1 Application. This test method shall apply to complete SCBA.

19.1.2 Samples. Each sample shall be tested as specified in 15.3.2.

19.1.3 Specimen Preparation.

19.1.3.1 Specimens for conditioning shall be complete SCBA.

19.1.3.2 Prior to testing, specimens shall be conditioned for a minimum of 4 hours at an ambient temperature of 22°C, ±3°C (72°F, ±5°F), and relative humidity (RH) of 50 percent, ±25 percent.

19.1.3.3* The air used in the SCBA breathing air cylinders shall comply with the air quality requirements of NFPA 1989.

19.1.4 Apparatus.

19.1.4.1 A test headform as specified in Figure 19.1.4.1, or equivalent, shall be used.

19.1.4.2 A pressure probe shall be attached to the test headform to monitor facepiece pressure.

19.1.4.2.1 The pressure probe shall be a 6.5 mm (¼ in.) O.D. with a 1.5 mm (1⁄16 in.) wall thickness metal tube having one open end and one closed end, or equivalent.

19.1.4.2.2 The closed end of the pressure probe shall have four equally spaced holes, each 1.5 mm, ±0.1 mm (1⁄16 in., ±0.0 in.), and each shall be positioned 6.5 mm, ±0.4 mm (¼ in., ±0.0 in.) from the end of the pressure probe, or equivalent.

19.1.4.2.3 The closed end of the pressure probe shall extend through the test headform, exiting out the center of the left eye.

19.1.4.2.4 The pressure probe shall extend 13 mm, +1.5 mm/−0 mm (½ in., +1⁄16 in./−0 in.) outward from the surface of the center of the left eye.

19.1.4.3 A length of tubing, including connections, of a 1.5 m (5 ft) length with a nominal 5 mm (3⁄16 in.) I.D. flexible smoothbore tubing with a nominal 1.5 mm (1⁄16 in.) wall thickness shall be permitted to be connected to the open end of the pressure probe and to the inlet of the pressure transducer.

19.1.4.4 A differential pressure transducer having the following characteristics shall be used:

(1) Range: 225 mm (8.9 in.) of water differential
(2) Linearity: ±0.5 percent full-scale (FS) best straight line
(3) Line pressure effect: less than 1 percent FS zero shift/1000 psig
(4) Output: ±2.5 Vdc for +FS
(5) Output ripple: 10 mV peak to peak
(6) Regulation: FS output shall not change more than ±0.1 percent for input voltage change from 22 to 35 Vdc
(7) Temperature, operating: −54°C to 121°C (−65°F to 250°F)
(8) Temperature, compensated: −18°C to 71°C (0°F to 160°F)
(9) Temperature effects: within 2 percent FS/55.6°C (100°F) error band

19.1.4.5 Recorders.

19.1.4.5.1 Mechanical Strip Recorder. The differential pressure transducer shall be connected to a strip chart or digital recorder having the following characteristics:

(1) Chart width of 250 mm (mechanically or digitally)
(2) Pen or digital speed of at least 750 mm/sec
(3) Accuracy of ±0.25 percent FS
(4) Input voltage range of 1 V FS
(5) Span set at 25 mm (1 in.) of chart per 25.4 mm (1 in.) water column

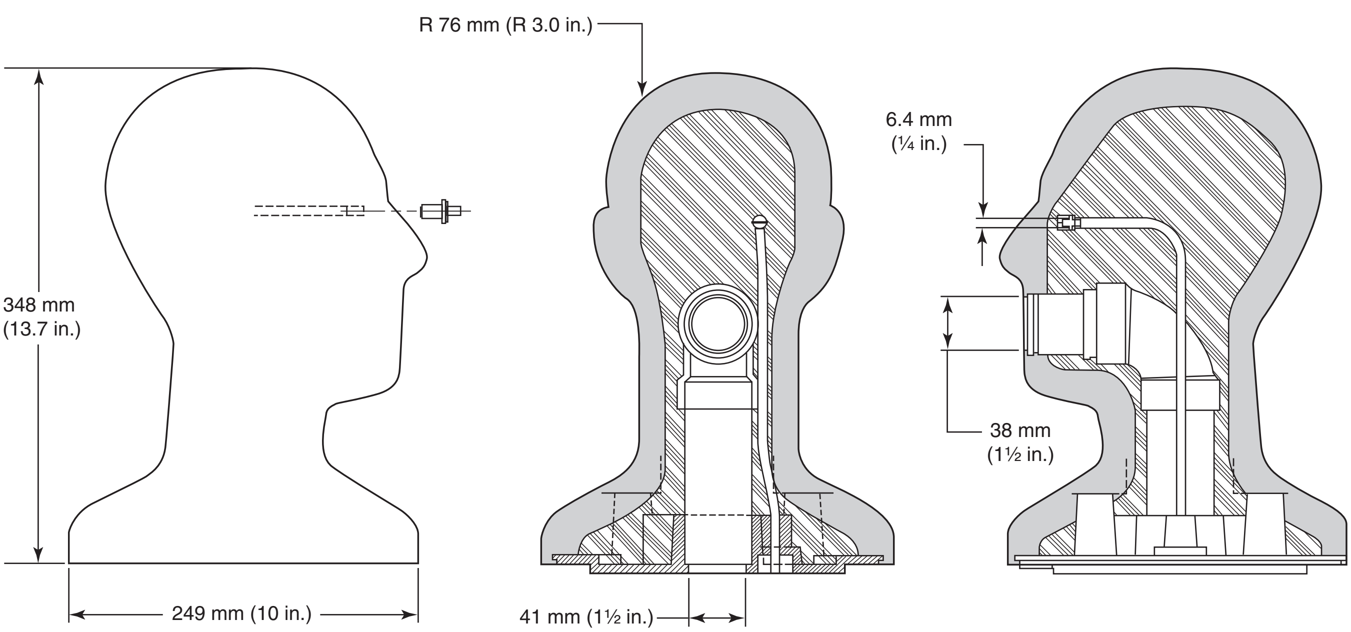


FIGURE 19.1.4.1 Test Headform.

19.1.4.5.2 Digital Recorder.

19.1.4.5.2.1 All pressure and other applicable measurements shall be made using a Vdc digital acquisition input module with the following requirements:

(1) Measurement type: referenced single end
(2) Number of channels: greater than or equal to eight referenced single ended
(3) ADC resolution: greater than or equal to 12 bits
(4) Vdc input range: ±5 Vdc
(5) Accuracy at full scale: less than or equal to 3230 μV at full scale
(6) Sample rate: greater than or equal to 1 kS/s

19.1.4.5.2.2 A digital IIR filter second order Butterworth Low Pass 5 Hz lower cutoff shall be applied to all measurements.

19.1.4.6 The test headform shall be equipped with a breathing passage.

19.1.4.6.1 The breathing passage shall lead from the mouth of the test head to the lung, or equivalent.

19.1.4.6.2 The volume of dead space in the breathing system shall be kept to a minimum.

19.1.4.6.3 The breathing passage shall be located on the centerline of the mouth and shall be flush with the test headform.

19.1.4.7 The breathing passage shall extend a minimum of 200 mm (8 in.) and a maximum of 450 mm (18 in.).

19.1.4.8 Where flexible smooth-bore tubing is used from the metal breathing tube to the inlet connection of the breathing machine, it shall have a maximum length of 1.2 m (4 ft) and a 19 mm (¾ in.) I.D. with a nominal 3 mm (⅛ in.) wall thickness.

19.1.4.8.1 When 19.2.5.5.2 of the environmental temperature test and 19.27.5.5 of the emergency breathing safety system cold temperature performance test are performed, air exhaled through the headform shall be conditioned to an average temperature of 27°C, ±6°C (80°F, ±10°F) when measured at the breathing passage outlet at the mouth of the test headform. *(See Figure 19.1.4.8.1)*.

19.1.4.9 The breathing machine shown in Figure 19.1.4.9, or equivalent, shall be used.

19.1.4.9.1 The breathing machine shall have the capability to conduct breathing resistance testing at 40 L/min, ±1.0 L/min and 103 L/min, ±3.0 L/min.

19.1.4.9.2 The tidal volume of the lung, or equivalent, shall determine the volume of air moved during each inhalation/exhalation cycle.

19.1.4.9.3 The airflow shall be determined by three factors:

(1) Number of inhalation/exhalation cycles per minute
(2) Tidal volume of the lung, or equivalent
(3) Breathing waveform

19.1.4.9.4 The breathing waveform shall be produced by the compression of a lung, or equivalent.

19.1.4.9.5 Inspired and expired volumes as a function of time shall be incorporated in accordance with the values given in

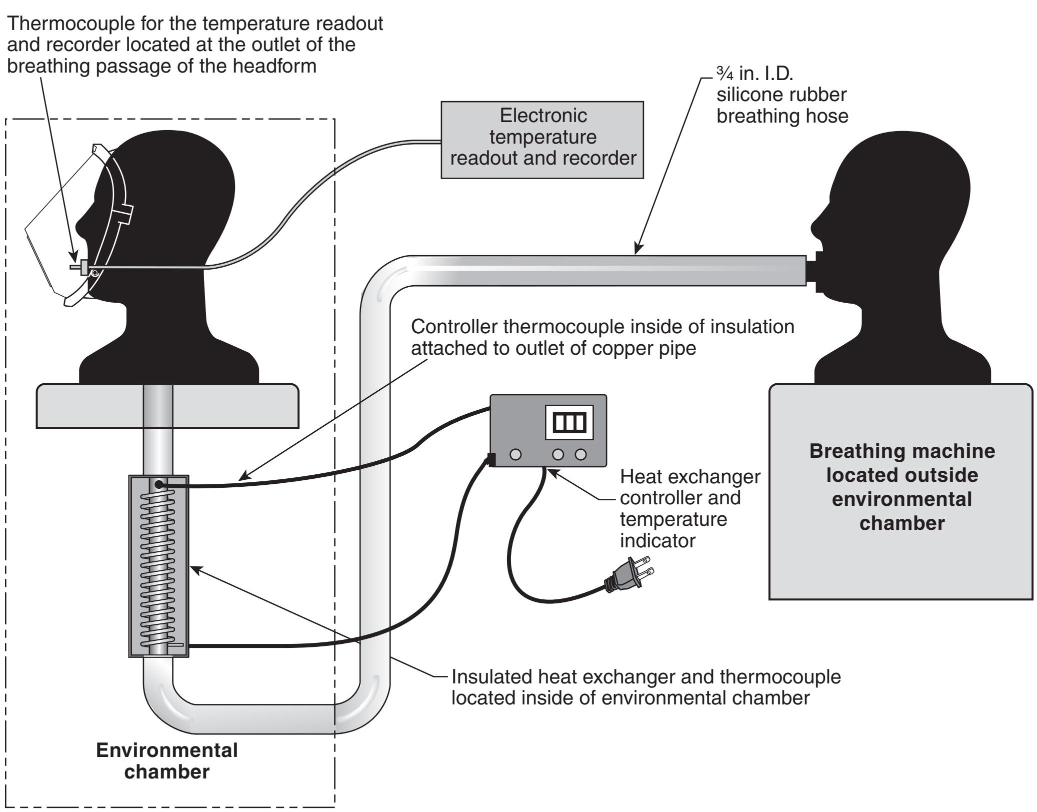


FIGURE 19.1.4.8.1 Cold Temperature Performance Test.

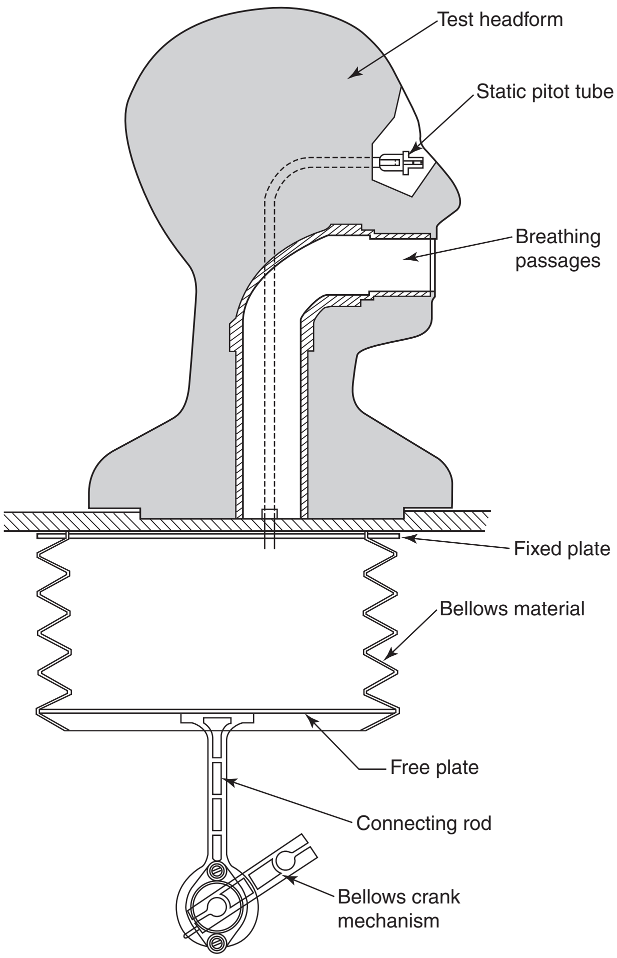


FIGURE 19.1.4.9 Breathing Machine.

Table 19.1.4.9.5(a) and Table 19.1.4.9.5(b) as a function of time for 103 L/min volume and 40 L/min volume work rates.

19.1.4.9.6 Switching between the two work rates shall be performed within 10 seconds.

19.1.4.9.7 The construction of the breathing machine shall be such that the respiration rate, tidal volume, peak flow, and face-piece pressure measurement system accuracy are unaffected by temperature changes caused by the environmental airflow performance tests as specified in Section 19.2.

19.1.5 Procedure.

19.1.5.1* The test setup for conducting the airflow performance test shall be calibrated at least once each day before tests are conducted and shall be verified at least once each day after testing.

19.1.5.1.1 The calibration procedure utilized for the differential pressure transducer shall consist of confirmation of at least three different pressures between 0 mm and 125 mm (0 in. and 5 in.) water column.

19.1.5.1.2 The pressure shall be measured using an incline manometer or equivalent with a scale measuring in increments of ±0.5 mm (±0.02 in.) water column or less.

Table 19.1.4.9.5(a) Breathing Waveforms for 103 L/min Volume Work Rate

Step No.	Time (sec)	Inspire/ Expire	Volume (L, ±0.1 L)	Volume Change (L, ±5%)
0	0.00	—	−1.7	−0.012
1	0.02	Inspire	−1.688	0.012
2	0.04	Inspire	−1.662	0.025
3	0.06	Inspire	−1.626	0.036
4	0.08	Inspire	−1.581	0.045
5	0.10	Inspire	−1.529	0.052
6	0.12	Inspire	−1.471	0.058
7	0.14	Inspire	−1.409	0.062
8	0.16	Inspire	−1.345	0.064
9	0.18	Inspire	−1.277	0.068
10	0.20	Inspire	−1.207	0.07
11	0.22	Inspire	−1.134	0.073
12	0.24	Inspire	−1.059	0.075
13	0.26	Inspire	−0.984	0.076
14	0.28	Inspire	−0.906	0.077
15	0.30	Inspire	−0.828	0.079
16	0.32	Inspire	−0.748	0.08
17	0.34	Inspire	−0.667	0.081
18	0.36	Inspire	−0.586	0.081
19	0.38	Inspire	−0.504	0.082
20	0.40	Inspire	−0.421	0.083
21	0.42	Inspire	−0.337	0.084
22	0.44	Inspire	−0.254	0.084
23	0.46	Inspire	−0.169	0.085
24	0.48	Inspire	−0.085	0.085
25	0.50	Inspire	0	0.085
26	0.52	Inspire	0.085	0.085
27	0.54	Inspire	0.169	0.085
28	0.56	Inspire	0.254	0.085
29	0.58	Inspire	0.337	0.084
30	0.60	Inspire	0.421	0.084
31	0.62	Inspire	0.504	0.083
32	0.64	Inspire	0.586	0.082
33	0.66	Inspire	0.667	0.081
34	0.68	Inspire	0.748	0.081
35	0.70	Inspire	0.828	0.08
36	0.72	Inspire	0.906	0.079
37	0.74	Inspire	0.984	0.077
38	0.76	Inspire	1.059	0.076
39	0.78	Inspire	1.134	0.075
40	0.80	Inspire	1.207	0.073
41	0.82	Inspire	1.277	0.07
42	0.84	Inspire	1.345	0.068
43	0.86	Inspire	1.409	0.064
44	0.88	Inspire	1.471	0.062
45	0.90	Inspire	1.529	0.058
46	0.92	Inspire	1.581	0.052
47	0.94	Inspire	1.626	0.045
48	0.96	Inspire	1.662	0.036
49	0.98	Inspire	1.688	0.025
50	1.00	—	1.7	0.012
51	1.02	Expire	1.688	−0.012
52	1.04	Expire	1.662	−0.025
53	1.06	Expire	1.626	−0.036
54	1.08	Expire	1.581	−0.045
55	1.10	Expire	1.529	−0.052
56	1.12	Expire	1.471	−0.058
57	1.14	Expire	1.409	−0.062
58	1.16	Expire	1.345	−0.064

(continues)

Table 19.1.4.9.5(a) ***Continued***

Step No.	Time (sec)	Inspire/ Expire	Volume (L, ±0.1 L)	Volume Change (L, ±5%)
59	1.18	Expire	1.277	−0.068
60	1.20	Expire	1.207	−0.07
61	1.22	Expire	1.134	−0.073
62	1.24	Expire	1.059	−0.075
63	1.26	Expire	0.984	−0.076
64	1.28	Expire	0.906	−0.077
65	1.30	Expire	0.828	−0.079
66	1.32	Expire	0.748	−0.08
67	1.34	Expire	0.667	−0.081
68	1.36	Expire	0.586	−0.081
69	1.38	Expire	0.504	−0.082
70	1.40	Expire	0.421	−0.083
71	1.42	Expire	0.337	−0.084
72	1.44	Expire	0.254	−0.084
73	1.46	Expire	0.169	−0.085
74	1.48	Expire	0.085	−0.085
75	1.50	Expire	0	−0.085
76	1.52	Expire	−0.085	−0.085
77	1.54	Expire	−0.169	−0.085
78	1.56	Expire	−0.254	−0.085
79	1.58	Expire	−0.337	−0.084
80	1.60	Expire	−0.421	−0.084
81	1.62	Expire	−0.504	−0.083
82	1.64	Expire	−0.586	−0.082
83	1.66	Expire	−0.667	−0.081
84	1.68	Expire	−0.748	−0.081
85	1.70	Expire	−0.828	−0.08
86	1.72	Expire	−0.906	−0.079
87	1.74	Expire	−0.984	−0.077
88	1.76	Expire	−1.059	−0.076
89	1.78	Expire	−1.134	−0.075
90	1.80	Expire	−1.207	−0.073
91	1.82	Expire	−1.277	−0.07
92	1.84	Expire	−1.345	−0.068
93	1.86	Expire	−1.409	−0.064
94	1.88	Expire	−1.471	−0.062
95	1.90	Expire	−1.529	−0.058
96	1.92	Expire	−1.581	−0.052
97	1.94	Expire	−1.626	−0.045
98	1.96	Expire	−1.662	−0.036
99	1.98	Expire	−1.688	−0.025

19.1.5.2 The SCBA being tested shall utilize a fully charged breathing air cylinder.

19.1.5.3 The facepiece of the SCBA being tested shall be secured to the test headform. The facepiece seal to the headform shall ensure that an initial pressure of 25 mm, ±2.5 mm (1 in., ±0.1 in.) water column below ambient shall not decay by more than 5 mm (0.2 in.) water column in 5 seconds.

19.1.5.4 The remaining components of the SCBA shall be mounted to simulate the proper wearing position as specified by the manufacturer's instructions.

19.1.5.5 SCBA shall be tested at an ambient temperature of 22°C, ±3°C (72°F, ±5°F) and RH of 50 percent, ±25 percent.

19.1.5.6 The airflow performance test shall begin after five cycles of the breathing machine and shall continue to operate through at least 20 bar (290 psi) of cylinder inlet pressure.

Table 19.1.4.9.5(b) Breathing Waveforms for 40 L/min Volume Work Rate

Step No.	Time (sec)	Inspire/ Expire	Volume (L, ±0.1 L)	Volume Change (L, ±5%)
0	0	—	−0.833	0.001
1	0.025	Inspire	−0.831	0.002
2	0.050	Inspire	−0.825	0.005
3	0.075	Inspire	−0.816	0.009
4	0.100	Inspire	−0.803	0.013
5	0.125	Inspire	−0.787	0.016
6	0.150	Inspire	−0.768	0.019
7	0.175	Inspire	−0.745	0.022
8	0.200	Inspire	−0.720	0.025
9	0.225	Inspire	−0.692	0.028
10	0.250	Inspire	−0.661	0.031
11	0.275	Inspire	−0.628	0.033
12	0.300	Inspire	−0.592	0.035
13	0.325	Inspire	−0.555	0.038
14	0.350	Inspire	−0.515	0.039
15	0.375	Inspire	−0.474	0.041
16	0.400	Inspire	−0.431	0.043
17	0.425	Inspire	−0.387	0.044
18	0.450	Inspire	−0.341	0.046
19	0.475	Inspire	−0.295	0.047
20	0.500	Inspire	−0.247	0.048
21	0.525	Inspire	−0.198	0.049
22	0.550	Inspire	−0.149	0.049
23	0.575	Inspire	−0.100	0.050
24	0.600	Inspire	−0.050	0.050
25	0.625	Inspire	0.000	0.050
26	0.650	Inspire	0.051	0.050
27	0.675	Inspire	0.100	0.050
28	0.700	Inspire	0.150	0.050
29	0.725	Inspire	0.199	0.049
30	0.750	Inspire	0.248	0.048
31	0.775	Inspire	0.295	0.048
32	0.800	Inspire	0.342	0.047
33	0.825	Inspire	0.388	0.046
34	0.850	Inspire	0.432	0.044
35	0.875	Inspire	0.475	0.043
36	0.900	Inspire	0.516	0.041
37	0.925	Inspire	0.555	0.039
38	0.950	Inspire	0.592	0.037
39	0.975	Inspire	0.628	0.035
40	1.000	Inspire	0.661	0.033
41	1.025	Inspire	0.691	0.031
42	1.050	Inspire	0.719	0.028
43	1.075	Inspire	0.744	0.025
44	1.100	Inspire	0.767	0.022
45	1.125	Inspire	0.786	0.019
46	1.150	Inspire	0.802	0.016
47	1.175	Inspire	0.814	0.013
48	1.200	Inspire	0.823	0.009
49	1.225	Inspire	0.829	0.005
50	1.250	—	0.833	0.004
51	1.275	Expire	0.831	−0.002
52	1.300	Expire	0.825	−0.005
53	1.325	Expire	0.816	−0.009
54	1.350	Expire	0.803	−0.013
55	1.375	Expire	0.787	−0.016
56	1.400	Expire	0.768	−0.019
57	1.425	Expire	0.745	−0.022
58	1.450	Expire	0.720	−0.025

(continues)

Table 19.1.4.9.5(b) ***Continued***

Step No.	Time (sec)	Inspire/ Expire	Volume (L, ±0.1 L)	Volume Change (L, ±5%)
59	1.475	Expire	0.692	−0.028
60	1.500	Expire	0.661	−0.031
61	1.525	Expire	0.628	−0.033
62	1.550	Expire	0.592	−0.035
63	1.575	Expire	0.555	−0.038
64	1.600	Expire	0.515	−0.039
65	1.625	Expire	0.474	−0.041
66	1.650	Expire	0.431	−0.043
67	1.675	Expire	0.387	−0.044
68	1.700	Expire	0.341	−0.046
69	1.725	Expire	0.295	−0.047
70	1.750	Expire	0.247	−0.048
71	1.775	Expire	0.198	−0.049
72	1.800	Expire	0.149	−0.049
73	1.825	Expire	0.100	−0.050
74	1.850	Expire	0.050	−0.050
75	1.875	Expire	0.000	−0.050
76	1.900	Expire	−0.051	−0.050
77	1.925	Expire	−0.100	−0.050
78	1.950	Expire	−0.150	−0.050
79	1.975	Expire	−0.199	−0.049
80	2.000	Expire	−0.248	−0.048
81	2.025	Expire	−0.295	−0.048
82	2.050	Expire	−0.342	−0.047
83	2.075	Expire	−0.388	−0.046
84	2.100	Expire	−0.432	−0.044
85	2.125	Expire	−0.475	−0.043
86	2.150	Expire	−0.516	−0.041
87	2.175	Expire	−0.555	−0.039
88	2.200	Expire	−0.592	−0.037
89	2.225	Expire	−0.628	−0.035
90	2.250	Expire	−0.661	−0.033
91	2.275	Expire	−0.691	−0.031
92	2.300	Expire	−0.719	−0.028
93	2.325	Expire	−0.744	−0.025
94	2.350	Expire	−0.767	−0.022
95	2.375	Expire	−0.786	−0.019
96	2.400	Expire	−0.802	−0.016
97	2.425	Expire	−0.814	−0.013
98	2.450	Expire	−0.823	−0.009
99	2.475	Expire	−0.829	−0.005

19.1.5.7 The breathing machine shall be set at a rate of 103 L/min, ±3 L/min with a respiratory frequency of 30 breaths/min, ±1 breath/min.

19.1.6 Report.

19.1.6.1 The facepiece peak inhalation pressure and peak exhalation pressure shall be recorded and reported for each test.

19.1.6.2 The EOSTI activation and operation or the failure of the EOSTI to activate and operate shall be recorded and reported.

19.1.6.3 The activation and identification of HUD visual alert signals shall be recorded and reported.

19.1.7 Interpretation.

19.1.7.1 The peak inhalation pressure and peak exhalation pressure shall be used to determine pass or fail performance.

19.1.7.2 One or more specimens failing this test shall constitute failing performance.

19.1.7.3 Failure of any EOSTI alarm signal to activate and remain active during the test shall constitute failing performance.

19.1.7.4 Failure of the HUD to display the breathing air cylinder content or to display the visual alert signal during the test shall constitute failing performance.

19.2 Environmental Temperature Tests.

19.2.1 Application. This test method shall apply to complete SCBA.

19.2.2 Samples. Each sample to be tested shall be as specified in 15.3.2.

19.2.3 Specimen Preparation.

19.2.3.1 Specimens for conditioning shall be complete SCBA.

19.2.3.2 Prior to testing, the SCBA shall be placed in an ambient environment of 22°C, ± 3°C (72°F, ±5°F) and RH of 50 percent, ±25 percent for a minimum 12-hour dwell period.

19.2.4 Apparatus.

19.2.4.1 The SCBA shall be placed in an environmental chamber and positioned to simulate the normal wearing position of the SCBA on a person as specified by the manufacturer.

19.2.4.2 During the environmental exposures in 19.2.5.5, 19.2.5.6, 19.2.5.7, and 19.2.5.8, the SCBA shall be mounted on a Scott Aviation Model No. 803608-01 or 803608-02 test headform or equivalent.

19.2.4.3 The thermocouple or other temperature-sensing element used shall be mounted within the chamber in a manner in which it will be exposed directly to the chamber atmosphere.

19.2.4.4 The test headform shall be connected to the breathing machine specified in Section 19.1, Airflow Performance Test.

19.2.4.5 The breathing machine shall be permitted to be located either inside or outside the environmental chamber.

19.2.5 Procedure.

19.2.5.1 The variation in pressure extremes caused by the environmental test configuration shall be determined in the following manner. The airflow performance test as specified in Section 19.1, Airflow Performance Test, shall be carried out using the configuration specified in 19.2.4 at the 103 L/min, ±3 L/min ventilation rate. The difference in pressure between the two tests shall be calculated by subtracting the values obtained using the configuration defined in 19.2.4 from the values obtained using the configuration specified in Section 19.1, Airflow Performance Test.

19.2.5.2 The facepiece pressure during each entire test shall be read from the strip chart recorder and corrected by adding the value of the difference in pressure calculated in 19.2.5.1 to determine pass or fail as specified in 18.2.1.1 through 18.2.1.4.

19.2.5.3 These environmental temperature tests shall be permitted to be conducted in any sequence.

19.2.5.4 The dwell period between environmental temperature tests shall be used for refilling the breathing air cylinder and visually inspecting the SCBA for any gross damage that could cause unsafe test conditions.

19.2.5.5 Test 1.

19.2.5.5.1 The SCBA shall be cold soaked at −32°C, ±1°C (−25°F, ±2°F) for a minimum of 12 hours.

19.2.5.5.2 The SCBA shall then be tested for airflow performance as specified in Section 19.1, Airflow Performance Test, at a chamber air temperature of −32°C, ±5°C (−25°F, ±10°F).

19.2.5.5.3 The SCBA shall be operated according to the manufacturer's instructions to test the data logging function as specified in 17.1.12 to determine pass or fail performance.

19.2.5.6 Test 2.

19.2.5.6.1 The SCBA shall be hot soaked at 71°C, ±1°C (160°F, ±2°F) for a minimum of 12 hours.

19.2.5.6.2 The SCBA shall then be tested for airflow performance as specified in Section 19.1, Airflow Performance Test, at a chamber air temperature of 71°C, ±5°C (160°F, ±10°F).

19.2.5.6.3 The SCBA shall be operated according to the manufacturer's instructions to test the data logging function as specified in 17.1.12 to determine pass or fail performance.

19.2.5.7 Test 3.

19.2.5.7.1 The SCBA shall be hot soaked at 71°C, ±1°C (160°F, ±2°F) for a minimum of 12 hours.

19.2.5.7.2 Immediately following the 12-hour hot soak, the SCBA shall be transferred to a chamber with an air temperature of −32°C, ±1°C (−25°F, ±2°F).

19.2.5.7.3 The SCBA shall then be tested for airflow performance as specified in Section 19.1, Airflow Performance Test, at a chamber air temperature of −32°C, ±5°C (−25°F, ±10°F).

19.2.5.7.4 The airflow performance test shall commence within 3 minutes after removal of the SCBA from the hot soak.

19.2.5.7.5 The SCBA shall be operated according to the manufacturer's instructions to test the data logging function as specified in 17.1.12 to determine pass or fail performance.

19.2.5.8 Test 4.

19.2.5.8.1 The SCBA shall be cold soaked at −32°C, ±1°C (−25°F, ±2°F) for a minimum of 12 hours.

19.2.5.8.2 Immediately following the 12-hour cold soak, the SCBA shall be transferred to a chamber with an air temperature of 71°C, ±1°C (160°F, ±2°F).

19.2.5.8.3 The SCBA shall then be tested for airflow performance as specified in Section 19.1, Airflow Performance Test, at a chamber air temperature of 71°C, ±5°C (160°F, ±10°F).

19.2.5.8.4 The airflow performance test shall commence within 3 minutes after removal of the SCBA from the cold soak.

19.2.5.8.5 The SCBA shall be operated according to the manufacturer's instructions to test the data logging function as specified in 17.1.12 to determine pass or fail performance.

19.2.6 Report.

19.2.6.1 The facepiece peak inhalation pressure and peak exhalation pressure shall be recorded and reported for each test condition.

19.2.6.2 The activation and operation or the failure to activate and operate of the EOSTI shall be recorded and reported.

19.2.6.3 The activation and identification of HUD visual alert signals shall be recorded and reported.

19.2.6.4 The functioning of the data logging shall be recorded and reported.

19.2.7 Interpretation.

19.2.7.1 The peak inhalation and peak exhalation shall be used to determine pass or fail performance for each test procedure.

19.2.7.2 One or more specimens failing any test procedure shall constitute failing performance.

19.2.7.3 Failure of any EOSTI alarm signal to activate and remain active during the test shall constitute failing performance.

19.2.7.4 Failure of the HUD to display the breathing air cylinder content or to display the visual alert signal during the test shall constitute failing performance.

19.3 Vibration Test.

19.3.1 Application. This test method shall apply to complete SCBA.

19.3.2 Samples. Each sample to be tested shall be as specified in 15.3.2.

19.3.3 Specimen Preparation.

19.3.3.1 Specimens for conditioning shall be complete SCBA.

19.3.3.2 Prior to testing, specimens shall be conditioned for a minimum of 4 hours and tested at an ambient temperature of 22°C, ±3°C (72°F, ±5°F) and RH of 50 percent, ±25 percent.

19.3.4 Apparatus.

19.3.4.1 SCBA shall be tested on a typical package tester within the compartments specified in 19.3.4.2 through 19.3.4.4.

19.3.4.2 Compartments shall be set up as specified in Figure 19.3.4.2(a) and Figure 19.3.4.2(b).

19.3.4.2.1 The sides and base of the compartments shall be constructed of nominal 6 mm (¼ in.) stainless steel, and the top of the compartments shall remain open.

19.3.4.2.2 There shall be no burrs, sharp edges, surface discontinuities, or fasteners on the internal surfaces of the holding boxes.

19.3.4.2.3 If the SCBA does not fit the compartment as specified in Figure 19.3.4.2(a) and Figure 19.3.4.2(b), the compartment shall be designed to accommodate the size and shape of the SCBA, allowing a clearance of 150 mm, +150/−0 mm (6 in., +6/−0 in.) between the top to bottom length and width of the SCBA.

19.3.4.3 The large compartments shall encase the complete SCBA.

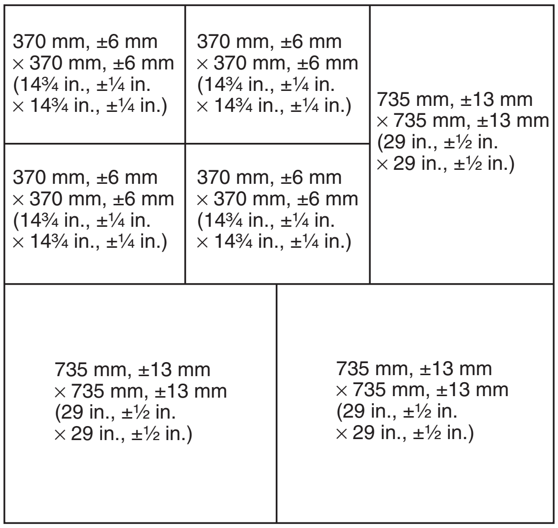


FIGURE 19.3.4.2(a) Vibration Table Compartments — Top View (Not to Scale).

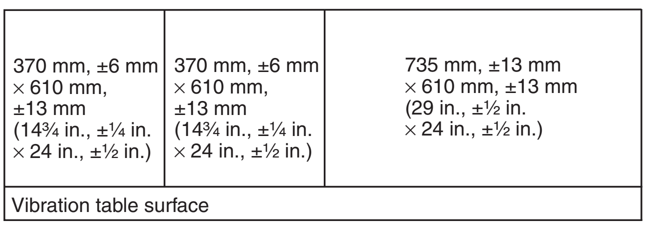


FIGURE 19.3.4.2(b) Vibration Table Compartments — Side View (Not to Scale).

19.3.4.3.1 SCBA regulators and hose shall remain attached to the complete SCBA.

19.3.4.3.2 Regulators shall be allowed to be placed in the regulator holder of the SCBA.

19.3.4.3.3 The SCBA facepiece and those components that attach directly to the facepiece, excluding regulators, shall not be included in the SCBA compartment.

19.3.4.4 The small compartments shall encase the facepiece and those components that attach directly to the facepiece, excluding the regulator and associated hose.

19.3.4.5* The breathing air cylinder of the SCBA shall be replaced by a surrogate cylinder.

19.3.4.6 The surrogate cylinder and cylinder valve shall be of identical design and construction as the breathing air cylinder and cylinder valve of the SCBA to be tested.

19.3.4.7 The mass of the breathing air of a fully pressurized breathing air cylinder shall be replaced in the surrogate cylinder with a substitute mass. The substitute mass shall consist of a brass rod and surrounding foam constructed as shown in Figure 19.3.4.7.

19.3.4.8 The surrogate cylinder and cylinder valve with the substitute mass shall have the same total mass ±5 percent as the fully pressurized breathing air cylinder and cylinder valve.

19.3.4.9 The attachment of the cylinder valve shall be tightened to a torque setting of 5 N-m, +0.5/−0.0 5 N-m (45 in. lb, +5/−0 in. lb) prior to the test. An opposing line no wider than 3 mm (⅛ in.) shall be placed on both the male and female CGA fitting prior to the start of the test, to identify the relationship between the male and the female CGA fittings when tightened at the proper torque setting.

19.3.5 Procedure.

19.3.5.1 The test items shall be placed unrestrained in the compartments specified in 19.3.4.2, and all SCBA adjustment straps shall be fully extended.

19.3.5.2 No tie-downs shall be allowed to be made to the SCBA.

19.3.5.3 The basic movement of the bed of the test table shall be a 25 mm (1 in.) orbital path, such as can be obtained on a standard package tester operating in synchronous mode at 250 rpm, ±5 rpm.

19.3.5.4 The test duration shall be 3 hours.

19.3.5.5 After being subjected to the vibration test, the male and female CGA fittings shall be observed for movement.

19.3.5.6 After being subjected to the vibration test, the SCBA shall be reattached to the breathing air cylinder originally provided with the SCBA and shall then be tested as specified in Section 19.1, Airflow Performance Test.

19.3.5.7 The SCBA shall be operated according to the manufacturer's instructions to test the data logging function as specified in 17.1.12 to determine pass or fail performance.

19.3.6 Report.

19.3.6.1 The observation of movement or no movement of the male and female CGA fittings shall be recorded and reported.

19.3.6.2 The facepiece peak inhalation pressure and peak exhalation pressure shall be recorded and reported for each test condition.

19.3.6.3 The activation and operation, or failure to activate and operate, of the EOSTI shall be recorded and reported.

19.3.6.4 The activation and identification of HUD visual alert signals shall be recorded and reported.

19.3.6.5 The functioning of the data logging shall be recorded and reported.

19.3.7 Interpretation.

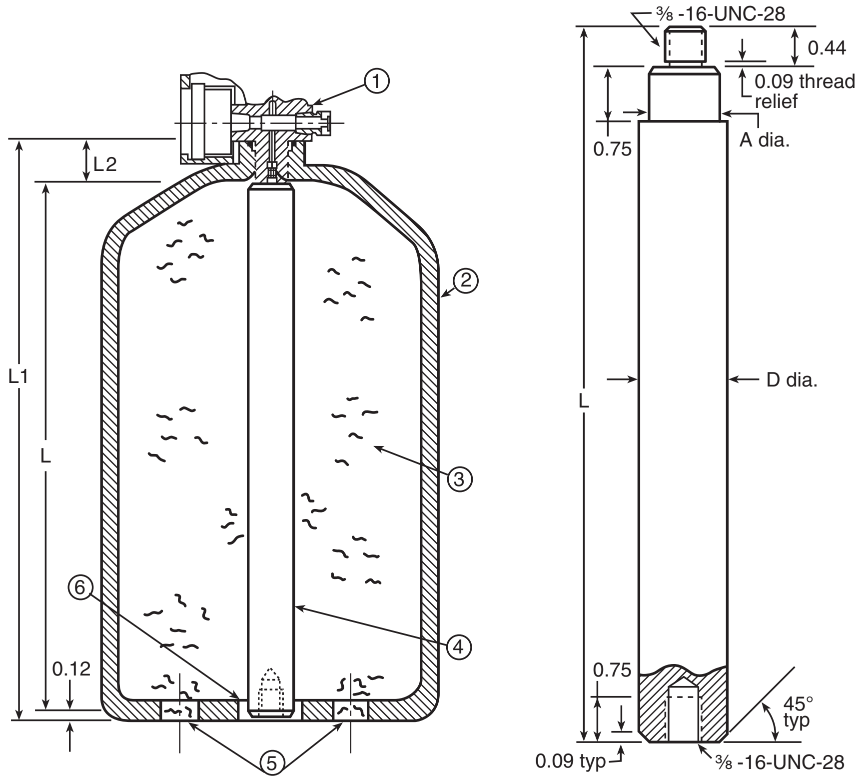
19.3.7.1 The movement of either the male or female CGA fitting causing a break in the line of any width shall constitute a failure.

19.3.7.2 The peak inhalation and peak exhalation shall be used to determine pass or fail performance for each test procedure.

19.3.7.3 One or more specimens failing this test shall constitute failing performance.

19.3.7.4 Failure of any EOSTI alarm signal to activate and remain active during the test shall constitute failing performance.

Item	Description	Quantity
1	Cylinder valve assembly w/gauge and guards, etc.	1
2	SCBA air storage cylinder	1
3	Polyurethane foam	A/R
4	Ballast rod — ASTM B16/B16M brass, ½ hard	A/R
5	Fill/vent holes ¾ – ⅞ in. diameter	2
6	Ballast rod installation hole — diameter A/R	1



Note: All dimensions are inches.

Complete Surrogate Cylinder

Ballast Rod Detail

FIGURE 19.3.4.7 Surrogate Cylinder.

19.3.7.5 Failure of the HUD to display the breathing air cylinder content or to display the visual alert signal during the test shall constitute failing performance.

19.3.7.6 Failure of the data logging function shall constitute failing performance.

19.4 Fabric Flame Tests.

19.4.1 Application.

19.4.1.1 This test method shall apply to each different fabric component of the SCBA.

19.4.1.2 Modifications for testing fabrics less than 75 mm (3 in.) wide shall be as specified in 19.4.8.

19.4.1.3 Modifications for testing fabrics less than 305 mm (12 in.) long shall be as specified in 19.4.9.

19.4.2 Specimens.

19.4.2.1 Specimens shall consist of a 75 mm × 305 mm (3 in. × 12 in.) rectangle.

19.4.2.2 A total of 10 test specimens shall be cut from a standard production run of the fabric components used in the SCBA.

19.4.3 Specimen Preparation.

19.4.3.1 Five test specimens shall be tested without any conditioning.

19.4.3.2 The remaining five test specimens shall be conditioned by five cycles of washing and drying in accordance with the procedures specified in Machine Cycle 1, Wash Temperature V, Drying Procedure Ai, of AATCC LP1, *Home Laundering: Machine Washing*.

19.4.4 Apparatus. The test apparatus specified in ASTM D6413/D6413M, *Standard Test Method for Flame Resistance of Textiles (Vertical Test)*, shall be used.

19.4.5 Procedure.

19.4.5.1 Specimens shall be tested in accordance with ASTM D6413/D6413M, *Standard Test Method for Flame Resistance of Textiles (Vertical Test)*.

19.4.5.2 Each specimen shall be examined for evidence of melting or ignition to determine pass or fail.

19.4.6 Report.

19.4.6.1 Afterflame time and char length shall be recorded and reported for each specimen.

19.4.6.2 The average afterflame time and char length for each material tested shall be calculated and reported.

19.4.6.3 The afterflame time shall be reported to the nearest 0.2 second and the char length to the nearest 3.2 mm (⅛ in.).

19.4.6.4 Observations of melting or dripping for each specimen shall be reported.

19.4.7 Interpretation.

19.4.7.1 Pass or fail performance shall be based on any observed melting or dripping, the average afterflame time, and the average char length.

19.4.7.2 One or more specimens failing this test shall constitute failing performance.

19.4.8 Specific Requirements for Testing Fabrics Less Than 75 mm (3 in.) Wide.

19.4.8.1 If the fabric components are not available in the width specified in 19.4.2.1, the width of the test specimen shall be the width as used on the SCBA, but shall be a minimum of 305 mm (12 in.) long.

19.4.8.2 The test frame in Figure 19.4.8.2 shall be utilized to hold samples not available in the width specified in 19.4.2.1.

19.4.8.3 Testing shall be performed as specified in 19.4.5.

19.4.9 Specific Requirements for Testing Fabrics Less Than 305 mm (12 in.) Long.

19.4.9.1 Where the fabric components are not available in the length specified in 19.4.2.1, the length of the test specimen shall be the length as used on the SCBA.

19.4.9.2 Samples that are not available in the length required in 19.4.2.1 shall be positioned such that the bottom edge of the sample is positioned at the bottom of the test frame.

19.4.9.3 Testing shall be performed as specified in 19.4.5.

19.5 Fabric Heat Tests.

19.5.1 Application.

19.5.1.1 This test method shall apply to each different fabric component of the SCBA.

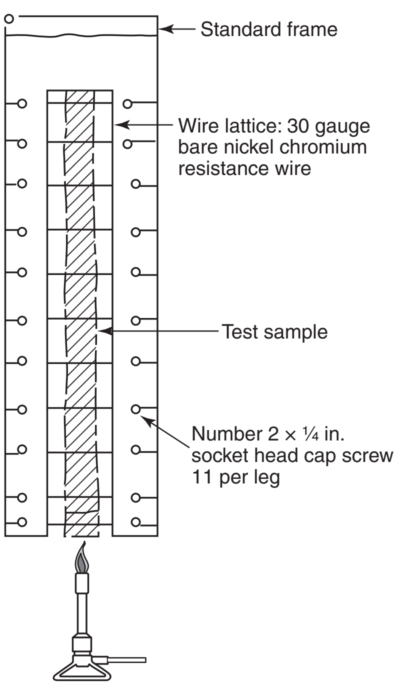


FIGURE 19.4.8.2 Wire Lattice Test Frame.

19.5.1.2 Modifications for testing fabrics less than 380 mm (15 in.) wide shall be as specified in 19.5.8.

19.5.1.3 Modifications for testing fabrics less than 380 mm (15 in.) long shall be as specified in 19.5.9.

19.5.2 Specimens.

19.5.2.1 Specimens shall consist of a 380 mm × 380 mm (15 in. × 15 in.) square.

19.5.2.2 A total of 10 test specimens shall be cut from a standard production run of the fabric components used in the SCBA.

19.5.3 Specimen Preparation.

19.5.3.1 Five test specimens shall be tested without any conditioning.

19.5.3.2 The remaining five test specimens shall be conditioned by five cycles of washing and drying in accordance with the procedures specified in Machine Cycle 1, Wash Temperature V, Drying Procedure Ai, of AATCC LP1, *Home Laundering: Machine Washing*.

19.5.4 Apparatus.

19.5.4.1 The test oven shall be a horizontal flow circulating oven with minimum interior dimensions so that the specimens can be suspended and are at least 50 mm (2 in.) from any interior oven surface and other test specimens.

19.5.4.2 The test oven shall have an airflow rate of 38 m/min to 76 m/min (125 ft/min to 250 ft/min) at the standard temperature and pressure of 21°C (70°F) at 1 atmosphere measured at the center point of the oven.

19.5.4.3 A test thermocouple shall be positioned so that it is level with the horizontal centerline of a mounted sample specimen.

19.5.4.3.1 The thermocouple shall be equidistant between the vertical centerline of a mounted specimen placed in the middle of the oven and the oven wall where the airflow enters the test chamber.

19.5.4.3.2 The thermocouple shall be an exposed bead, Type J or Type K, No. 30 AWG thermocouple.

19.5.4.3.3 The test oven shall be heated and the test thermocouple stabilized at 260°C, +6°C/−0°C (500°F, +10°F/−0°F) for a period of not less than 30 minutes.

19.5.5 Procedure.

19.5.5.1 The test specimen shall be suspended by a metal hook(s) at the top and centered in the oven so that the entire test specimen is at least 50 mm (2 in.) from any oven surface and other test specimens.

19.5.5.2 Oven airflow shall be parallel to the plane of the material.

19.5.5.3 The oven door shall not remain open more than 15 seconds.

19.5.5.3.1 The air circulation shall be shut off while the door is open, and turned on when the door is closed.

19.5.5.3.2 The total oven recovery time after the door is closed shall not exceed 30 seconds.

19.5.5.4 The specimen, mounted as specified, shall be exposed in the test oven for 5 minutes, +0.15 minute/−0 minutes.

19.5.5.5 The test exposure time shall begin when the test thermocouple recovers to the temperature of 260°C, +6°C/−0°C (500°F, +10°F/−0°F).

19.5.5.6 Immediately after the specified exposure, the specimen shall be removed and examined for evidence of ignition or melting.

19.5.6 Report. Observations of ignition or melting shall be recorded and reported for each specimen.

19.5.7 Interpretation. Any evidence of ignition or melting on any specimen shall constitute failing performance.

19.5.8 Specific Requirements for Testing Fabrics Less Than 380 mm (15 in.) Wide.

19.5.8.1 If the fabric components are not available in the width specified in 19.5.2.1, the width of the test specimen shall be the width as used on the SCBA but shall be a minimum of 380 mm (15 in.) long.

19.5.8.2 Testing shall be performed as specified in 19.5.5.

19.5.9 Specific Requirements for Testing Fabrics Less Than 380 mm (15 in.) Long.

19.5.9.1 If the fabric components are not available in the length specified in 19.5.2.1, the length of the test specimen shall be the length as used on the SCBA.

19.5.9.2 Testing shall be performed as specified in 19.5.5.

19.6 Thread Heat Test.

19.6.1 Application. This test shall apply to sewing thread used in construction of the SCBA.

19.6.2 Specimens.

19.6.2.1 A total of three specimens of each thread type shall be tested.

19.6.2.2 All specimens shall be conditioned as specified in 8.1.3 prior to testing.

19.6.3 Procedure.

19.6.3.1 The melting temperature of specimens shall be determined using Procedure 1 or Procedure 2 of ASTM D7138, *Standard Test Method to Determine Melting Temperature of Synthetic Fibers*.

19.6.4 Report.

19.6.4.1 The melting point of the sample unit shall be the average of the results obtained from the specimens tested and be recorded and reported to the nearest degree Celsius (degree Fahrenheit).

19.6.4.2 The pass/fail results for each specimen tested shall be recorded and reported.

19.6.5 Interpretation. One or more thread specimens failing this test shall constitute failing performance for the thread type.

19.7 Accelerated Corrosion Test.

19.7.1 Application. This test method shall apply to complete SCBA.

19.7.2 Samples. Each sample to be tested shall be as specified in 15.3.2.

19.7.3 Specimen Preparation.

19.7.3.1 Prior to testing, specimens shall be conditioned for a minimum of 4 hours and tested at an ambient temperature of 22°C, ±3°C (72°F, ±5°F) and RH of 50 percent, ±25 percent.

19.7.3.2 Specimens for conditioning shall be complete SCBA.

19.7.4 Apparatus. A salt fog chamber shall be used for testing and shall meet the requirements of Section 4 of ASTM B117, *Standard Practice for Operating Salt Spray (Fog) Apparatus*.

19.7.5 Procedure.

19.7.5.1 The SCBA with a fully charged breathing air cylinder, with the breathing air cylinder valve fully closed, shall be placed in the test chamber attached to a manikin to simulate its typical wearing position on a firefighter as specified by the manufacturer.

19.7.5.2 SCBA shall not contact each other or the sides of the test chamber.

19.7.5.3 The SCBA shall be placed in the temperature-stabilized chamber for a minimum of 2 hours prior to introduction of the salt solution.

19.7.5.4 The SCBA shall then be exposed to the salt fog for 48 hours, +15 minutes/−0 minutes.

19.7.5.5 Specimen SCBA shall be subjected to a 5 percent, ±1 percent salt solution fog.

19.7.5.5.1 The salt solution shall be prepared by dissolving 5 parts, ±1 part by mass of sodium chloride in 95 parts of water.

19.7.5.5.2 The salt used shall be sodium chloride substantially free of nickel and copper and containing on the dry basis not more than 0.1 percent of sodium iodide and not more than 0.3 percent of total impurities.

19.7.5.5.3 The pH of the salt solution shall be in the range of 6.5 to 7.2.

19.7.5.6 The compressed air supply to the nozzle or nozzles for atomizing the salt solution shall be free of oil and dirt and maintained between 69 kPa/m and 172 kPa/m (10 psi and 25 psi).

19.7.5.7 The exposure temperature in the chamber shall be maintained at 35°C, ±1°C (95°F, ±2°F) for the duration of the test.

19.7.5.8 At least two clean fog collectors shall be placed within the exposure zone so that no drops of solution from the test specimens or any other source shall be collected in them.

19.7.5.8.1 The collectors shall be placed in the proximity of the test specimens, one nearest to any nozzle and the other farthest from all nozzles.

19.7.5.8.2 The fog shall be such that for each 80 cm^2 (12.4 $in.^2$) of horizontal collecting area from 1.0 mL to 2.0 mL of solution per hour will be collected in each collector.

19.7.5.9 After completion of the salt fog exposure, the SCBA shall be stored in an environment of 22°C, ±3°C (72°F, ±5°F) and RH of 50 percent, ±5 percent for a minimum of 48 hours.

19.7.5.10 The SCBA shall then be tested as specified in Section 9.1, Airflow Performance Test, to determine pass or fail.

19.7.5.11 All controls or operating features of the SCBA shall operate per the SCBA manufacturer's instructions to determine pass or fail.

19.7.5.12 The SCBA shall be operated according to the manufacturer's instructions to test the data logging function as specified in 17.1.12 to determine pass or fail performance.

19.7.6 Report.

19.7.6.1 The facepiece pressure peak inhalation and peak exhalation shall be recorded and reported for each test condition.

19.7.6.2 The activation and operation, or failure to activate and operate, of the EOSTI shall be reported and recorded.

19.7.6.3 The activation and identification of HUD visual alert signals shall be reported and recorded.

19.7.6.4 The functioning of the data logging shall be recorded and reported.

19.7.7 Interpretation.

19.7.7.1 The peak inhalation and peak exhalation shall be used to determine pass or fail performance.

19.7.7.2 One or more specimens failing this test shall constitute failing performance.

19.7.7.3 Failure of any EOSTI alarm signal to activate and remain active during the test shall constitute failing performance.

19.7.7.4 Failure of the HUD to display the breathing air cylinder content or to display the visual alert signal during the test shall constitute failing performance.

19.7.7.5 Failure of the data logging function shall constitute failing performance.

19.8 Particulate Test.

19.8.1 Application. This test method shall apply to complete SCBA.

19.8.2 Samples. Each sample to be tested shall be as specified in 15.3.2.

19.8.3 Specimen Preparation.

19.8.3.1 Prior to testing, specimens shall be conditioned for a minimum of 4 hours and tested at an ambient temperature of 22°C, ±3°C (72°F, ±5°F) and RH of 50 percent, ±25 percent.

19.8.3.2 Specimens for conditioning shall be complete SCBA.

19.8.4 Apparatus.

19.8.4.1 A Scott Aviation model No. 803608-01 or 803608-02 test headform or equivalent shall be joined to a manikin to simulate its typical wearing position, as specified by the manufacturer.

19.8.4.2 The test headform shall be connected, as specified in Section 19.1, Airflow Performance Test, to the breathing machine specified in 19.1.4.9 or other respiration simulator producing a 1-minute volume of 40 L, ±2 L at the ambient conditions specified in 19.1.3.2, with a minimum tidal volume of 1.6 L per breath at a minimum respiration of 10 breaths/min.

19.8.4.3 A test facility consisting of a chamber and accessories to control dust concentration, velocity, temperature, and humidity of dust-laden air shall be used.

19.8.4.4 To provide adequate circulation of the dust-laden air, no more than 50 percent of the cross-sectional area and no more than 30 percent of the volume of the test chamber shall be occupied by the test item(s).

19.8.4.5* The chamber shall be provided with a means of maintaining and verifying the dust circulation.

19.8.4.6 The dust-laden air shall be introduced into the test space in such a manner as to allow the air to become laminar in flow before it strikes the test item.

19.8.4.7* Dust shall be silica flour and shall contain 97 percent to 99 percent by weight silicon dioxide (SiO_2).

19.8.4.8 The following size distribution shall apply:

(1) 100 percent shall pass through a 100 mesh screen.
(2) 98 percent, ±2 percent shall pass through a 140 mesh screen.
(3) 90 percent, ±2 percent shall pass through a 200 mesh screen.
(4) 75 percent, ±2 percent shall pass through a 325 mesh screen.

19.8.5 Procedure.

19.8.5.1 A fully charged SCBA shall be secured to a test headform and manikin as specified in 19.8.4.1.

19.8.5.2 The manikin, including the test headform, shall be mounted upright and placed inside the test chamber.

19.8.5.3 The temperature of the test chamber shall be adjusted to 22°C, ±3°C (72°F, ±5°F) and the RH to less than 30 percent.

19.8.5.4 The air velocity shall be adjusted to 530 m/min, ±15 m/min (1750 ft/min, ±50 ft/min).

19.8.5.5 The dust concentration for the blowing dust shall be maintained at 10.6 g/m^3, ±7 g/m^3 (0.3 g/ft^3, ±0.2 g/ft^3).

19.8.5.6 The test duration shall be 1 hour, and the breathing machine shall be operating throughout the entire test.

19.8.5.6.1 The test shall be permitted to be interrupted to change the SCBA breathing air cylinder.

19.8.5.6.2 Test item configuration and orientation shall be turned around its vertical axis 180 degrees midway through the test.

19.8.5.7 After the completion of the test, the SCBA shall be removed from the test compartment.

19.8.5.8 The SCBA shall be lightly shaken or brushed free of dust and then shall be tested as specified in Section 19.1, Airflow Performance Test, to determine pass or fail.

19.8.6 Report.

19.8.6.1 The facepiece pressure peak inhalation and peak exhalation shall be recorded and reported for each test condition.

19.8.6.2 The activation and operation, or failure to activate and operate, of both EOSTI shall be recorded and reported.

19.8.6.3 The activation and identification of HUD visual alert signals shall be recorded and reported.

19.8.7 Interpretation.

19.8.7.1 The peak inhalation and peak exhalation shall be used to determine pass or fail performance.

19.8.7.2 One or more specimens failing this test shall constitute failing performance.

19.8.7.3 Failure of any EOSTI alarm signal to activate and remain active during the test shall constitute failing performance.

19.8.7.4 Failure of the HUD to display the breathing air cylinder content or display the visual alert signal during the test shall constitute failing performance.

19.9 Facepiece Lens Abrasion Test.

19.9.1 Application. This test method shall apply to facepiece lenses.

19.9.2 Samples. A minimum of four faceshield lenses shall be tested.

19.9.3 Specimen Preparation.

19.9.3.1 Seven specimens shall be chosen from a minimum of four facepiece lenses.

19.9.3.1.1 Four specimens shall be taken from the left viewing area, and three samples shall be taken from the right viewing area.

19.9.3.1.2 One of the four specimens taken from the left viewing area shall be the set-up specimen.

19.9.3.2 The left test specimens shall conform to all the following criteria:

(1) The specimen shall be a square measuring 50 mm × 50 mm (2 in. × 2 in.).
(2) Two edges of the square section shall be parallel within ±2 degrees of the axis of the cylinder or cone in the center of the specimen.
(3) At least 38 mm (1½ in.) of the 50 mm × 50 mm (2 in. × 2 in.) square shall be taken from the left side of the center line of the lens.
(4) The 50 mm × 50 mm (2 in. × 2 in.) square shall be cut at approximately eye level.

19.9.3.3 The right test specimens shall conform to all the following criteria:

(1) The specimen shall be a square measuring 50 mm × 50 mm (2 in. × 2 in.).
(2) Two edges of the square section shall be parallel within ±2 degrees of the axis of the cylinder or cone in the center of the specimen.
(3) At least 38 mm (1½ in.) of the 50 mm × 50 mm (2 in. × 2 in.) square shall be taken from the right side of the center line of the lens.
(4) The 50 mm × 50 mm (2 in. × 2 in.) square shall be cut at approximately eye level.

19.9.3.4 Each of the specimens shall be cleaned in the following manner:

(1) The specimen shall be rinsed with clean tap water.
(2) The specimen shall be washed with a solution of nonionic/low-phosphate detergent and water using a clean, soft gauze pad.
(3) The specimen shall be rinsed with de-ionized water.
(4) The specimen shall be blown dry with clean compressed air or nitrogen.

19.9.4 Apparatus. The test apparatus shall be constructed in accordance with Figure 19.9.4(a) and Figure 19.9.4(b).

19.9.5 Procedure.

19.9.5.1 The haze of the specimen shall be measured using a haze meter in accordance with ASTM D1003, *Standard Test Method for Haze and Luminous Transmittance of Transparent Plastics,* and recorded with the following additions:

(1) The haze shall be measured in the middle of the specimen ±1.6 mm (±1⁄16 in.).
(2) The specimen shall be repositioned to achieve the maximum haze value within the area defined in 19.9.5.1(1).
(3) The haze meter shall have a specified aperture of 22.4 mm (7⁄8 in.).
(4) The haze meter shall have a visual display showing 0.1 percent resolution.
(5) The haze meter shall be calibrated before and after each day's use following procedures specified in ASTM D1003, *Standard Test Method for Haze and Luminous Transmittance of Transparent Plastics*.

19.9.5.2 The set-up specimen shall be placed cover side up in the test apparatus specimen holder.

19.9.5.3 The specimen holder shall be configured with a flat surface under the lens or with an inner radius support.

19.9.5.4 The pad holder shall consist of a cylinder 10 mm (3⁄8 in.) high and 25 mm (1 in.) in diameter with a radius of curvature equal to the radius of curvature of the outside of the lens in the viewing area, ±0.25 diopter. This cylinder shall be rigidly affixed to the stroking arm by a #10-32 UNF threaded rod.

19.9.5.5 The pad shall be a Blue Streak M306M wool felt polishing pad or equivalent, 24 mm (15⁄16 in.) in diameter.

19.9.5.6 The abrasive disc shall be made from 3M Part Number 7415, Wood Finishing Pad or equivalent.

19.9.5.6.1 A disc 24 mm (15⁄16 in.) in diameter shall be cut from the abrasive sheet.

19.9.5.6.2 The marked side of the disc shall be placed against the pad.

19.9.5.6.3 Care shall be exercised to maintain the orientation described in 19.9.5.6.2 for each abrasive disc throughout the testing.

19.9.5.7 The pad holder, pad, and abrasive disc shall be installed on the stroking arm.

19.9.5.7.1 The stroking arm shall be leveled to ±3 degrees by adjusting the threaded pin.

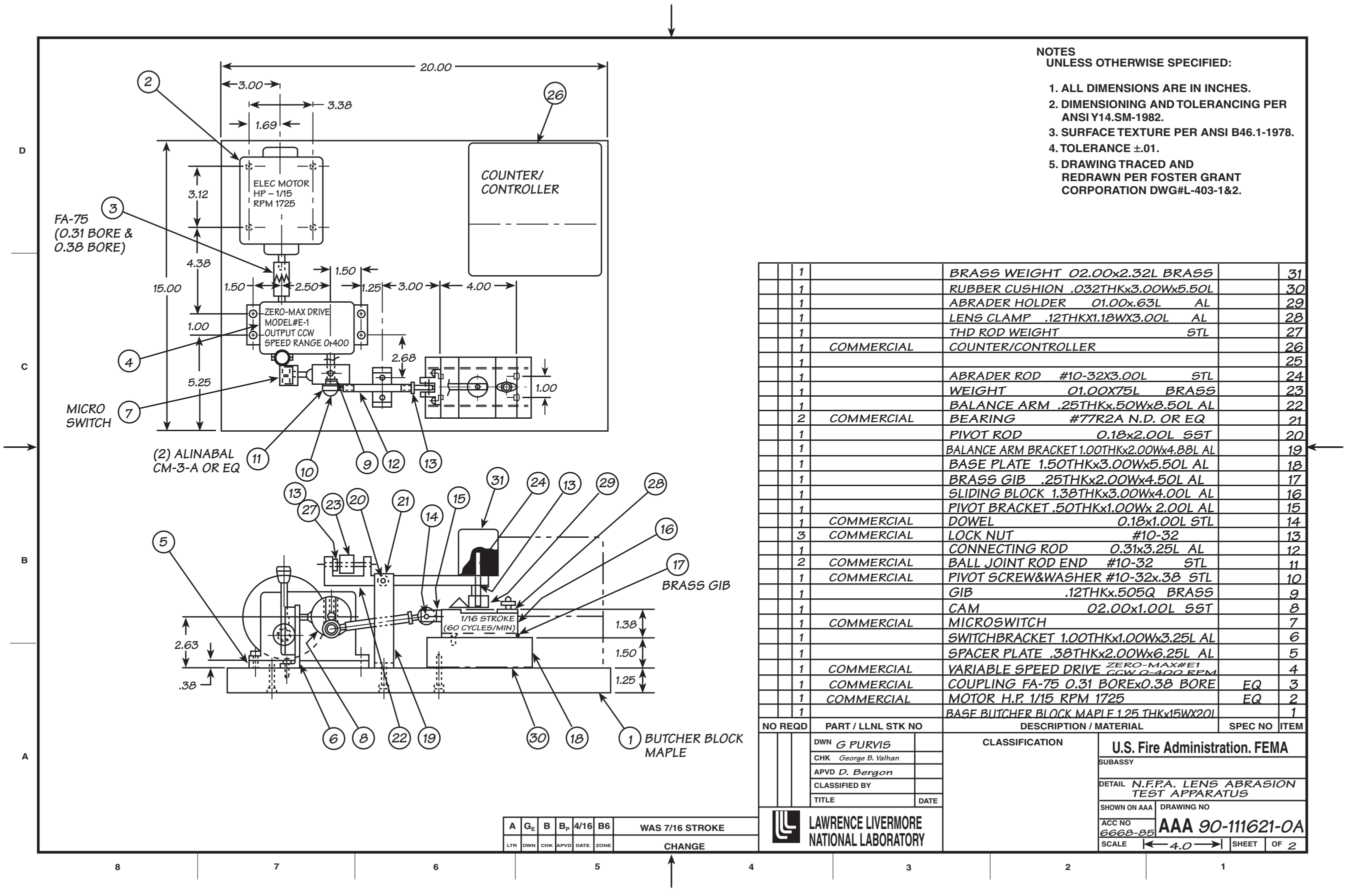


FIGURE 19.9.4(a) Lens Abrasion Tester.

19.9.5.7.2 The pin shall be secured to prevent rotation of the pad holder.

19.9.5.7.3 The axis of curvature of the pad holder shall be coincident with the axis of curvature of the lens.

19.9.5.8 The stroking arm shall be counterbalanced with the pad holder, pad, and abrasive disc in place.

19.9.5.9 The set-up specimen shall be replaced with one of the six specimens to be tested.

19.9.5.10 The 1000 g, ±5 g (2.2 lb, ±0.18 lb) test weight shall be installed on the pin above the test specimen.

19.9.5.11 The test shall be run for 200 cycles, ±1 cycle. One cycle shall consist of a complete revolution of the eccentric wheel.

19.9.5.12 The length of stroke shall be 14.5 mm (9⁄16 in.), producing a pattern 38 mm (1½ in.) long.

19.9.5.12.1 The frequency of the stroke shall be 60 cycles, ±1 cycle, per minute.

19.9.5.12.2 The center of the stroke shall be within ±2 mm (±1⁄16 in.) of the center of the specimen.

19.9.5.13 The specimen shall be removed and cleaned following the procedure specified in 19.9.3.4.

19.9.5.14 The abrasive disc shall be discarded.

19.9.5.15 The haze of the specimen shall be measured following the procedure specified in 19.9.5.1.

19.9.5.16 The delta haze shall be calculated by subtracting the initial haze from the final haze.

19.9.5.17 The testing steps specified in 19.9.3.4 through 19.9.5.16 shall be repeated five times with a new specimen and abrasive disc.

19.9.6 Report.

19.9.6.1 The six delta haze values shall be recorded, and the values shall be averaged and reported.

19.9.6.2 The average value shall be used to determine pass or fail.

19.9.7 Interpretation.

19.9.7.1 The average delta haze shall be used to determine pass or fail performance.

19.9.7.2 Failure of the average value shall constitute failure for the entire sample.

19.10 Nonelectronic Communications Test.

19.10.1 Application. This test method shall apply to complete SCBA facepieces and second stage regulator(s).

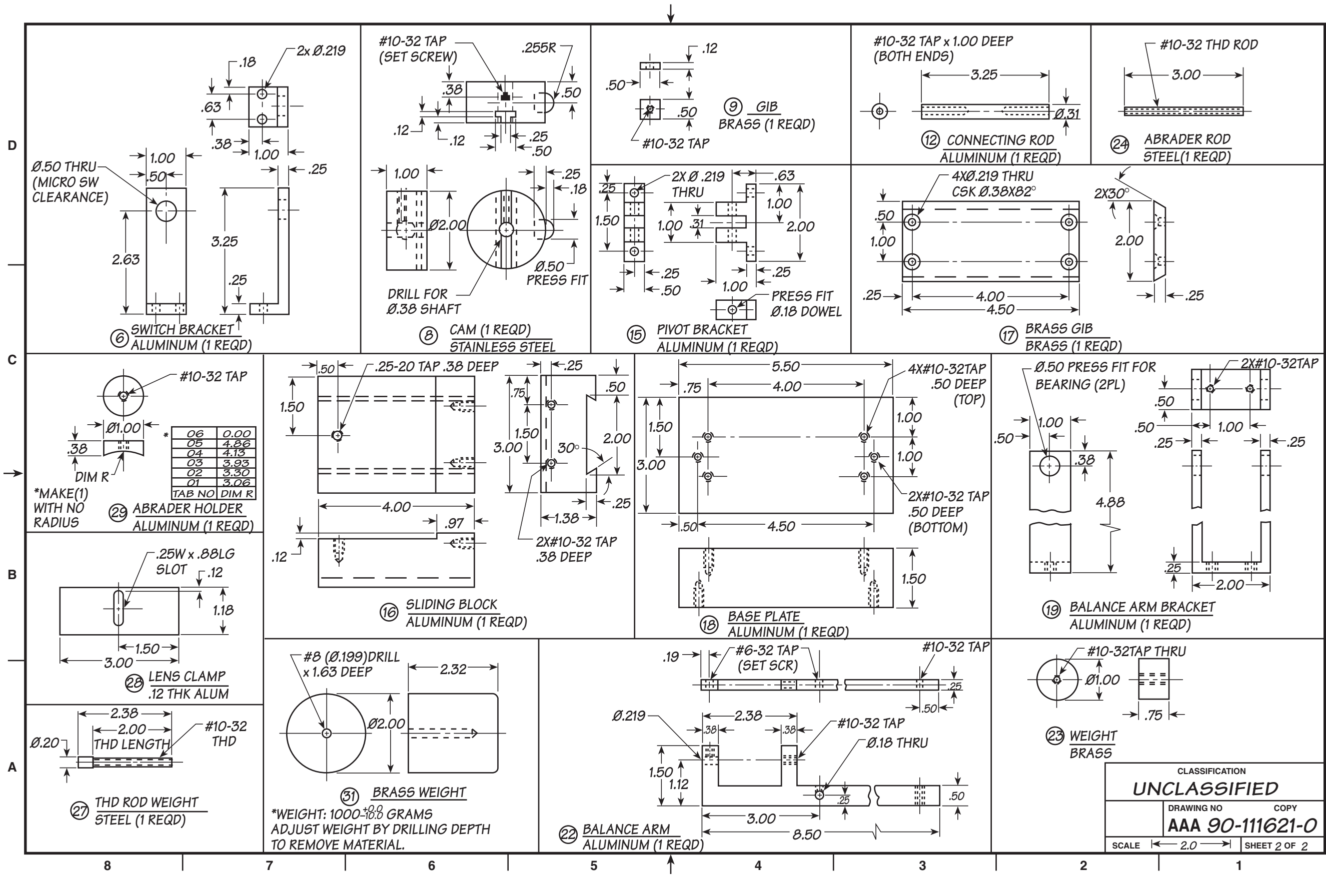


FIGURE 19.9.4(b) Lens Abrasion Tester (details).

19.10.2 Samples. Each sample to be tested shall be as specified in 15.3.2 with all voice communications systems installed, including supplementary voice communications systems, and in the "off" mode in accordance with the manufacturer's instructions.

19.10.3 Specimen Preparation.

19.10.3.1 Prior to testing, specimens shall be conditioned for a minimum of 4 hours and tested at an ambient temperature of 22°C, ±3°C (72°F, ±5°F) and RH of 50 percent, ±25 percent.

19.10.3.2 Specimens for conditioning shall be complete medium-size SCBA facepiece(s) and inner mask(s), with the second stage regulator(s) installed in the "as worn" position as specified by the manufacturer.

19.10.4 Apparatus.

19.10.4.1 Testing shall be conducted in a chamber having the following minimum characteristics:

(1) Minimum room dimensions: 4.6 m long × 3.1 m wide × 2.7 m high (15 ft long × 10 ft wide × 9 ft high)
(2) Construction: hemi-anechoic
(3) Ambient noise level inside chamber: NC-25
(4) Walls and ceiling: ≥90 percent absorptive for 100 Hz

19.10.4.1.1 All surfaces above the floor shall be acoustically treated for internal acoustic absorption, as well as for external noise mitigation.

19.10.4.2 A G.R.A.S. KEMAR Head and Torso Simulator (HATS) Type 45BM shall be used for testing.

19.10.4.2.1 The mouth simulator shall be capable of producing 112 dB/1 kHz sine tone at 25 mm (1 in.) with the mouth reference point unequalized, and the total harmonic distortion (THD) shall be ≤3 percent.

19.10.4.2.2 The mouth simulator frequency response shall be able to be equalized flat ±1 dB between 100 Hz and 10 kHz, and the response shall be –15 dB or less at 100 Hz and –20 dB or less at 15 kHz.

19.10.4.3 The sound pressure level (SPL) meter having the following characteristics shall be used:

(1) The SPL meter shall be capable of applying an equivalent continuous sound pressure level (Leq) using an A-weighted filter.
(2) The SPL meter shall have a dynamic range from 30 dB (or less) to 130 dB (or more).
(3) The SPL meter shall display the measurement to at least one decimal place.

19.10.4.4 The signal/pink noise analog audio signal generators having the following characteristics shall be used.

19.10.4.4.1 One generator shall be capable of playing wave files in the following format: 48 kHz, 16-bit mono at the output level of 0 dB, FS = 18 dBu, according to EBU Technical Recommendation R068, *Alignment level in digital audio production equipment and in digital audio recorders.*

19.10.4.4.2 The second generator shall be capable of generating pink noise and sine waves from −80 dBu to −2 dBu in one-digit steps, with a THD + N of −90 dB (0.0032 percent) at 8 dBu noise floor type 25 uv, and shall also have the following characteristics:

(1) A frequency range of 10 Hz to 20 kHz in one-digit steps ±0.01 percent
(2) An amplitude accuracy of within ±0.5 dB or less

19.10.4.5 A digital equalizer having the following characteristics shall be used:

(1) The digital equalizer shall be capable of at least two concurrently selectable equalizer sections:
   (a) One 31-band graphic with an adjustment range of at least ±18 dB
   (b) A 10-band parametric with an adjustment range of at least ±18 dB
(2) The digital equalizer shall have a dynamic range of 112 dB.
(3) The digital equalizer shall be capable of equalizing the frequency response of the HATS manikin of ±1 dB flat between 100 Hz and 10 kHz, applying a 180 Hz high pass filter with a slope of –24 dB octave, and a 10 Hz low pass filter with a slope of –24 dB octave (–15 dB at 100 Hz, –20 dB at 15 kHz).

19.10.4.6 A powered speaker having the following characteristics shall be used:

(1) The sensitivity shall be ≥84 dB at one watt at 1 meter.
(2) The frequency response shall be rated at ≤80 Hz to ≥13 kHz.
(3) The amplifier shall deliver ≥10 watts with a total harmonic distortion <1 percent.

19.10.4.7 A microphone having the following characteristics shall be used:

(1) The microphone shall be a condenser type.
(2) The microphone polar pattern shall be omnidirectional.
(3) The frequency response shall be flat ±0.5 dB from 100 Hz to 15 kHz.
(4) The residual noise shall be ≤–30 dB.
(5) The microphone shall accept signals of at least 130 dBA.

19.10.4.8 A Speech Transmission Index (STI) analyzer having the following characteristics shall be used:

(1) The STI PA analyzer shall be capable of measuring and displaying a single value STI PA result to two decimal places with a seven octave band modulated noise test signal using the Netherlands Organization for Applied Scientific Research (TNO) verified algorithm.
(2) The STI PA analyzer shall conform to IEC-60268-16, *Sound System Equipment — Part 16: Objective Rating of Speech Intelligibility by Speech Transmission Index.*

19.10.4.9 All of the apparatus identified in 19.10.4.2, 19.10.4.3, 19.10.4.4, 19.10.4.5, 19.10.4.6, and 19.10.4.7 shall be located in the hemi-anechoic chamber and arranged as shown in Figure 19.10.4.9(a) and Figure 19.10.4.9(b).

19.10.4.10 The HATS test manikin shall be positioned in the chamber in the following manner as shown in Figure 19.10.4.9(a) and Figure 19.10.4.9(b).

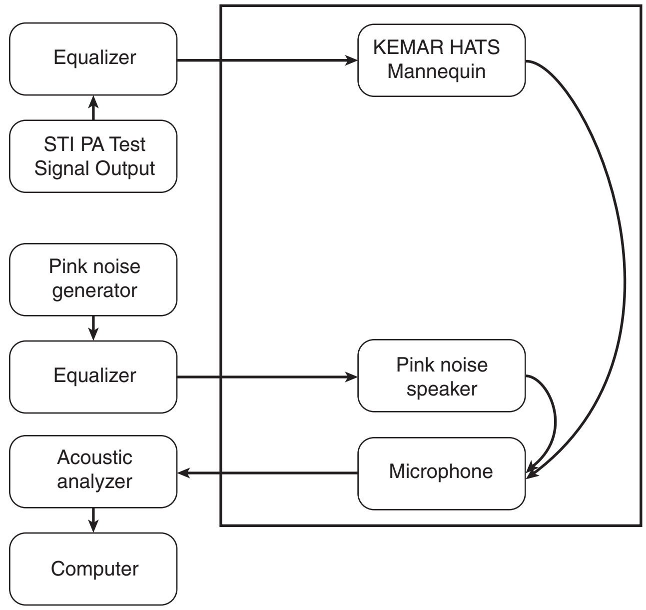


FIGURE 19.10.4.9(a) Hemi-Anechoic Chamber.

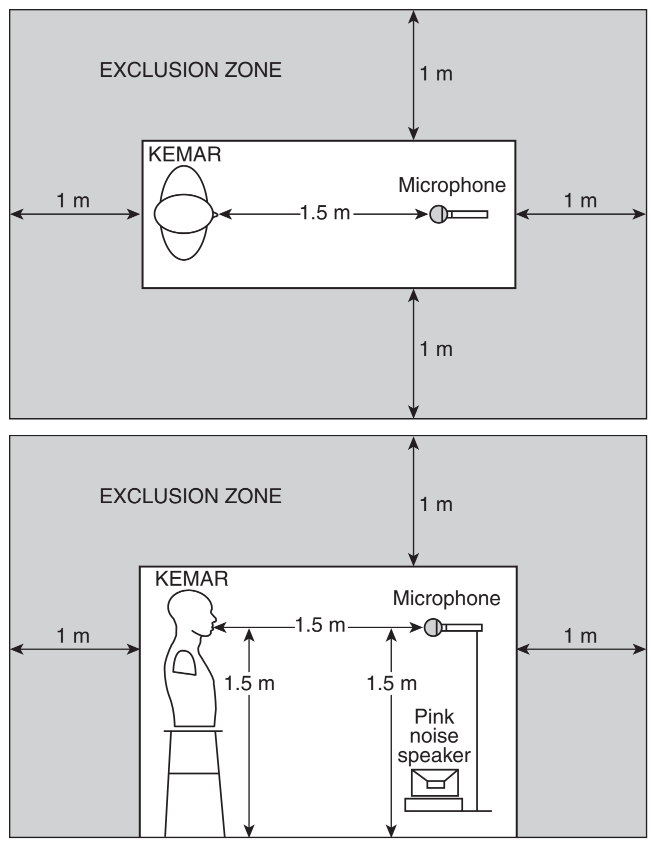


FIGURE 19.10.4.9(b) HATS Test Manikin Position.

19.10.4.10.1 The distance between the HATS test manikin and the microphone shall be 1.5 m, +25 mm/–0 mm (5 ft, +1 in./–0 in.), and they shall be facing each other.

19.10.4.10.2 The distance between the HATS test manikin mouth reference point (MRP) and the floor shall be 1.5 m, +25 mm/–0 mm (5 ft, +1 in./–0 in.).

19.10.4.10.3 The distance between the microphone and the floor shall be 1.5 m, +25 mm/–0 mm (±5 ft, +1 in./–0 in.).

19.10.4.11 The test chamber shall be filled with broadband pink noise with a tolerance of ±1 dB per octave band from 100 Hz to 10 kHz.

19.10.4.12 The pink noise speaker shall be placed directly beneath the microphone and oriented such that the central axis of the speaker cone is directly facing the microphone.

19.10.4.12.1 The speaker shall be situated on top of a block of isolating acoustic foam such that no part of the speaker box is contacting the floor or the microphone stand, to prevent conduction of sound to the microphone.

19.10.4.12.2* The height of the speaker off the floor shall be at least 0.125 m (5 in.), as measured from the bottom of the speaker box, and the distance between the speaker and microphone shall be no less than 1 m (40 in.), as measured from the top of the speaker grille/enclosure.

19.10.4.12.3 The pink noise speaker shall be placed as indicated in Figure 19.10.4.12.3.

19.10.4.13 The pink noise speaker shall be fully equalized flat, from 100 Hz to 10 kHz, to within ±1dB on a relative scale in ⅓ octave bands, as measured at the microphone position.

19.10.4.14 The STI test signal from the manikin shall be adjusted to achieve an A-weighted sound level of 97 dB, ±0.5 dB at the mouth reference point (MRP), 50 mm, ±3 mm (2 in. ±⅛ in.) from the test manikin's mouth.

19.10.4.14.1 The microphone used for calibrating the STI signal shall be omnidirectional and oriented in a horizontal front-facing manner.

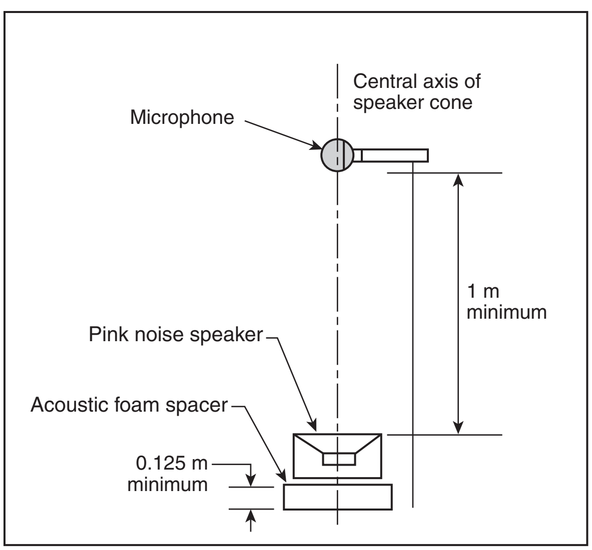


FIGURE 19.10.4.12.3 Test Chamber.

19.10.4.14.2 The STI signal shall be equalized flat to within ±1 dB on a relative scale in ⅓ octave bands as measured at the MRP of the HATS.

19.10.4.14.3 The HATS shall be calibrated as follows:

(1) Equalize flat with pink noise to 97 dBA from 100 Hz – 10 kHz to ±1 dB on a ⅓ octave scale.
(2) Reduce the levels for the 125 Hz octave band (the 100, 125, 160 ⅓ octave bands) by 10 dB.
(3) Reduce the levels for the 250 Hz octave band (the 200, 250, 315 ⅓ octave bands) by 2 dB.
(4) Apply the STI PA signal and adjust the Sound Pressure Level (SPL) to 97 dBA, ±0.5 dBA.

19.10.4.15 The gain of the powered speaker amplifier used to generate the pink noise shall be adjusted to achieve an A-weighted sound level of 15 dB, ±0.5 dB below the signal level generated as identified in 19.10.4.14, measured at the microphone placed as identified in 19.10.4.10.1 and 19.10.4.10.3.

19.10.5 Procedure.

19.10.5.1 The method for measuring the Speech Transmission Index (STI) shall be as specified in IEC 60268-16, *Sound System Equipment — Part 16: Objective Rating of Speech Intelligibility by Speech Transmission Index*, with the modified apparatus specified in 19.10.4.

19.10.5.2 The medium-size facepiece with inner mask and second stage regulator in the normal use mode shall be fitted to the HATS test manikin in the following manner:

(1) Place the chin of the manikin in the "chin cup" of the facepiece.
(2) Place the facepiece to seal against the face of the HATS test manikin.
(3) Pass the head harness of the facepiece over the HATS test manikin and tighten it in a manner that maintains the symmetry of the facepiece on the HATS test manikin, using talc to minimize friction between the HATS test manikin and the strap.
(4) Tighten the straps to a tension of 50 N (11.2 lbf).

19.10.5.3 Three medium-size facepieces shall be tested in the chamber having an ambient noise field as specified in 19.10.4.11 through 19.10.4.15. Each facepiece shall be mounted as specified in 19.10.5.2 and then tested as follows:

(1) Three separate measurements shall be recorded for each donning of the facepiece.
(2) Five separate donnings shall be performed.
(3) Total of 45 measurements: 3 (facepieces) × 3 (measurements) × 5 (donnings) = 45 measurements.

19.10.6 Report.

19.10.6.1 The STI PA signal Sound Pressure Level (SPL) per octave band, the Modulation Transfer Index per octave band, and overall STI score at the mouth reference point (MRP) described in 3.3.118 shall be recorded and reported.

19.10.6.2 The STI PA signal SPL per octave band, the Modulation Transfer Index per octave band, and overall STI score at the microphone measurement point (MMP) described in 3.3.113 shall be recorded and reported.

19.10.6.3 The pink noise SPL per octave band at the MMP described in 3.3.113 shall be recorded and reported.

19.10.6.4 The STI score for each facepiece measurement sampled as described in 19.10.5.3 (a total of 45 scores) shall be recorded and reported, and the starting time of each facepiece donning shall be recorded.

19.10.6.5 The average for each donning shall be calculated, recorded, and reported. There shall be a total of 15 averages of 3 measurements (5 averages for each of the 3 facepiece samples). See Figure 19.10.6.5.

19.10.7 Interpretation.

19.10.7.1 The averages calculated in 19.10.6.5 shall be used to determine a pass or fail per Section 18.10.

19.10.7.2 If any of the 15 averages score less than the minimum threshold specified in Section 18.10, the facepiece shall be considered to have failed and shall be reported as such.

19.10.7.3 If all of the 15 averages score equal to or greater than the minimum threshold specified in Section 18.10, the facepiece shall be considered to have passed and shall be reported as such.

19.11 Heat and Flame Test.

19.11.1 Application. This test method shall apply to complete SCBA.

19.11.2 Samples. Each sample to be tested shall be as specified in 15.3.2.

19.11.3 Specimen Preparation.

19.11.3.1 Prior to testing, specimens shall be conditioned for a minimum of 4 hours and tested at an ambient temperature of 22°C, ±3°C (72°F, ±5°F) and RH of 50 percent, ±25 percent.

19.11.3.2 Specimens for conditioning shall be complete SCBA.

19.11.4 Apparatus.

19.11.4.1 A test manikin meeting the requirements specified in Figure 19.11.4.1 shall be provided.

19.11.4.2 Both the calibration manikin and the heat and flame test manikin shall have protective coverings.

19.11.4.2.1 The protective coverings shall be a weld blanket made of fireproof silica cloth of a minimum weight of 18 oz/sq yd.

19.11.4.2.2 The protective coverings shall be designed and constructed to provide coverage over the surface of the manikins.

19.11.4.2.3 Where additional insulation is needed to protect the manikin electronics, an additional thermal liner underlayer shall be permitted.

19.11.4.2.4 The complete protective covering shall be discarded and shall not be used where the damage to any portion indicates the covering can no longer provide thermal protection for the test manikin.

19.11.4.3 A test headform meeting the requirements specified in 19.1.4.1 shall be used on the test manikin.

19.11.4.4 The test headform shall be attached to the breathing machine as specified in Figure 19.1.4.9, with the modification that a 38 mm (1½ in.) I.D. breathing hose, not longer than 7.6 m (25 ft), shall be interconnected between the breathing machine and the throat tube of the test manikin headform.

19.11.4.5 The test headform shall be covered with an undyed aramid hood for protection of the headform during testing.

19.11.4.5.1 The protective hood shall meet the hood requirements of Chapters 4 through 9 of this standard.

19.11.4.5.2 The protective hood, when placed on the test headform, shall not affect the seal of the facepiece to the headform.

19.11.4.5.3 The protective hood shall not cover or protect any part of the facepiece or the facepiece retention system that holds the facepiece to the headform.

19.11.4.6 The heat and flame test apparatus shall be as specified in Figure 19.11.4.6.

19.11.4.6.1 The test oven shall be a horizontal forced circulating air oven with a range of flow of 38 m/min to 76 m/min (125 ft/min to 250 ft/min).

19.11.4.6.2 The test oven shall have minimum dimensions of 915 mm depth × 915 mm width × 1.22 m height (36 in. depth × 36 in. width × 48 in. height).

19.11.5 Procedure.

19.11.5.1 The SCBA shall be mounted on the test manikin to simulate the correct wearing position on a person as specified by the SCBA manufacturer's instructions.

19.11.5.2 The facepiece shall be mounted and tested on the test headform as specified in 19.1.4.1.

19.11.5.3 For calibration prior to the heat and flame test, the manikin for calibration shall be the same as the test manikin specified in 19.11.4.1 and shall be exposed to direct flame contact for 10 seconds using the heat and flame test apparatus.

19.11.5.3.1 All peak temperature readings shall be within a temperature range of 815°C to 1150°C (1500°F to 2102°F).

19.11.5.3.2 The average mean of all peak temperature readings specified in 19.11.5.3.1 shall be no higher than 950°C (1742°F).

19.11.5.4 The test oven recovery time, after the door is closed, shall not exceed 1.0 minute.

19.11.5.5 The airflow performance test shall be conducted as specified in 19.1.5, with modifications to the ventilation rate specified in 19.11.5.7 with the test temperatures specified in 19.11.5.3 and 19.11.5.8.

19.11.5.5.1 The variation in pressure extremes caused by the heat and flame test manikin configuration shall be determined as specified in 19.11.5.5.2 and 19.11.5.5.3.

19.11.5.5.2 The airflow performance test as specified in Section 19.1, Airflow Performance Test, shall be carried out using the configuration specified in 19.11.4.4 at the same ventilation rates.

19.11.5.5.3 The difference in pressure between the two tests shall be calculated by subtracting the values obtained using the configuration defined in 19.11.4.4 from the values obtained using the configuration specified in Section 19.1, Airflow Performance Test.

Sample Recording Sheet for STI Test

1. Tested Per Procedure:

________ **18.10** Nonelectronic Communications Performance Requirements.

________ **18.17** Supplementary Voice Communications System Performance Requirements.

2. Setup Information:

STIPA Signal data at Mouth Reference Point (MRP)

		Sound Pressure Levels							Modulation Transfer Index						
#	**STI**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**
1															
2															
3															
4															

1 — Initial measurement prior to fireplace testing started
2 — Final measurement after fireplace testing commenced
3 & 4 — Supplemental measurements for testing breaks greater than 1 hour during testing

STIPA Signal data at Microphone Measurement Point (MMP)

		Sound Pressure Levels							Modulation Transfer Index						
#	**STI**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**
1															
2															
3															
4															

1 — Initial measurement prior to fireplace testing started
2 — Final measurement after fireplace testing commenced
3 & 4 — Supplemental measurements for testing breaks greater than 1 hour during testing

Pink Noise data at Microphone Measurement Point (MMP)

		Sound Pressure Levels							Modulation Transfer Index						
#	**STI**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**
1															
2															
3															
4															

1 — Initial measurement prior to fireplace testing started
2 — Final measurement after fireplace testing commenced
3 & 4 — Supplemental measurements for testing breaks greater than 1 hour during testing

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FIGURE 19.10.6.5 Sample Recording Sheet for STI Test.

3. Measurement Information

- Record STI score per facepiece/donning/measurement
- Use the notes column to indicate Pass/Fail and/or observations
- Extra rows are provided if necessary

Faceplate Sample 1

	STI Scores				
Don #	**Meas 1**	**Meas 2**	**Meas 3**	**Avg**	**Notes**
1					
2					
3					
4					
5					

Faceplate Sample 2

	STI Scores				
Don #	**Meas 1**	**Meas 2**	**Meas 3**	**Avg**	**Notes**
1					
2					
3					
4					
5					

Faceplate Sample 3

	STI Scores				
Don #	**Meas 1**	**Meas 2**	**Meas 3**	**Avg**	**Notes**
1					
2					
3					
4					
5					

4. Pass/Fail

Indicate whether the facepiece passed or failed as whole per 19.10.7.1 or 19.25.7.1 respectively

_______ PASS

_______ FAIL

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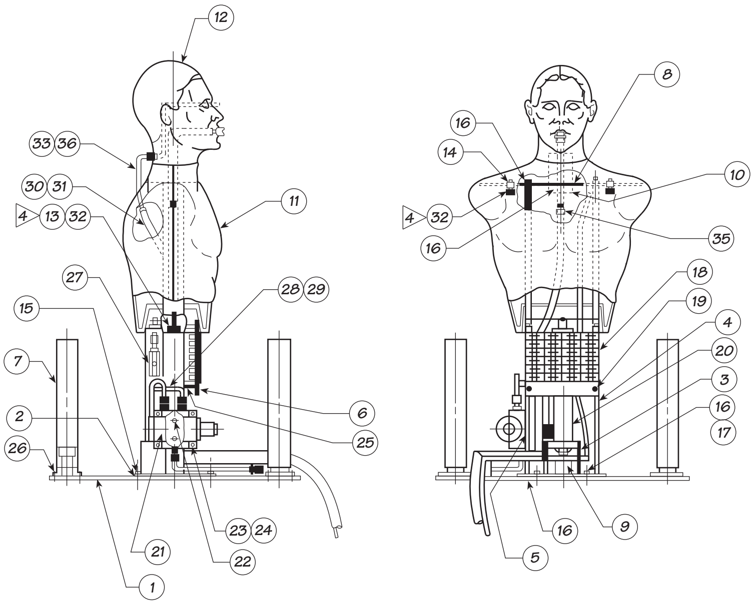
FIGURE 19.10.6.5 ***Continued***

NOTES
Unless otherwise specified:
1. All dimensions are in inches.
2. Dimensioning and tolerancing per ANSI Y14.SM-1982.
3. Surface texture per ANSI B46.1-1978.
4. $4 \times 0.197 ^{+.010}_{-.002}$ THRU ITEM II, MATCH DRILL FROM ITEMS 13 & 14 FOR ITEM 32.



NO REQD	PART/LLNL STK NO	DESCRIPTION/MATERIAL		SPEC NO.	ITEM
A/R		TUBE, S/STL, 1/4 O.D.			36
1		CLAMP, AEROSEAL, O 1/2			35
1	SWAGELOK-400-6	UNION, 1/4 TUBE	CRES		33
12		SCR, #8-32 UNC-2A RD HD X 3/8 LG	CRES		32
1		CLAMP, AEROSEAL, O 1/2	CRES		31
A/R		TUBE, PVC REINFORCED 1/4 I.D.		9330-51405	30
5	SWAGELOK-600-1-2	MALE CONNECTOR, 3/8 TUBE X 1/8 NPT	CRES		29
A/R		TUBE,0.375 X .035W.	CRES	4710-14193	28
1	ARO CORP	SNUBBER			27
12		SCR,1/4-20 UNC-2A SOC HD X 1.00 LG	STL		26
4		STANDOFF, #6-32 THD, X 1.00 LG	ALUM	5975-53447	25
4		NUT, HEX, #10-32 UNF-28 STD	STL		24
4		SCR, #10-32 UNF-2A SOC HD X 1.50 LG	STL		23
4		SCR, #10-32 UNF-2A FLT HD X 1.00 LG	STL		22
1	ARO CORP MODELK 21355120A	VALVE			21
1	ARO CORP 0418-1003-080	CYLINDER, AIR, 1 1/8 BORE			20
4		SCR, #6-32 UNC-2A RD HD X 1 1/2 LG	STL		19
4	MARLIN CORP. 1032-6	CONNECTOR, T.C., 6 JACK, 2 HOLE, TYPE K		5935-58196	18
		NUT, HEX, 1/4-20 UNC-2B STD	STL		17
12		SCR, 1/4-20 UNC-2A FLT HD X .75 LG	STL		16
4		SCR, 1/4-20 UNC-2A SOC HD X .50 LG	STL		15
4	90-101459	BRACKET			14
2	90-101473 A	TIE STRAP			13
1	90-101456	HEAD			12
1	90-10146 OR 90-101458	TORSO I OR TORSO II			11
1	89-113884	COLLAR-MOUNT			10
1	89-113883	SHAFT END			9
1	89-111724	MOUNT PLATE, MANNEQUIN			8
4	89-113882	GUIDE VERTICAL			7
1	89-113881	T.C. PANEL			6
1	89-113880	VALVE PLATE			5
2	89-113878	FRAMEBAR			4
1	89-113877	MOUNT-AIR CYL.			3
1	89-113876	BASE MOUNT			2
1	89-113879	LIFT PLATE			1

DWN G PURVIS
CHK George B. Valhan
APVD D. Bergon
CLASSIFIED BY:
TITLE
LAWRENCE LIVERMORE NATIONAL LABORATORY
MAJOR UNIT U.S. Fire Administration FEMA
SUB ASSY NFPA HEAT & FLAME TEST APPARATUS
DETAIL MANNEQUIN ASSY
SHOWN ON AAA 3265-30
DRAWING NO AAA 90-101453-0A
SCALE 8.00 SHEET OF

FIGURE 19.11.4.1 Test Manikin.

19.11.5.6 The airflow performance test shall continue through the drop test specified in 19.11.5.15.

19.11.5.7 The ventilation rate shall be set at 40 L/min, ±2 L/min, with a respiratory frequency of 24 breaths/min, ±1 breath/min at ambient conditions as specified in 19.1.3.2.

19.11.5.8 The SCBA mounted on the test manikin shall be placed in the test oven that has been preheated to 95°C, ±2°C (203°F, ±4°F).

19.11.5.9 After the test oven door is closed and the oven temperature recovers to 95°C (203°F), the test exposure time of 15 minutes shall begin.

19.11.5.10 At the completion of the 15-minute exposure, the ventilation rate shall be increased to 103 L/min, ±3 L/min, as specified in 19.1.4.9.5.

19.11.5.11 The oven door shall be opened, and the SCBA mounted on the test manikin shall be moved out of the oven and into the center of the burner array.

19.11.5.12 The SCBA shall then be exposed to direct flame contact for 10 seconds, +0.25 second/−0.0 seconds.

19.11.5.13 This exposure shall begin within 20 seconds of removal of the SCBA from the test oven.

19.11.5.14 The SCBA shall be observed for any afterflame, and the afterflame duration shall be recorded to determine pass or fail as specified in 18.11.2.

19.11.5.15 Within 20 seconds after the direct flame exposure has been completed, the SCBA mounted on the test manikin shall be raised 150 mm, +6 mm/−0 mm (6 in., +¼ in./−0 in.) and dropped freely.

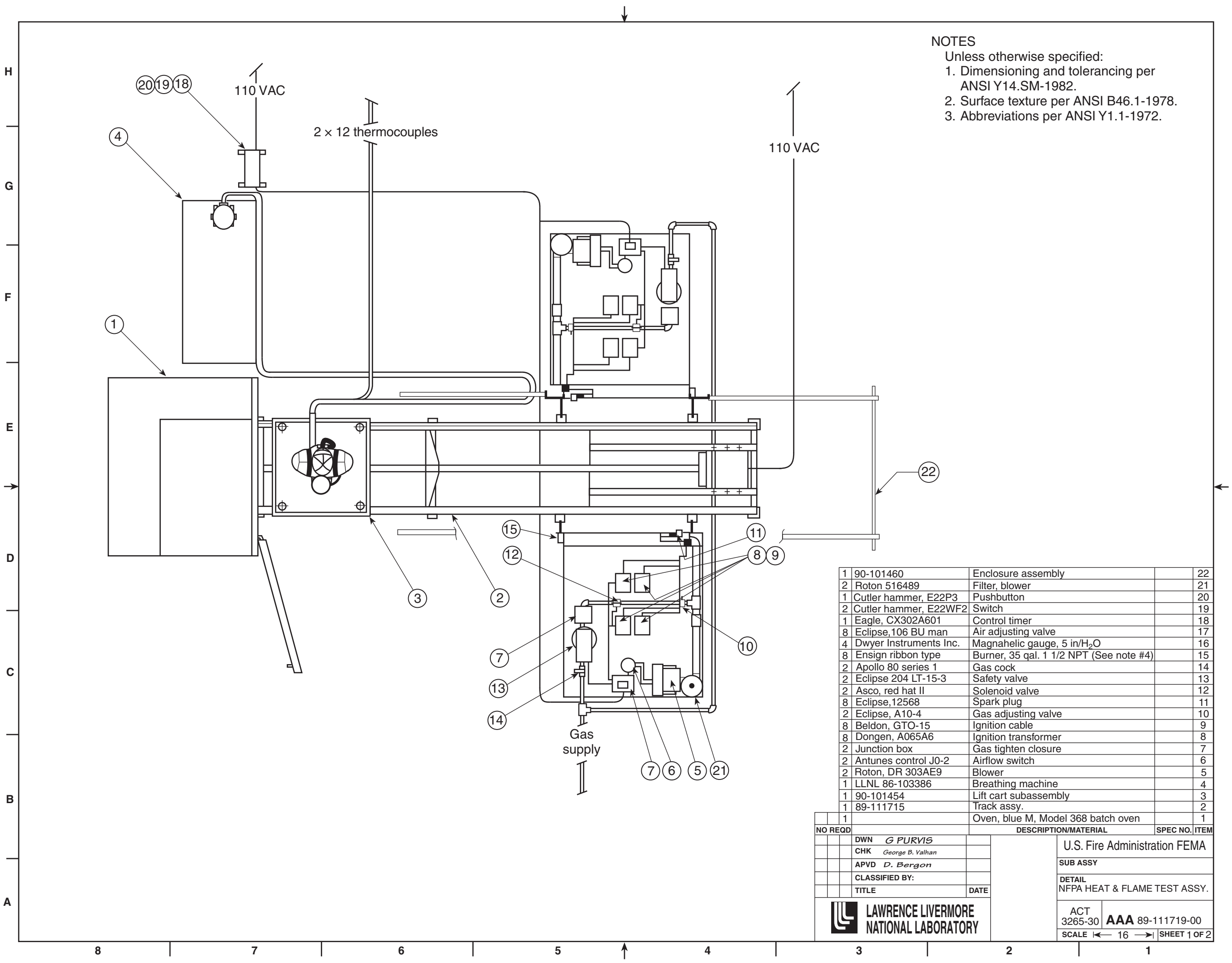
19.11.5.16 The SCBA shall be observed to determine pass or fail performance as specified in 18.11.3.

19.11.5.17 The facepiece pressure during the entire test shall be read from the strip chart recorder and corrected by adding the value of the difference in pressure calculated in 19.11.5.5.1 to determine pass or fail as specified in 18.11.1.

19.11.5.18 Any pressure spike caused by the impact of the drop test and measured within a duration of three cycles of the breathing machine after the apparatus drop shall be disregarded.

19.11.5.19 The SCBA facepiece and HUD shall be removed from the test headform and shall be donned by a test subject without touching the facepiece lens or HUD.

19.11.5.19.1 The test subject shall have visual acuity of 20/20 in each eye, uncorrected or corrected with contact lenses.



NO REQD		DESCRIPTION/MATERIAL	SPEC NO.	ITEM
1	90-101460	Enclosure assembly		22
2	Roton 516489	Filter, blower		21
1	Cutler hammer, E22P3	Pushbutton		20
2	Cutler hammer, E22WF2	Switch		19
1	Eagle, CX302A601	Control timer		18
8	Eclipse,106 BU man	Air adjusting valve		17
4	Dwyer Instruments Inc.	Magnahelic gauge, 5 in/H_2O		16
8	Ensign ribbon type	Burner, 35 qal. 1 1/2 NPT (See note #4)		15
2	Apollo 80 series 1	Gas cock		14
2	Eclipse 204 LT-15-3	Safety valve		13
2	Asco, red hat II	Solenoid valve		12
8	Eclipse,12568	Spark plug		11
2	Eclipse, A10-4	Gas adjusting valve		10
8	Beldon, GTO-15	Ignition cable		9
8	Dongen, A065A6	Ignition transformer		8
2	Junction box	Gas tighten closure		7
2	Antunes control J0-2	Airflow switch		6
2	Roton, DR 303AE9	Blower		5
1	LLNL 86-103386	Breathing machine		4
1	90-101454	Lift cart subassembly		3
1	89-111715	Track assy.		2
1		Oven, blue M, Model 368 batch oven		1

FIGURE 19.11.4.6 Heat and Flame Test Apparatus.

19.11.5.19.2 The test subject shall then observe the HUD display to see that visual alert signal(s) have activated.

19.11.5.19.3 The test subject shall identify the visual alert signals that are activated.

19.11.5.20 The SCBA facepiece, removed from the test headform and donned by the test subject as specified in 19.11.5.19, shall be used for determining facepiece lens vision.

19.11.5.20.1 The test shall be conducted using a standard 6.1 m (20 ft) eye chart with normal lighting range of 120 to 150 ft-candles at the chart and with the test subject positioned at a distance of 6.1 m (20 ft) from the chart.

19.11.5.20.2 The test subject shall then read the standard eye chart at some point through the nominal center of the lens of the facepiece to determine pass or fail performance as specified in 18.11.4.

19.11.5.20.3 The nominal center of the lens shall be the area bounded by a line 50 mm (2 in.) above, 50 mm (2 in.) below, 50 mm (2 in.) left, and 50 mm (2 in.) right of the intersection of the basic and mid-sagittal planes.

19.11.5.21 The activation of the EOSTI shall be observed.

19.11.5.22 The SCBA shall be operated according to the manufacturer's instructions to test the data logging function as specified in 17.1.12 to determine pass or fail performance.

19.11.6 Report.

19.11.6.1 The facepiece pressure peak inhalation and peak exhalation shall be recorded and reported for each test condition.

19.11.6.2 Any afterflame beyond 2.2 seconds shall be recorded and reported.

19.11.6.3 The facepiece lens vision shall also be recorded and reported.

19.11.6.4 The activation and operation or failure to activate and operate of EOSTI shall be recorded and reported.

19.11.6.5 The activation and identification of HUD visual alert signals shall be recorded and reported.

19.11.6.6 The functioning of the data logging shall be recorded and reported.

19.11.7 Interpretation.

19.11.7.1 Pass or fail performance shall be based on any observed afterflame, the peak inhalation and exhalation values, and the facepiece vision value.

19.11.7.2 Failure to meet any of the test condition requirements shall constitute failure of the SCBA.

19.11.7.3 Failure of any EOSTI alarm signals to activate and remain active during the test shall constitute failing performance.

19.11.7.4 Failure of the HUD to display the breathing air cylinder content or to display the visual alert signals during the test shall constitute failing performance.

19.12 Facepiece Carbon Dioxide Content Test.

19.12.1 Application. This test shall apply to all SCBA facepieces.

19.12.2 Specimens. Each SCBA facepiece model and size shall be tested.

19.12.3 Specimen Preparation. Prior to testing, specimens shall be conditioned for a minimum of 4 hours and tested at an ambient temperature of 22°C, ±3°C (72°F, ±5°F) and RH of 50 percent, ±25 percent.

19.12.4 Procedure. Specimens shall be tested as specified in Section 8.14 of BS EN 136, *Respiratory protective devices — Full face masks — Requirements, testing, marking.*

19.12.5 Report. The facepiece carbon dioxide content shall be recorded and reported for each test specimen.

19.12.6 Interpretation.

19.12.6.1 The facepiece carbon dioxide content shall be used to determine pass or fail performance.

19.12.6.2 One or more specimens failing this test shall constitute failing performance.

19.13 EOSTI Independent Activation Test.

19.13.1 Application. This test method shall apply to complete SCBA.

19.13.2 Samples. Samples for testing shall be selected as specified in 15.3.2.

19.13.3 Specimen Preparation. Prior to testing, specimens shall be conditioned for a minimum of 4 hours at an ambient temperature of 22°C, ±3°C (72°F, ±5°F) and RH of 50 percent, ±25 percent.

19.13.4 Apparatus.

19.13.4.1 Testing shall be performed using a calibrated pressure gauge accurate to within ±0.25 percent of full span and graduated in increments of 0.5 bar (7.5 psi) or smaller.

19.13.4.2 A bleed valve capable of bleeding pressure at a rate not exceeding 50 bar (750 psi) per minute shall be used.

19.13.4.3 An adapter shall be provided to connect the calibrated pressure gauge and bleed valve to the SCBA breathing air cylinder connection.

19.13.5 Procedure.

19.13.5.1 Each SCBA test specimen shall be modified so that all EOSTI sensing mechanisms, other than the one being tested, are blocked to simulate failure.

19.13.5.2 SCBA test specimens shall be tested at an ambient temperature of 22°C, ±3°C (72°F, ±5°F) and RH of 50 percent, ±25 percent.

19.13.5.3 The adapter to connect the calibrated pressure gauge and bleed valve shall be installed at the breathing air cylinder connection on the SCBA test specimen.

19.13.5.4 After pressurizing the SCBA test specimen breathing air cylinder to greater than 40 percent of cylinder rated service pressure, the pressure shall be bled to ambient pressure at a rate not greater than 50 bar (750 psi) per minute.

19.13.5.5 The EOSTI alarm signal from the unblocked EOSTI shall function as specified in 18.13.1.

19.13.5.6 This test shall be repeated for each EOSTI.

19.13.6 Report.

19.13.6.1 The activation of the EOSTI alarm signal and the breathing air cylinder pressure at which the alarm signal activates shall be recorded and reported.

19.13.6.2 The breathing air cylinder pressure at which the EOSTI alarm signal stops shall be recorded and reported.

19.13.6.3 The proper functioning of the EOSTI alarm signal as specified in 18.13.1 shall be recorded and reported.

19.13.7 Interpretation.

19.13.7.1 The proper activation and continued operation to the specified pressure shall be used to determine pass or fail performance.

19.13.7.2 One or more specimens failing this test shall constitute failing performance.

19.14 EOSTI Recognition Test.

19.14.1 Application. This test method shall apply to complete SCBA.

19.14.2 Samples. Samples for testing shall be selected as specified in 15.3.2.

19.14.3 Specimen Preparation. Prior to testing, specimens shall be conditioned for a minimum of 4 hours at an ambient temperature of 22°C, ±3°C (72°F, ±5°F) and RH of 50 percent, ±25 percent.

19.14.4 Apparatus.

19.14.4.1 An adapter shall be provided that allows the person conducting the test to manually switch between a breathing air supply greater than 30 percent of the SCBA breathing air cylinder rated service pressure and a breathing air supply pressure of 18 bar, ±1 bar (265 psi, ±15 psi).

19.14.4.2 Each SCBA test specimen shall be tested separately by two individual test subjects.

19.14.4.3 Test subjects shall wear full structural firefighting protective ensemble, including coat, trousers, helmet, hood, gloves, and footwear, that is certified as compliant with Chapters 4 through 9 of this standard.

19.14.4.4 Testing shall be performed with test subjects walking at 5 km/hr, ±0.2 km/hr (3 mph, ±0.12 mph) on a treadmill at zero percent grade.

19.14.4.5 Testing shall be conducted in a test chamber that absorbs a minimum of 90 percent of all sound from 500 Hz to 5000 Hz.

19.14.4.6 Test subjects shall have "audiometrically normal" hearing as defined in Section 5.3 of ANSI/ASA S3.2, *Measuring the Intelligibility of Speech Over Communication Systems,* in the range of 500 Hz to 3000 Hz.

19.14.4.7 Test subjects shall have had a physical examination conducted by a physician within the past 12 months of the date of testing.

19.14.4.8 The treadmill shall be positioned in the test chamber specified in 19.14.4.5 in a location where the conditions for background noise, lighting, and distraction specified in 19.14.4.9 and 19.14.4.10 are met.

19.14.4.9 The test chamber shall be filled with "pink" noise with a tolerance of 6 dB per octave band from 400 Hz to 4000 Hz and shall be adjusted to achieve an A-weighted sound level of 75 dB, ±2 dB measured at each ear of the test subject when the subject is walking on the treadmill as specified in 19.14.4.4.

19.14.4.9.1 The forward axis of the loudspeaker shall be located as far as possible from and pointed away from the test subject so as to create a quasi-uniform sound field at the test subject's ears.

19.14.4.9.2 More than one loudspeaker shall be permitted to be used to achieve the desired sound level.

19.14.4.10 The area in the test chamber where the test subject's head is positioned when the subject is standing in the walking location on the treadmill shall be artificially lighted to achieve a light level between 100 lux and 500 lux.

19.14.4.11 A reading stand containing printed text shall be positioned relative to the treadmill as follows:

(1) The vertical center of the text shall be in line with the center of the treadmill track within ±100 mm (±4 in.).
(2) The horizontal center of the text shall be at the same height, ±100 mm (±4 in.), as the eye level of the test subject when the subject is standing in the walking position on the treadmill.
(3) The text shall be at a distance from the test subject that permits the text to be read by the subject while the subject is walking on the treadmill.

19.14.5 Procedure.

19.14.5.1* Each specimen to be tested shall be an SCBA modified such that all EOSTI sensing mechanisms other than the one being tested are blocked so as to simulate failure.

19.14.5.2 Prior to testing, the special adapter specified in 19.14.4.1 shall be installed at the breathing air cylinder connection on the SCBA specimen and the cylinder replaced with the air source specified in 19.14.4.1.

19.14.5.3 Each SCBA test specimen shall be modified so that all EOSTI sensing mechanisms, other than the one being tested, are blocked to simulate failure.

19.14.5.4 SCBA test specimens shall be tested at an ambient temperature of 22°C, ±3°C (72°F, ±5°F) and RH of 50 percent, ±25 percent.

19.14.5.5 A test subject wearing the protective ensemble specified in 19.14.4.3 shall don the test specimen SCBA and begin walking on the treadmill in the ambient conditions specified in 19.14.4.9 and 19.14.4.10.

19.14.5.6 While breathing from the SCBA, the test subject shall read aloud the printed text.

19.14.5.7 The person conducting the testing shall switch from the breathing air supply at greater than 40 percent of cylinder rated service pressure to 18 bar, ±1 bar (265 psi, ±15 psi) at a random point between 30 seconds and 120 seconds from the commencement of the test.

19.14.5.8 The test subject shall acknowledge recognition of the alarm signal immediately upon becoming aware of it by a gesture that has been predetermined between the test subject and the person performing the testing.

19.14.5.9 The test shall be repeated by the second test subject.

19.14.6 Report. The time elapsed between the switch to low supply air pressure and the acknowledgement of recognition of the EOSTI alarm signal by the test subject shall be recorded and reported.

19.14.7 Interpretation. Failure of either of the two test subjects to acknowledge recognition of the EOSTI alarm signal within the time period specified in 18.13.2 shall constitute failing performance.

19.15 HUD Wiring Connection Strength Test.

19.15.1 Application. This test method shall apply to SCBA facepieces with HUD and any associated assemblies with interconnecting wiring.

19.15.2 Samples. Each sample to be tested shall be as specified in 15.3.2.

19.15.3 Specimen Preparation.

19.15.3.1 Specimens for conditioning shall be SCBA facepieces with HUD and any associated assemblies with interconnecting wiring.

19.15.3.2 Prior to testing, specimens shall be conditioned for a minimum of 4 hours and tested at an ambient temperature of 22°C, ±3°C (72°F, ±5°F) and RH of 50 percent, ±25 percent.

19.15.4 Apparatus. A mass of known weight with the means for attachment to wiring shall be provided.

19.15.5 Procedure. A force of 156 N, ±9 N (35 lbf, ±2 lbf) shall be applied gradually, in an axial direction, to the wiring of the specimen being tested.

19.15.6 Report. Observations of the HUD functionality shall be recorded and reported.

19.15.7 Interpretation. Observation of HUD functionality in accordance with 17.3.5 shall be used to determine pass or fail performance.

19.16 HUD Low Power Capacity and Visual Alert Signal Test.

19.16.1 Application. This test shall apply to all HUD power sources and low power source visual alert signals.

19.16.2 Samples. Each sample to be tested shall be as specified in 15.3.2.

19.16.3 Specimen Preparation. Specimens shall be conditioned for a minimum of 4 hours and tested at an ambient temperature of 22°C, ±3°C (72°F, ±5°F) and RH of 50 percent, ±25 percent.

19.16.4 Procedure.

19.16.4.1 Each HUD shall be configured to operate in the operational mode that utilizes maximum power consumption. The power source discharge method and rate shall be provided to the certification organization by the manufacturer and must include consideration of all electronic devices that share a common power source and consideration of all configurations and operational modes that consume maximum power.

19.16.4.2 Each HUD shall be operated until activation of the HUD low power source visual alert signal.

19.16.4.3 After activation of the HUD low power source visual alert signal, each HUD device shall be operated for 1 additional hour.

19.16.5 Report.

19.16.5.1 HUD shall be observed for activation of the low power source visual alert signal.

19.16.5.2 HUD shall be observed for the display of the visual information and visual alert signals for 1 hour after activation of the HUD low power source visual alert signal.

19.16.5.3 The events in 19.16.5.1 and 19.16.5.2 shall be recorded and reported.

19.16.6 Interpretation.

19.16.6.1 HUD low power source visual alert signal function shall be evaluated to determine pass or fail performance.

19.16.6.2 HUD display of the visual information and visual alert signals shall be evaluated to determine pass or fail performance.

19.17 HUD Visibility Test.

19.17.1 Darkness Test.

19.17.1.1 Application. This test method shall apply to complete SCBA.

19.17.1.2 Samples. Each sample to be tested shall be as specified in 15.3.2.

19.17.1.3 Specimen Preparation. Prior to testing, specimens shall be conditioned for a minimum of 4 hours and tested at an ambient temperature of 22°C, ±3°C (72°F, ±5°F) and RH of 50 percent, ±25 percent.

19.17.1.4 Apparatus.

19.17.1.4.1 The SCBA breathing air cylinder shall be permitted to be replaced with a cylinder of lesser capacity. The breathing air capacity of the replacement cylinder shall be greater than 200 L (7.1 ft^3).

19.17.1.4.2 Testing shall be performed in a light-controlled enclosure designated as the "testing enclosure." A diffused-light source that provides a luminance of 2 lux, ±1 lux shall be used to illuminate across the surface of the SCBA facepiece lens.

19.17.1.5 Procedure.

19.17.1.5.1 The selected test subjects shall have visual acuity of 20/20 in each eye uncorrected or corrected with contact lenses. Selected test subjects shall be able to read lowercase letters measuring 2.5 mm (3⁄32 in.) in height at a distance of 305 mm (12 in.).

19.17.1.5.2 The test subject shall don a complete SCBA.

19.17.1.5.3 The test subject shall enter the testing enclosure and be positioned so that the SCBA facepiece is illuminated as specified in 19.17.1.4.2.

19.17.1.5.4 The test subject shall wait 1 minute to allow the eyes to acclimate to the illumination.

19.17.1.5.5 The SCBA shall be activated so as to activate the HUD.

19.17.1.5.6 The cylinder shall be fully charged, and the HUD shall show full cylinder charge.

19.17.1.5.7 The SCBA pressure shall be slowly decreased so as to activate all HUD visual displays.

19.17.1.6 Report.

19.17.1.6.1 Each visual display of information and each visual alert signal as defined by the manufacturer's instructions shall be observed for distinctness and identifiability.

19.17.1.6.2 The test subject's observations of distinctness and identifiability shall be recorded and reported.

19.17.1.7 Interpretation.

19.17.1.7.1 The test subject's ability to distinguish between each visual display of information and each visual alert signal as defined by the manufacturer's instructions shall be observed, and the distinguishing features shall be distinct and identifiable.

19.17.1.7.2 Failure of the test subject to be able to observe each visual display of information and each visual alert signal as distinct, identifiable, or both shall constitute failing performance.

19.17.2 Light Test.

19.17.2.1 Application. This test method shall apply to complete SCBA.

19.17.2.2 Samples. Each sample to be tested shall be as specified in 15.3.2.

19.17.2.3 Specimen Preparation. Prior to testing, specimens shall be conditioned for a minimum of 4 hours and tested at an ambient temperature of 22°C, ±3°C (72°F, ±5°F) and RH of 50 percent, ±25 percent.

19.17.2.4 Apparatus.

19.17.2.4.1 The SCBA breathing air cylinder shall be permitted to be replaced with a cylinder of lesser capacity. The breathing air capacity of the replacement cylinder shall be greater than 200 L (7.1 ft^3).

19.17.2.4.2 Testing shall be performed in a light-controlled enclosure designated as the "testing enclosure." A diffused light source that provides a luminance of 10,000 lux, ±1000 lux shall be used to illuminate across the surface of the SCBA facepiece lens.

19.17.2.5 Procedure.

19.17.2.5.1 The selected test subjects shall have visual acuity of 20/20 in each eye uncorrected or corrected with contact lenses. Selected test subjects shall be able to read lowercase letters measuring 2.5 mm (3⁄32 in.) in height at a distance of 305 mm (12 in.).

19.17.2.5.2 The test subject shall don a complete SCBA.

19.17.2.5.3 The test subject shall enter the testing enclosure and be positioned so that the SCBA facepiece is illuminated as specified in 19.17.2.4.2.

19.17.2.5.4 The test subject shall wait 1 minute to allow the eyes to acclimate to the illumination.

19.17.2.5.5 The SCBA shall be activated so as to activate the HUD.

19.17.2.5.6 The cylinder shall be fully charged, and the HUD shall show full cylinder charge.

19.17.2.5.7 The SCBA pressure shall be slowly decreased so as to activate all HUD visual displays.

19.17.2.6 Report.

19.17.2.6.1 Each visual display of information and each visual alert signal as defined by the manufacturer's instructions shall be observed and shall be distinct and identifiable.

19.17.2.6.2 The test subject's observations shall be recorded and reported.

19.17.2.7 Interpretation. The test subject's ability to distinguish among the visual displays of information and the visual alert signals as defined by the manufacturer's instructions shall be observed, and distinguishing features shall be distinct and identifiable.

19.18 HUD Obscuration Test.

19.18.1 Application. This test method shall apply to complete SCBA where there is a gap greater than 1 mm (1⁄32 in.) between the HUD and the exterior surface of the SCBA facepiece lens.

19.18.2 Samples. Each sample to be tested shall be as specified in 15.3.2.

19.18.3 Specimen Preparation. Prior to testing, specimens shall be conditioned for a minimum of 4 hours and tested at an ambient temperature of 22°C, ±3°C (72°F, ±5°F) and RH of 50 percent, ±25 percent.

19.18.4 Apparatus.

19.18.4.1 Each test specimen to be tested shall be an SCBA with the facepiece modified by the application of a light-reducing film to the entire outer lens surface of the facepiece. The film shall exclude 94.5 percent to 95.5 percent of visible light.

19.18.4.2 The SCBA breathing air cylinder shall be permitted to be replaced with a cylinder of lesser capacity. The breathing air capacity of the replacement cylinder shall be greater than 200 L (7.1 ft^3).

19.18.4.3 Testing shall be performed in a light-controlled enclosure designated as the "testing enclosure." A diffuse light source that provides a luminance of 20 lux, +0/−5 lux shall be used to illuminate across the surface of the SCBA facepiece lens.

19.18.5 Procedure.

19.18.5.1 The selected test subjects shall have visual acuity of 20/20 in each eye uncorrected or corrected with contact lenses.

19.18.5.2 The test subject shall don a complete SCBA.

19.18.5.3 The test subject shall enter the testing enclosure and be positioned so that the SCBA facepiece is illuminated as specified in 19.18.4.3.

19.18.5.4 The test subject shall wait at least 1 minute to allow the eyes to acclimate to the illumination.

19.18.5.5 The SCBA shall be activated so as to activate the HUD.

19.18.5.6 The SCBA pressure shall be slowly decreased until the breathing air supply in the cylinder is exhausted.

19.18.6 Report.

19.18.6.1 The test subject shall report which informational displays and visual alert signals were observed.

19.18.6.2 The test subject's observations shall be recorded and reported.

19.18.7 Interpretation. The test subject's observations shall be compared to the manufacturer's specified informational displays and visual alert signals to determine pass or fail performance.

19.19 HUD Disabling Glare Test.

19.19.1 Application. This test method shall apply to complete SCBA.

19.19.2 Samples. Each sample to be tested shall be as specified in 15.3.2.

19.19.3 Specimen Preparation. Prior to testing, test specimens shall be conditioned for a minimum of 4 hours and tested at an ambient temperature of 22°C, ±3°C (72°F, ±5°F) and RH of 50 percent, ±25 percent.

19.19.4 Apparatus.

19.19.4.1 Testing shall be performed in a light-controlled enclosure designated as the "testing enclosure," with a diffused light source that provides a luminance of 2 lux, +0/−1 lux measured at the surface of the reading text card.

19.19.4.2 At least eight text cards for reading shall be provided. Each text card shall have 10 different randomly selected letters of 2.5 mm (3⁄32 in.) in height printed in lowercase on the card.

19.19.4.3 The SCBA breathing air cylinder shall be permitted to be replaced with a cylinder of lesser capacity. The breathing air capacity of the replacement cylinder shall be greater than 200 L (7.1 ft^3).

19.19.5 Procedure.

19.19.5.1 The selected test subjects shall have visual acuity of 20/20 in each eye uncorrected or corrected with contact lenses. Selected test subjects shall be able to read lowercase letters measuring 2.5 mm (3⁄32 in.) in height at a distance of 305 mm (12 in.).

19.19.5.2 The test subject shall enter the testing enclosure that is illuminated as specified in 19.19.4.1.

19.19.5.3 The test subject shall wait at least 1 minute to allow the eyes to acclimate to the illumination.

19.19.5.4 A text card as specified in 19.19.4.2 shall be used for each before-reading procedure and each after-reading procedure of a single test.

19.19.5.5 Different text cards as specified in 19.19.4.2 shall be used for each test.

19.19.5.6 With the test subject's vision blocked, the text card shall be placed in a fixed position inside the testing enclosure at a distance of 305 mm, +0/−25 mm (12 in., +0/−1 in.) from the test subject's face.

19.19.5.7 For the before-reading portion of the test procedure, the test subject shall read out loud the 10 letters on the text card.

19.19.5.8 The test subject shall then don a complete SCBA.

19.19.5.9 The SCBA shall be activated so as to activate the HUD.

19.19.5.10 With the test subject's vision blocked, a different text card shall be placed in a fixed position inside the testing enclosure at a distance of 305 mm, +0/−25 mm (12 in., +0/−1 in.) from the test subject's SCBA facepiece lens.

19.19.5.11 The SCBA cylinder pressure shall then be slowly decreased until the breathing air supply in the cylinder is exhausted.

19.19.5.12 The after-reading portion of the test procedure shall be conducted while the cylinder pressure is being slowly decreased. The test subject shall read out loud the 10 letters on the text card.

19.19.6 Report.

19.19.6.1 The test subject's visual acuity as required in 19.19.5.1 shall be recorded and reported.

19.19.6.2 The test subject's ability to read the lowercase letters as required in 19.19.5.1 shall be recorded and reported.

19.19.6.3 The test subject's reading of the 10 letters in the before-reading portion of the test as required in 19.19.5.7 shall be recorded and reported for each letter.

19.19.6.4 The test subject's reading of the 10 letters in the after-reading portion of the test as required in 19.19.5.12 shall be recorded and reported for each letter.

19.19.7 Interpretation.

19.19.7.1 The test subject's inability to read at least 9 of the 10 before-reading letters shall constitute failing performance.

19.19.7.2 The test subject's inability to read at least 9 of the 10 after-reading letters shall constitute failing performance.

19.20 Cylinder Refill Breathing Performance Test.

19.20.1 Application. This test method shall apply to complete SCBA.

19.20.2 Samples. Each sample to be tested shall be as specified in 15.3.2.

19.20.3 Specimen Preparation. Prior to testing, test specimens shall be conditioned for a minimum of 4 hours at an ambient temperature of 22°C, ±3°C (72°F, ±5°F) and RH of 50 percent, ±25 percent.

19.20.4 Apparatus.

19.20.4.1 The test apparatus shall be as specified in 19.1.4.

19.20.4.2 An RIC UAC filling hose assembly shall be provided.

19.20.4.3 The breathing air source shall provide a constant pressure equal to the rated service pressure of the SCBA breathing air cylinder, +0/−6.8 bar (+0/−100 psi).

19.20.5 Procedure.

19.20.5.1 The SCBA shall be tested for airflow performance as specified in 19.1.5, with the modification that the test will begin with the SCBA breathing air cylinder pressurized to 25 percent of the rated pressure.

19.20.5.2 The RIC UAC filling hose shall be connected to the constant pressure source.

19.20.5.3 At 10 cycles, ±5 cycles of the breathing machine, the RIC UAC female fitting on the RIC filling hose shall be connected to the RIC UAC male fitting on the SCBA. The RIC UAC coupling shall remain connected until the air transfer is completed.

19.20.5.4 The duration of the airflow performance test shall end 4 minutes after the air transfer has commenced per 19.20.5.3.

19.20.6 Report. The facepiece peak inhalation and exhalation pressure shall be recorded and reported.

19.20.7 Interpretation. The peak inhalation and peak exhalation pressures shall be used to determine pass or fail performance.

19.21 RIC UAC System Fill Rate Test.

19.21.1 Application. This test method shall apply to complete SCBA.

19.21.2 Samples. Each sample to be tested shall be as specified in 15.3.2.

19.21.3 Specimen Preparation. Prior to testing, the specimens shall be conditioned for a minimum of 4 hours at an ambient temperature of 22°C, ±3°C (72°F, ±5°F) and RH of 50 percent, ±25 percent.

19.21.4 Apparatus.

19.21.4.1 An RIC UAC filling hose assembly shall be provided.

19.21.4.2 The air source shall provide a constant pressure equal to the rated service pressure of the SCBA cylinder, +0/−6.8 bar (+0/−100 psi).

19.21.4.3 Testing shall be performed using a timer capable of measuring elapsed time within the range of 0 to 5 minutes.

19.21.5 Procedure.

19.21.5.1 The pressure of the SCBA breathing air cylinder shall be 0 bar (0 psi).

19.21.5.2 The RIC UAC filling hose shall be connected to the constant pressure air source.

19.21.5.3 With the SCBA breathing air cylinder valve fully open, the RIC UAC filling hose shall be connected to the RIC UAC male fitting.

19.21.5.4 The test timer shall begin when the RIC UAC filling hose is connected to the SCBA.

19.21.5.5 The pressure in the SCBA breathing air cylinder shall be monitored.

19.21.5.6 When the pressure in the SCBA breathing air cylinder reaches 75 percent of the rated service pressure of the SCBA cylinder, the test timer shall be stopped.

19.21.6 Report. The elapsed time shall be observed, recorded, and reported.

19.21.7 Interpretation. The elapsed fill time shall be used to determine pass or fail.

19.22 Breathing Air Cylinder and Valve Assembly Retention Test.

19.22.1 Application. This test method shall apply to complete SCBA assemblies.

19.22.2 Samples.

19.22.2.1 Samples shall be complete SCBA.

19.22.2.2 Samples shall be fitted with each of the SCBA manufacturer's breathing air cylinder and valve assemblies.

19.22.3 Specimen Preparation.

19.22.3.1 One SCBA sample shall be tested with a cylinder and valve assembly as specified in 19.22.5.

19.22.3.2 Prior to testing, specimens shall be conditioned for a minimum of 4 hours at an ambient temperature of 22°C, ±3°C (72°F, ±5°F), with RH of 50 percent, ±25 percent.

19.22.4 Apparatus.

19.22.4.1 A test bench or similar fixture that can firmly fix a fully assembled SCBA to the test bench or fixture and that will not allow movement of the SCBA shall be used.

19.22.4.2 Measurements shall be taken with a calibrated measuring device having a resolution of better than ±0.25 mm (±0.010 in.).

19.22.4.3 Loops, straps, or pads shall be positioned on the valve to facilitate the application and measurement of an applied load to the intersection of the valve connection plane with the center line of the breathing air cylinder body.

19.22.5 Procedure.

19.22.5.1 The specimen, fitted with the SCBA manufacturer's breathing air cylinder and valve assembly, shall be fixed to the backplate and harness assembly in accordance with the manufacturer's end user instructions provided with the SCBA.

19.22.5.2 The fully assembled SCBA shall be firmly fixed to the test bench or fixture in a manner that prevents movement of the SCBA but shall not interfere with the breathing air cylinder and valve assembly retention method.

19.22.5.3 The distances for each of the six directions specified in 19.22.5.4, the original starting positions, shall be measured and recorded.

19.22.5.4 A force of 200 N (45 lbf) shall be applied to the intersection point specified in 19.22.4.3, in the six directions shown in Figure 19.22.5.4. The force shall be applied for a period of 10 seconds, +5/−0 seconds, allowing the measurements to be taken.

19.22.5.5 Following the application of force for each direction, the distance for each of the six directions shall be measured and recorded.

19.22.6 Report.

19.22.6.1 The distance moved from the original starting position for each of the six directions shall be recorded and reported.

19.22.6.2 No portion of the breathing air cylinder and valve assembly shall show movement greater than 25 mm (1 in.) from its original position prior to load application.

19.22.7 Interpretation. Movement of any part of the breathing air cylinder and valve assembly that exceeds 25 mm (1 in.) shall constitute failing performance.

19.23 Cylinder Connections and Accessibility Test.

19.23.1 Application. This test method shall apply to complete SCBA assemblies.

19.23.2 Samples.

19.23.2.1 Samples shall be complete SCBA.

19.23.2.2 Samples shall be fitted with each of the SCBA manufacturer's air cylinder and valve assemblies.

19.23.3 Specimen Preparation.

19.23.3.1 The SCBA manufacturer's cylinder and valve assembly shall be fixed to the backplate harness assembly following the manufacturer's end user instructions.

19.23.3.2 Prior to testing, specimens shall be conditioned for a minimum of 4 hours at an ambient temperature of 22°C, ±3°C (72°F, ±5°F), with RH of 50 percent, ±25 percent.

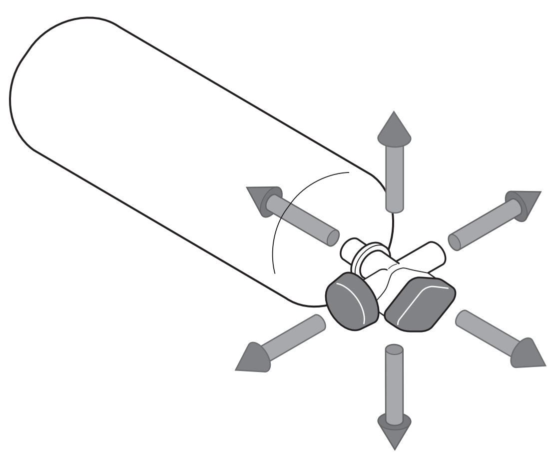


FIGURE 19.22.5.4 Directions of Force Applied for Retention Testing.

19.23.4 Procedure.

19.23.4.1 The specimen, fitted with each of the SCBA manufacturer's cylinder and valve assemblies, shall be fixed to the backplate and harness assembly in accordance with the manufacturer's end user instructions provided with the SCBA.

19.23.4.2 Specimens shall be evaluated for accessibility, attachment, and detachment by a test subject with a hand that is categorized as large, and the test subject shall perform the test while wearing a size large structural firefighting glove that is compliant with Chapters 4 through 9 of this standard.

19.23.4.3 The test subject shall fully attach the cylinder and valve assembly to the SCBA and then fully detach the cylinder and valve assembly from the SCBA. The time in seconds to attach and then to detach the cylinder and valve assembly shall be measured.

19.23.4.4 The test subject shall fully attach the breathing air fill hose to the RIC UAC connection and then fully detach the breathing air fill hose from the RIC UAC connection. The time in seconds to attach and then to detach the breathing air fill hose shall be measured.

19.23.5 Report.

19.23.5.1 The time to fully attach and to fully detach the cylinder and valve assemblies, timed in 19.23.4.3, shall be recorded and reported.

19.23.5.2 The time to fully attach and to fully detach the breathing air fill hose to and from the RIC UAC connection, timed in 19.23.4.4, shall be recorded and reported.

19.23.6 Interpretation.

19.23.6.1 One or more specimens failing the attachment and detachment times for the cylinder and valve assemblies shall constitute failing performance.

19.23.6.2 One or more specimens failing the attachment and detachment times for the RIC UAC connection shall constitute failing performance.

19.24 Heat and Immersion Leakage Tests.

19.24.1 Application. This test method shall apply to each electronic device of the SCBA required to meet the mandatory design requirements of Chapter 17.

19.24.2 Samples.

19.24.2.1 The sample to be tested shall be as specified in 15.3.2.

19.24.2.2 Samples for conditioning shall be complete SCBA.

19.24.3 Specimens.

19.24.3.1 Prior to testing, specimens shall be conditioned for a minimum of 4 hours at an ambient temperature of 22°C, ±3°C (72°F, ±5°F) and RH of 50 percent, ±25 percent.

19.24.3.2 The specimen shall be tested after conditioning within an oven specified in 19.24.4 at 177°C, +5°C/−0°C (350°F, +10°F/−0°F) for 15 minutes.

19.24.4 Apparatus.

19.24.4.1 The test oven shall have an airflow rate of 38 m/min to 76 m/min (125 ft/min to 250 ft/min) at the standard temperature and pressure of 21°C (70°F) at 1 atmosphere measured at the center point of the oven.

19.24.4.2 The test oven shall have minimum dimensions of 915 mm depth × 915 mm width × 1220 mm height (36 in. depth × 36 in. width × 48 in. height).

19.24.4.3 A test thermocouple shall be positioned so that it is level with the horizontal centerline of a mounted sample specimen.

19.24.4.4 The test water container shall be capable of covering the uppermost point of the specimen SCBA with a depth of 1.5 m (4.9 ft) of water.

19.24.4.5 The water temperature shall be 18°C, ±10°C (64°F, ±18°F).

19.24.5 Procedure.

19.24.5.1 The SCBA shall be mounted on the test manikin and tested for a watertight seal per 19.1.5.3. It shall then be placed in the test oven that has been preheated to 177°C, +5°C/−0°C (350°F, +10°F/−0°F).

19.24.5.2 After the test oven door is closed and the oven temperature recovers to 177°C (350°F), the test exposure time of 15 minutes shall begin.

19.24.5.3 Within 2 minutes, the specimen, mounted to the manikin, shall be immersed in the test water container for 15 minutes. After 15 minutes, the specimen shall be removed from the test water container and shall be wiped dry.

19.24.5.4 The specimen shall be subjected to 19.24.5.1 through 19.24.5.3 for six complete cycles.

19.24.5.5 The specimen shall be removed following the sixth conditioning cycle, and testing shall begin within 30 seconds of removal from conditioning.

19.24.5.6 The specimen's electronic components shall be operated in accordance with the manufacturer's instructions for normal use to determine the proper functioning.

19.24.5.7 The specimen shall then be re-immersed in the test water container for an additional 5 minutes. The power source compartment(s) shall be open, and the power source shall not be installed.

19.24.5.8 After the 5-minute immersion, the specimen shall be removed from the test water container and shall be wiped dry.

19.24.5.9 The electronic compartment(s) of the specimen shall be opened and inspected for water leakage to determine pass or fail, and the functioning of the data logging shall be recorded and reported to determine pass or fail.

19.24.5.10 The SCBA shall be operated according to the manufacturer's instructions to test the data logging function as specified in 17.1.12 to determine pass or fail performance.

19.25 Supplementary Voice Communications System Performance Test.

19.25.1 Application. This test method shall apply to the complete SCBA facepiece(s), second stage regulator(s), and Supplementary Voice Communications System(s).

19.25.2 Samples. Each sample to be tested shall be as specified in 15.3.2, with voice communications systems installed and in the “on” mode in accordance with the manufacturer's instructions.

19.25.3 Specimen Preparation.

19.25.3.1 Prior to testing, specimens shall be conditioned for a minimum of 4 hours and tested at an ambient temperature of 22°C, ±3°C (72°F, ±5°F) and RH of 50 percent, ±25 percent.

19.25.3.2 Specimens for conditioning shall be complete medium-size SCBA facepiece(s) and inner mask(s) with the second stage regulator(s) installed in the “as worn” position as specified by the manufacturer.

19.25.3.3 Signal processing options that use specific features of natural speech such as, but not limited to, pitch, formant analysis, and voice or non-voiced sound to enhance the speech intelligibility or the usability of Supplementary Voice Communications Systems shall be disabled during the STI test.

19.25.4 Apparatus.

19.25.4.1 Testing shall be conducted in a chamber having the following minimum characteristics:

(1) Minimum room dimensions: 4.6 m long × 3.1 m wide × 2.7 m high (15 ft long × 10 ft wide × 9 ft high)
(2) Construction: hemi-anechoic
(3) Ambient noise level inside chamber: NC-25
(4) Walls and ceiling: ≥90 percent absorptive for 100 Hz< f<10000 Hz

19.25.4.1.1 All surfaces above the floor shall be acoustically treated for internal acoustic absorption, as well as for external noise mitigation.

19.25.4.2 A G.R.A.S. KEMAR Head and Torso Simulator (HATS) model 45BM shall be used for testing.

19.25.4.2.1 The mouth simulator shall be capable of producing 112 dB/1 kHz sine tone at 25 mm (1 in.) with the mouth reference point unequalized, and the total harmonic distortion (THD) shall be ≤3 percent.

19.25.4.2.2 The mouth simulator frequency response shall be able to be equalized flat ±1 dB between 100 Hz and 10 kHz, and the response shall be –15 dB or less at 100 Hz and –20 dB or less at 15 kHz.

19.25.4.3 The sound pressure level (SPL) meter having the following characteristics shall be used:

(1) The SPL meter shall be capable of applying an equivalent continuous sound pressure level (Leq) using an A-weighted filter.
(2) The SPL meter shall have a dynamic range from 30 dB (or less) to 130 dB (or more).
(3) The SPL meter shall display the measurement to at least one decimal place.

19.25.4.4 The signal/pink noise analog audio signal generators having the following characteristics shall be used.

19.25.4.4.1 One generator shall be capable of playing wave files in the following format: 48 kHz, 16-bit mono at the output level of 0 dB, FS = 18 dBu, according to EBU Technical Recommendation R068, *Alignment level in digital audio production equipment and in digital audio recorders.*

19.25.4.4.2 The second generator shall be capable of generating pink noise and sine waves from −80 dBu to −2 dBu in one-digit steps, with a THD + N of −90 dB (0.0032 percent) at 8 dBu noise floor type 25 uv, and shall also have the following characteristics:

(1) A frequency range of 10 Hz to 20 kHz in one-digit steps ±0.01 percent
(2) An amplitude accuracy of within ±0.5 dB or less

19.25.4.5 A digital equalizer having the following characteristics shall be used:

(1) A digital equalizer shall be capable of at least two concurrently selectable equalizer sections:
    (a) One 31-band graphic with an adjustment range of at least ±18 dB
    (b) A 10-band parametric with an adjustment range of at least ±18 dB
(2) The digital equalizer shall have a dynamic range of ≥112 dB.
(3) The digital equalizer shall be capable of equalizing the frequency response of the HATS manikin of ±1 dB flat between 100 Hz and 10 kHz, applying a 180 Hz high pass filter with a slope of –24 dB octave, and a 10 Hz low pass filter with a slope of –24 dB octave (–15 dB at 100 Hz, –20 dB at 15 kHz).

19.25.4.6 A powered speaker having the following characteristics shall be used:

(1) The sensitivity shall be ≥84 dB at one watt at 1 meter.
(2) The frequency response shall be rated at ≤80 Hz to ≥13 kHz.
(3) The amplifier shall deliver ≥10 watts with a total harmonic distortion <1 percent.

19.25.4.7 A microphone having the following characteristics shall be used:

(1) The microphone shall be a condenser type.
(2) The microphone polar pattern shall be omnidirectional.
(3) The frequency response shall be flat ±0.5 dB from 100 Hz to 15 kHz.
(4) The residual noise shall be ≤–30 dB.
(5) The microphone shall accept signals of at least 130 dBA.

19.25.4.8 A Speech Transmission Index (STI) analyzer having the following characteristics shall be used:

(1) The STI PA analyzer shall be capable of measuring and displaying a single value STI PA result to two decimal places with a seven octave band modulated noise test signal using the Netherlands Organization for Applied Scientific Research (TNO) verified algorithm.
(2) The STI PA analyzer shall conform to IEC-60268-16, *Sound System Equipment — Part 16: Objective Rating of Speech Intelligibility by Speech Transmission Index.*

19.25.4.9 All of the apparatus identified in 19.10.4.6 and 19.10.4.7 shall be located in the hemi-anechoic chamber and arranged as shown in Figure 19.10.4.9(a) and Figure 19.10.4.9(b).

19.25.4.10 The HATS test manikin shall be positioned in the chamber as shown in Figure 19.10.4.9(a) and Figure 19.10.4.9(b).

19.25.4.10.1 The distance between the HATS test manikin and the microphone shall be 1.5 m, +25 mm/–0 mm (5 ft, +1 in./–0 in.), and they shall be facing each other.

19.25.4.10.2 The distance between the HATS test manikin MRP and the floor shall be 1.5 m, +25 mm/–0 mm (5 ft, +1 in./–0 in.).

19.25.4.10.3 The distance between the microphone and the floor shall be 1.5 m, +25 mm/–0 mm (5 ft, +1 in./–0 in.).

19.25.4.11 The test chamber shall be filled with broadband pink noise with a tolerance of ±1 dB per octave band from 100 Hz to 10 kHz.

19.25.4.12 The pink noise speaker shall be placed directly beneath the microphone and oriented such that the central axis of the speaker cone is directly facing the microphone.

19.25.4.12.1 The speaker shall be situated on top of a block of isolating acoustic foam such that no part of the speaker box is contacting the floor or the microphone stand, to prevent conduction of sound to the microphone.

19.25.4.12.2* The height of the speaker off the floor shall be at least 0.125 m (5 in.), as measured from the bottom of the speaker box, and the distance between the speaker and microphone shall be no less than 1 m (40 in.), as measured from the top of the speaker grille/enclosure.

19.25.4.12.3 The pink noise speaker shall be placed as indicated in Figure 19.10.4.12.3.

19.25.4.13 The pink noise speaker shall be fully equalized flat, from 100 Hz to 10 kHz, to within ±1 dB on a relative scale in ⅓ octave bands, as measured at the microphone position.

19.25.4.14 The STI test signal from the manikin shall be adjusted to achieve an A-weighted sound level of 97 dB, ±0.5 dB at the mouth reference point (MRP), 50 mm, ±3 mm (2 in. ±⅛ in.) from the test manikin's mouth.

19.25.4.14.1 The microphone used for calibrating the STI signal shall be omnidirectional and oriented in a horizontal front-facing manner.

19.25.4.14.2 The STI signal shall be equalized flat to within ±1 dB on a relative scale in ⅓ octave bands, as measured at the MRP of the HATS.

19.25.4.14.3 The HATS shall be calibrated as follows:

(1) Equalize flat with pink noise to 97 dBA from 100 Hz – 10 kHz to ±1 dB on a ⅓ octave scale.
(2) Reduce the levels for the 125 Hz octave band (the 100, 125, 160 ⅓ octave bands) by 10 dB.
(3) Reduce the levels for the 250 Hz octave band (the 200, 250, 315 ⅓ octave bands) by 2 dB.
(4) Apply the STI PA signal and adjust the Sound Pressure Level (SPL) to 97 dBA, ±0.5 dBA.

19.25.4.15 The gain of the powered speaker amplifier used to generate the pink noise shall be adjusted to achieve an A-weighted sound level of 9 dB, ±0.5 dB below the signal level generated as identified in 19.25.4.14, measured at the microphone placed as identified in 19.25.4.10.1 and 19.25.4.10.3.

19.25.5 Procedure.

19.25.5.1 The method for measuring the Speech Transmission Index (STI) shall be as specified in IEC 60268-16, *Sound System Equipment — Part 16: Objective Rating of Speech Intelligibility by Speech Transmission Index*, with the modified apparatus specified in 19.25.4.

19.25.5.2 The medium-size facepiece with inner mask and second stage regulator in the normal use mode shall be fitted to the HATS test manikin in the following manner:

(1) Place the chin of the manikin in the "chin cup" of the facepiece.
(2) Place the facepiece to seal against the face of the HATS test manikin.
(3) Pass the head harness of the facepiece over the HATS test manikin and tighten it in a manner that maintains the symmetry of the facepiece on the HATS test manikin, using talc to minimize friction between the HATS test manikin and the strap.
(4) Tighten the straps to a tension of 50 N (11.2 lbf).

19.25.5.3 Three medium-size facepieces shall be tested in the chamber having an ambient noise field as specified in 19.25.4.11 through 19.25.4.15. Each facepiece shall be mounted as specified in 19.25.5.2 and then tested as follows:

(1) Record three separate measurements for each donning of the facepiece.
(2) Perform five separate donnings.
(3) Record a total of 45 measurements: 3 (facepieces) × 3 (measurements) × 5 (donnings) = 45 measurements.

19.25.6 Report.

19.25.6.1 The STI PA signal Sound Pressure Level (SPL) per octave band, the Modulation Transfer Index per octave band, and overall STI score at the mouth reference point (MRP) described in 3.3.118 shall be recorded and reported.

19.25.6.2 The STI PA signal SPL per octave band, the Modulation Transfer Index per octave band, and overall STI score at the microphone measurement point (MMP) described in 3.3.113 shall be recorded and reported.

19.25.6.3 The pink noise SPL per octave band at the MMP described in 3.3.113 shall be recorded and reported.

19.25.6.4 The STI score for each facepiece measurement sampled as described in 19.25.5.3 (a total of 45 scores) shall be recorded and reported, and the starting time of each facepiece donning shall be recorded.

19.25.6.5 The average for each donning shall be calculated, recorded, and reported. There shall be a total of 15 averages of 3 measurements (5 averages for each of the three facepiece samples). See Figure 19.10.6.5.

19.25.7 Interpretation.

19.25.7.1 The averages calculated in 19.25.6.5 shall be used to determine a pass or fail per Section 18.17.

19.25.7.2 If any of the 15 averages score less than the minimum threshold specified in Section 18.17, the facepiece shall be considered to have failed and shall be reported as such.

19.25.7.3 If all of the 15 averages score equal to or greater than the minimum threshold specified in Section 18.17 the facepiece shall be considered to have passed and shall be reported as such.

19.26 Low Power Capacity Test.

19.26.1 Application. This test shall apply to all electronic devices required for SCBA by the requirements of Chapter 17.

19.26.2 Samples. Each sample to be tested shall be as specified in 15.3.2.

19.26.3 Specimen Preparation.

19.26.3.1 Specimens shall be conditioned for a minimum of 4 hours and tested at an ambient temperature of 22°C, ±3°C (72°F, ±5°F) and RH of 50 percent, ±25 percent.

19.26.3.2 Power sources shall either be at a state of maximum capacity or discharged to a point before the activation of the low power source visual alert signal.

19.26.4 Apparatus. A variable power source that is capable of supplying dc voltage of at least 30 percent more than the nominal power source voltage shall be provided.

19.26.5 Procedure.

19.26.5.1 Each electronic device shall be configured to operate in the operational mode that utilizes maximum power consumption, The power source discharge method and rate shall be provided to the certification organization by the manufacturer and must include consideration of all electronic devices that share a common power source and consideration for all configurations and operational nodes that consume maximum power.

19.26.5.2 Each electronic device shall be operated until activation of the low power source visual alert signal.

19.26.5.3 After activation of the low power source visual alert signal, each electronic device shall be operated for 1 additional hour.

19.26.6 Report.

19.26.6.1 The electronic device shall be observed for activation of the low power source visual alert signal.

19.26.6.2 The electronic device shall be observed for functionality for 1 hour after activation of the low power source visual alert signal.

19.26.6.3 The events in 19.26.6.1 and 19.26.6.2 shall be recorded and reported.

19.26.7 Interpretation.

19.26.7.1 Electronic device low power source visual alert signal function shall be evaluated to determine pass or fail performance.

19.26.7.2 Electronic device function shall be evaluated to determine pass or fail performance.

19.27 Emergency Breathing Safety System Cold Temperature Performance Test.

19.27.1 Application. This test method shall apply to two complete SCBA.

19.27.2 Samples. Each sample to be tested shall be as specified in 15.3.2.

19.27.3 Specimen Preparation.

19.27.3.1 Specimens for conditioning shall be two complete SCBA.

19.27.3.2 Prior to testing, the SCBA shall be placed in an ambient environment of 22°C, ±3°C (72°F, ±5°F) and RH of 50 percent, ±25 percent for a minimum 12-hour dwell period.

19.27.3.3 The air used in the SCBA breathing air cylinders shall comply with the quality requirements of NFPA 1989.

19.27.4 Apparatus.

19.27.4.1 The SCBA shall be placed in an environmental chamber and positioned to simulate the normal wearing position of the SCBA on a person as specified by the manufacturer.

19.27.4.2 During the cold temperature exposures, the SCBA shall be mounted on a Scott Aviation Model No. 803608-01 or 803608-02 test headform or equivalent.

19.27.4.3 The thermocouple or other temperature-sensing element used shall be mounted within the chamber in a manner in which it will be exposed directly to the chamber atmosphere.

19.27.4.4 Two test headforms shall be connected to two breathing machines specified in Section 19.1, Airflow Performance Test.

19.27.4.5 The breathing machines shall be permitted to be located either inside or outside the environmental chamber.

19.27.5 Procedure.

19.27.5.1 The variation in pressure extremes caused by the cold temperature performance test configuration shall be determined as specified in 19.27.5.1.

19.27.5.1.1 For the receiving SCBA, the airflow performance test, as specified in Section 19.1, Airflow Performance Test, shall be carried out using the configuration specified in 19.2.4, with a breathing frequency set at 31, +1/–0 inhalation/exhalation cycles per minute and a tidal volume set at 3.4 L, ±0.1 L. The difference in pressure between the two tests shall be calculated by subtracting the values obtained using the configuration defined in 19.2.4 from the values obtained using the configuration specified in Section 19.1, Airflow Performance Test.

19.27.5.1.2 For the donor SCBA, the airflow performance test, as specified in Section 19.1, Airflow Performance Test, shall be carried out using the configuration specified in 19.2.4, with a breathing frequency set at 29, +0/–1 inhalation/exhalation cycles per minute and a tidal volume set at 3.4 L, ±0.1 L. The difference in pressure between the two tests shall be calculated by subtracting the values obtained using the configuration defined in 19.2.4 from the values obtained using the configuration specified in Section 19.1, Airflow Performance Test.

19.27.5.2 For the receiving SCBA, the facepiece pressure during each entire test shall be read from the strip chart recorder and corrected by adding the value of the difference in pressure calculated in 19.27.5.1.1 to determine pass or fail, as specified in 18.2.1.1.

19.27.5.3 For the donor SCBA, the facepiece pressure during each entire test shall be read from the strip chart recorder and corrected by adding the value of the difference in pressure calculated in 19.27.5.1.2 to determine pass or fail as specified in 18.2.1.1.

19.27.5.4 The receiving and donor SCBA shall be cold soaked at –32°C, ±1°C (–25°F, ±2°F) for a minimum of 12 hours.

19.27.5.5 The receiving SCBA shall then be tested for airflow performance as specified in Section 19.1, Airflow Performance

Test, with a ventilation rate set at 103 L/min, ±3 L/min, at a chamber air temperature of –32°C, ±5°C (–25°F, ±10°F).

19.27.5.5.1 For the UEBSS cold temperature performance test, the airflow performance test shall begin after five cycles of the breathing machine and shall continue to operate through at least 36 bar (520 psi) of the donor SCBA cylinder inlet pressure.

19.27.5.6 The donor SCBA shall then be tested for airflow performance as specified in Section 19.1, Airflow Performance Test, with a breathing frequency set at 29 +0/–1 inhalation/exhalation cycles per minute and a tidal volume set at 3.4 L, ±0.1 L, at a chamber air temperature of –32°C, ±5°C (–25°F, ±10°F).

19.27.6 Report.

19.27.6.1 The facepiece peak inhalation pressure and peak exhalation pressure shall be recorded and reported for each test condition.

19.27.6.2 The activation and operation of the donor SCBA EOSTI, or the failure of the donor SCBA EOSTI to activate and operate, shall be recorded and reported.

19.27.6.3 The activation and identification of the donor SCBA HUD visual alert signals shall be recorded and reported.

19.27.7 Interpretation.

19.27.7.1 The peak inhalation and peak exhalation shall be used to determine pass or fail performance for each test procedure.

19.27.7.2 One or more specimens failing this test shall constitute failing performance.

19.27.7.3 Failure of the donor SCBA EOSTI alarm signal to activate and remain active during the test shall constitute failing performance.

19.27.7.4 Failure of the donor SCBA HUD to display the breathing air cylinder content or to display the visual alert signal during the test shall constitute failing performance.

19.28 Lens Radiant Heat Test.

19.28.1 Application. This test method shall apply to SCBA facepiece assemblies without installed accessories.

19.28.2 Samples. Each sample to be tested shall be as specified in 15.3.2.

19.28.3 Specimen Preparation.

19.28.3.1 Prior to testing, specimens shall be conditioned for a minimum of 4 hours and tested at an ambient temperature of 22°C, ±3°C (72°F, ±5°F) and RH of 50 percent, ±25 percent.

19.28.3.2 Specimens for conditioning shall be complete SCBA without installed accessories.

19.28.4 Apparatus.

19.28.4.1 A test headform meeting the requirements specified in 19.1.4.1 shall be provided.

19.28.4.2 The test headform shall be attached to the breathing machine as specified in Figure 19.1.4.9, with the modification that a 38 mm (1½ in.) I.D. breathing hose, not longer than 7.6 m (25 ft), shall be interconnected between the breathing machine and the throat tube of the test manikin headform.

19.28.4.3 The test headform shall be covered with an undyed aramid hood for protection of the headform during testing.

19.28.4.3.1 The protective hood shall meet the hood requirements of Chapters 4 through 9 of this standard.

19.28.4.3.2 The protective hood, when placed on the test headform, shall not affect the seal of the facepiece to the headform.

19.28.4.3.2.1 The protective hood shall not ignite during the test.

19.28.4.3.3 The protective hood shall cover the facepiece retention system that holds the facepiece to the headform, cover the mask-mounted regulator and hoses, but not cover or protect any part of the facepiece lens.

19.28.4.4 The radiant heat test panel shall be as specified in ASTM E162, *Standard Test Method for Surface Flammability of Materials Using a Radiant Heat Energy Source*, Subsection 7.1.1 and Figure 1.

19.28.4.5 A radiation shield shall be used to block radiant heat from the headform and facepiece before and after the test.

19.28.4.5.1 The radiation shield shall be at least 64 cm (25 in.) wide by at least 56 cm (22 in.) high and be constructed of at least three layers of aluminum sheet separated by air gaps of 2 cm (0.8 in.) with a black-painted front side, or of similar design sufficient to block the radiant heat.

19.28.4.6 A heat flux transducer, having a water-cooled, total heat flux sensor of Schmidt-Boelter type, with a viewing angle of 180°and a standard range of 0–20 kW/m^2, shall be used to measure the heat flux from the radiant heat test apparatus.

19.28.4.6.1 The heat flux transducer shall have been calibrated in the last 12 months.

19.28.4.6.2 The heat flux transducer shall be mounted so the face is vertical and parallel to the face of the radiant heat test apparatus.

19.28.4.6.3 The heat flux transducer shall be centered both horizontally and vertically with respect to the face of the radiant heat test apparatus.

19.28.5 Procedure.

19.28.5.1 The SCBA facepiece shall be mounted on the test headform to simulate the correct wearing position on a person as specified by the SCBA manufacturer's instructions.

19.28.5.2 The headform shall be positioned (at an angle if necessary) so that the vertical centerline of the facepiece lens is parallel with the face of the radiant heat test apparatus.

19.28.5.3 The headform shall be positioned so that the center of the facepiece lens is centered both horizontally and vertically with respect to face of the radiant heat test apparatus.

19.28.5.4 The radiant heat test apparatus shall be ignited and allowed to preheat and stabilize for a minimum of 45 minutes.

19.28.5.4.1 The air flow rate to the radiant heat test apparatus shall be set to 434 L/min, ±24 L/min (920 SCFH, ±50 SCFH).

19.28.5.4.2* The natural gas flow rate to the radiant heat test apparatus shall be increased until it is just sufficient to produce a heat flux of 15 kW/m², ±0.5 kW/m², at a distance of 7 in., ±1 in. (178 mm, ±25 mm) from the panel.

19.28.5.4.3 During the conduct of the test, extraneous drafts shall be controlled by closing windows and doors, stopping air-circulating devices, and arranging baffles between the apparatus and any remaining sources of drafts.

19.28.5.5 To calibrate the radiant heat apparatus, the heat flux transducer shall be moved in front of the radiant heat test apparatus to a location 7 in., ±1 in. (178 mm, ±25 mm) from the panel so that the heat flux transducer measures 15 kW/m², ±0.5 kW/m² for 5 minutes.

19.28.5.5.1 The output voltage from the heat flux transducer shall be sampled at a minimum rate of 1 Hz by a data acquisition system, which has a minimum resolution of 1 part in 4096 of full scale (0.02 percent).

19.28.5.5.2 The output voltage shall be converted to units of heat flux using the most recent calibration coefficients.

19.28.5.5.3 The heat flux transducer shall be water cooled with 0.4 L/min to 0.8 L/min (0.1 gal/min to 0.2 gal/min) of water at 16°C to 30°C (61°F to 86°F), such that the exit temperature of the water does not vary more than ±2°C (4°F) during the test.

19.28.5.5.4 The horizontal distance from the radiant heat test apparatus to the face of the heat flux transducer shall be located and marked.

19.28.5.5.5 The heat flux transducer shall be removed from exposure to the radiant test apparatus.

19.28.5.6 After the radiant heat test apparatus has been preheated and has a calibration mark for 15 kW/m², the radiation shield shall be positioned in front of the radiant heat test apparatus.

19.28.5.7 The SCBA facepiece mounted on the test headform at the appropriate angle as described in 19.28.5.3 shall be placed behind the radiation shield.

19.28.5.8 The airflow performance test shall be conducted as specified in 19.1.5, and with the heat flux specified in 19.28.5.5.

19.28.5.9 The airflow performance test shall begin no longer than 30 s before the SCBA facepiece is exposed to the radiant heat apparatus and shall continue for a total duration of 24 minutes.

19.28.5.10 The ventilation rate shall be set at 40 L/min, ±2 L/min, with a respiratory frequency of 24 breaths/min, ±1 breath/min at ambient conditions as specified in 19.1.3.2.

19.28.5.11 The radiation shield shall be removed, and the headform shall be moved towards the radiant heat apparatus, within 5 seconds of shield removal, so that the vertical front face of the facepiece lens is lined up with the calibration mark for 15 kW/m².

19.28.5.12 After the test headform is placed in the position specified in 19.28.5.1, the test exposure time of 5 minutes, +2.0 seconds/–0.0 seconds shall begin.

19.28.5.13 At the completion of the 5-minute exposure, the headform shall be moved away from the radiant heat test apparatus, and the radiation shield shall be placed between the radiant heat test apparatus and the headform.

19.28.5.14 Within 15 seconds after the radiant heat exposure has been completed, the test headform shall be raised 150 mm, +6 mm/–0 mm (6 in., + ¼ in./–0 in.) and dropped freely.

19.28.5.15 The facepiece pressure during the entire test shall be read from the strip chart recorder to determine pass or fail as specified in 18.21.1.

19.28.5.16 Any pressure spike caused by the impact of the drop test and measured within a duration of three cycles of the breathing machine after the apparatus drop shall be disregarded.

19.28.6 Report.

19.28.6.1 The facepiece pressure peak inhalation and peak exhalation shall be recorded and reported for each test condition.

19.28.7 Interpretation.

19.28.7.1 Pass or fail performance shall be based on the facepiece pressure peak inhalation and exhalation values for the duration of the test.

19.28.7.2 Failure to meet any of the test condition requirements shall constitute failure of the SCBA.

19.29 Elevated Temperature Heat and Flame Resistance Test.

19.29.1 Application. This test method shall apply to complete SCBA.

19.29.2 Samples. Each sample to be tested shall be as specified in 15.3.2.

19.29.3 Specimen Preparation.

19.29.3.1 Prior to testing, specimens shall be conditioned for a minimum of 4 hours and tested at an ambient temperature of 22°C, ±3°C (72°F, ±5°F) and RH of 50 percent, ±25 percent.

19.29.3.2 Specimens for conditioning shall be complete SCBA.

19.29.4 Apparatus.

19.29.4.1 A test manikin meeting the requirements specified in Figure 19.11.4.1 shall be provided.

19.29.4.2 Both the calibration manikin and the heat and flame test manikin shall have protective coverings.

19.29.4.2.1 The protective coverings shall be a weld blanket made of fireproof silica cloth of a minimum weight of 18 oz/sq yd.

19.29.4.2.2 The protective coverings shall be designed and constructed to provide coverage over the surface of the manikins.

19.29.4.2.3 Where additional insulation is needed to protect the manikin electronics, an additional thermal liner underlayer shall be permitted.

19.29.4.2.4 The complete protective covering shall be discarded and shall not be used where the damage to any portion indicates the covering can no longer provide thermal protection for the test manikin.

19.29.4.3 A test headform meeting the requirements specified in 19.1.4.1 shall be used on the test manikin.

19.29.4.4 The test headform shall be attached to the breathing machine as specified in Figure 19.1.4.9, with the modification that a 38 mm (1½ in.) I.D. breathing hose, not longer than 7.6 m (25 ft), shall be interconnected between the breathing machine and the throat tube of the test manikin headform.

19.29.4.5 The test headform shall be covered with an undyed aramid hood for protection of the headform during testing.

19.29.4.5.1 The protective hood shall meet the hood requirements of Chapters 4 through 9 of this standard.

19.29.4.5.2 The protective hood, when placed on the test headform, shall not affect the seal of the facepiece to the headform.

19.29.4.5.3 The protective hood shall cover the facepiece retention system that holds the facepiece to the headform, but shall not cover or protect any part of the facepiece lens.

19.29.4.6 The heat and flame test apparatus shall be as specified in Figure 19.11.4.6.

19.29.4.6.1 The test oven shall be a horizontal forced circulating air oven with a range of flow of 38 m/min to 76 m/min (125 ft/min to 250 ft/min).

19.29.4.6.2 The test oven shall have minimum dimensions of 915 mm depth × 915 mm width × 1.22 m height (36 in. depth × 36 in. width × 48 in. height).

19.29.5 Procedure.

19.29.5.1 The SCBA shall be mounted on the test manikin to simulate the correct wearing position on a person as specified by the SCBA manufacturer's instructions.

19.29.5.2 The facepiece shall be mounted and tested on the test headform as specified in 19.1.4.1.

19.29.5.3 For calibration prior to the heat and flame test, the manikin for calibration shall be the same as the test manikin specified in 19.29.4.1 and shall be exposed to direct flame contact for 10 seconds using the heat and flame test apparatus.

19.29.5.3.1 All peak temperature readings shall be within a temperature range of 815°C to 1150°C (1500°F to 2102°F).

19.29.5.3.2 The average mean of all peak temperature readings specified in 19.29.5.3.1 shall be no higher than 950°C (1742°F).

19.29.5.4 The test oven recovery time, after the door is closed, shall not exceed 1 minute.

19.29.5.5 The airflow performance test shall be conducted as specified in 19.1.5, with modifications to the ventilation rate specified in 19.29.5.7 with the test temperatures specified in 19.29.5.3 and 19.29.5.8.

19.29.5.5.1 The variation in pressure extremes caused by the heat and flame test manikin configuration shall be determined as specified in 19.29.5.5.2 and 19.29.5.5.3.

19.29.5.5.2 The airflow performance test as specified in Section 19.1, Airflow Performance Test, shall be carried out using the configuration specified in 19.29.4.4.

19.29.5.5.3 The difference in pressure between the two tests shall be calculated by subtracting the values obtained using the configuration defined in 19.29.4.4 from the values obtained using the configuration specified in Section 19.1, Airflow Performance Test.

19.29.5.6 The airflow performance test shall begin no longer than 60 seconds before the SCBA and manikin are placed into the oven, with the door closed, and shall continue for a total duration of 24 minutes.

19.29.5.7 The ventilation rate shall be set at 40 L/min, ±2 L/min, with a respiratory frequency of 24 breaths/min, ±1 breath/min at ambient conditions as specified in 19.1.3.2.

19.29.5.8 The SCBA mounted on the test manikin shall be placed in the test oven at a temperature of 260°C, ±5°C (500°F, ±10°F).

19.29.5.9 After the test oven door is closed and the oven temperature recovers to 260°C, ±5°C (500°F, ±10°F), the test exposure time of 5 minutes, +2.0 seconds/–0.0 seconds shall begin. Recovery time shall be less than 60 seconds.

19.29.5.10 At the completion of the 5-minute exposure, the oven door shall be opened, and the SCBA mounted on the test manikin shall be moved out of the oven and into the center of the burner array.

19.29.5.11 The SCBA shall then be exposed to direct flame contact for 10 seconds, +0.25 second/–0.0 seconds.

19.29.5.12 This exposure shall begin within 20 seconds of removal of the SCBA from the test oven.

19.29.5.13 The SCBA shall be observed for any afterflame, and the afterflame shall be extinguished with multiple spray-type devices using room temperature water.

19.29.5.14 Within 20 seconds after the direct flame exposure has been completed, the SCBA mounted on the test manikin shall be raised 150 mm, +6 mm/–0 mm (6 in., +¼ in./–0 in.) and dropped freely.

19.29.5.15 The facepiece pressure during the entire test shall be read from the strip chart recorder and corrected by adding the value of the difference in pressure calculated in 19.29.5.5.1 to determine pass or fail as specified in 18.22.1.

19.29.5.16 Any pressure spike caused by the impact of the drop test and measured within a duration of three cycles of the breathing machine after the apparatus drop shall be disregarded.

19.29.6 Report.

19.29.6.1 The facepiece pressure peak inhalation and peak exhalation shall be recorded and reported for each test condition.

19.29.7 Interpretation.

19.29.7.1 Pass or fail performance shall be based on the facepiece pressure peak inhalation and exhalation values for the duration of the test.

19.29.7.2 Failure to meet any of the test condition requirements shall constitute failure of the SCBA.

19.30 Strength of Interface Between Facepiece and Second Stage Regulator Test.

19.30.1 Application. This test method shall apply to the facepiece and second stage regulator assembly.

19.30.2 Samples.

19.30.2.1 Samples shall be a facepiece and a second stage regulator assembly.

19.30.2.2 Each sample to be tested shall be as specified in 15.3.2.

19.30.3 Specimens. One specimen shall be tested.

19.30.4 Specimen Preparation. Prior to testing, specimens shall be conditioned for a minimum of 4 hours at an ambient temperature of 22°C, ±3°C (72°F, ±5°F), with RH of 50 percent, ±25 percent.

19.30.5 Apparatus.

19.30.5.1 The facepiece shall be mounted to a test head, and the facepiece shall be clamped to the head in a secure fashion to prevent the facepiece from pulling away from the head.

19.30.5.2 Measurements shall be taken with a calibrated measuring device having a resolution of better than ±5 N (±1.1 lbf).

19.30.6 Procedure.

19.30.6.1 A static load of 250 N, +10 N/−0 N (56.2 lbf, +2.2 lbf/−0 lbf) shall be applied at a rate of 25.4 mm/min, +2.54 mm/min/−0 mm/min (1 in/min, +1 in/min/−0 in/min) to the second stage regulator medium pressure supply hose at a point 250 mm to 300 mm (9.8 in. to 11.8 in.) from the point at which the hose enters the second stage regulator.

19.30.6.2 The load shall be applied for 10 seconds, +1/−0 seconds in the 5 directions shown in Figure 19.30.6.2.

19.30.6.3 Each load applied shall commence with the second stage regulator in an "as worn" position.

19.30.6.4 The center point of the applied loads shall be the entry point of the pressure hose to the second stage regulator.

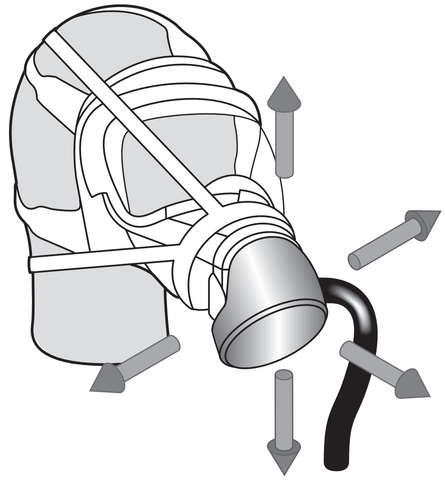


FIGURE 19.30.6.2 Directions of Force Applied for Strength of Interface Testing.

19.30.6.5 The loads shall be applied axially and orthogonally to the interface between facepiece and second-stage regulator.

19.30.7 Report. Any disconnection or partial disconnection of the regulator interface with the facepiece shall be recorded and reported.

19.30.8 Interpretation.

19.30.8.1 Disconnection or partial disconnection of the regulator interface with the facepiece shall constitute failing performance.

19.30.8.2 Disconnection or partial disconnection of wiring components shall not constitute failing performance.

Chapter 20 Certification (NFPA 1982)

20.1 Administration

20.1.1 Scope.

20.1.1.1* Chapters 20 through 24 of this standard shall specify minimum requirements for the design, performance, testing, and certification for all personal alert safety systems (PASS) for emergency services personnel.

20.1.1.2* Chapters 20 through 24 of this standard shall specify the requirements for all new PASS, including, but not limited to, stand-alone PASS, integrated PASS, and RF PASS.

20.1.1.3* Chapters 20 through 24 of this standard shall also specify the minimum requirements for the design, performance, testing, and certification of PASS or RF PASS devices certified to an earlier edition of this standard that incorporate parts, components, and/or software to meet this edition of NFPA 1970.

20.1.1.4 Chapters 20 through 24 of this standard shall not specify requirements for any accessories that could be attached to the PASS but that are not necessary for the PASS to meet the requirements of Chapters 20 through 24.

20.1.1.5 Chapters 20 through 24 of this standard shall not be construed as addressing all the safety concerns associated with the use of compliant PASS. It shall be the responsibility of the persons and organizations that use compliant PASS to establish safety and health practices and to determine the applicability of regulatory limitations prior to use.

20.1.1.6 Chapters 20 through 24 of this standard shall not be construed as addressing all the safety concerns, if any, associated with the use of this standard by testing facilities. It shall be the responsibility of the persons and organizations that use this standard to conduct testing of PASS to establish safety and health practices and to determine the applicability of regulatory limitations prior to using Chapters 20 through 24 for any designing, manufacturing, and testing.

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

20.1.2 Purpose.

20.1.2.1 The purpose of Chapters 20 through 24 of this standard shall be to establish minimum requirements for PASS that are intended for use by emergency services personnel during emergency operations and that emit an audible signal to summon aid in the event the user becomes incapacitated or needs assistance.

20.1.2.1.1 Chapters 20 through 24 of this standard shall establish minimum requirements for optional RF PASS that are capable of transmitting an alarm signal and receiving an evacuation alarm via an RF signal.

20.1.2.1.2 Chapters 20 through 24 of this standard shall establish minimum requirements for the base station used in optional RF PASS for the receipt of an alarm signal and the transmission of an evacuation alarm via an RF signal.

20.1.2.2* Controlled laboratory tests used to determine compliance with the performance requirements of Chapters 20 through 24 of this standard shall not be deemed as establishing PASS performance levels for all situations to which firefighting or emergency services personnel can be exposed.

20.1.2.3 Chapters 20 through 24 of this standard shall not be interpreted or used as a detailed manufacturing or purchase specification but shall be permitted to be referenced in purchase specifications as minimum requirements.

20.1.3 Application.

20.1.3.1 Chapters 20 through 24 of this standard shall apply to the design, performance, testing, and certification of PASS or RF PASS devices certified to an earlier edition of this standard that incorporate replacement parts, components, and/or software to be certified to this edition of NFPA 1970.

20.1.3.2* Chapters 20 through 24 of this standard shall not apply to any accessories that could be attached to the certified product before or after purchase but that are not necessary for the certified product to meet the requirements of Chapters 20 through 24.

20.1.3.3 Chapters 20 through 24 of this standard shall not apply to the use of PASS, the requirements for which are specified in NFPA 1550.

20.1.4 Units.

20.1.4.1 In Chapters 20 through 24 of this standard, values for measurement are followed by an equivalent in parentheses, but only the first value stated shall be regarded as the requirement.

20.1.4.2 Because the equivalent values in parentheses are approximate, they shall not be considered as the requirement.

20.2 General.

20.2.1 The certification process for PASS, as being compliant with Chapters 20 through 24 of this standard, shall also meet the requirements of Sections 4.1 through 4.9.

20.2.2 The certification organization shall not issue any new certifications based on the 2018 edition of NFPA 1982 after the NFPA effective date of the 2025 edition of NFPA 1970.

20.2.3 The certification organization shall not permit any manufacturer to continue to label any products that are certified as compliant with the 2018 edition of NFPA 1982 on the effective date of the 2025 edition of NFPA 1970, plus 18 months.

20.2.4 The certification organization shall require manufacturers to remove all certification labels and product labels indicating compliance with the 2018 edition of NFPA 1982 from all products that are under the control of the manufacturer on the effective date of the 2025 edition of NFPA 1970, plus 18 months, and the certification organization shall verify that this action is taken.

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

20.2.6 The certification organization and the manufacturer shall evaluate replacement parts, components, and software to determine any changes affecting the form, fit, or function of PASS or RF PASS devices certified to earlier editions of this standard to permit incorporation of replacement parts, components, or software, leading to certification of devices to this edition of the standard.

20.3 Inspection and Testing.

20.3.1* Testing conducted by the certification organization in accordance with the testing requirements of Chapter 24, for determining product compliance with the applicable performance requirements specified in Chapter 23, shall be performed on whole and complete PASS. Where the PASS is an integral part of another item of protective clothing or protective equipment, that item with the PASS incorporated shall be tested as a whole, unless otherwise specified by this standard.

20.3.2 PASS shall be tested for initial certification to this edition of NFPA 1970 and shall meet the performance requirements of the test series specified in the test matrix in Table 20.3.2(a) or Table 20.3.2(b), as applicable, for the type of PASS being certified.

20.3.2.1 Where there is more than one test for a single test specimen required by Table 20.3.2(a) or Table 20.3.2(b), the order of testing shall be from top to bottom of the test specimen column as shown in the table.

20.3.2.2 When testing removable integrated PASS, test specimens 1, 2, and 3, as identified in Table 20.3.2(a), shall be in the integrated PASS configuration.

20.3.2.3 When testing specimen PASS in accordance with Sections 24.3, 24.4, 24.5, 24.6, 24.8, and 24.13, one specimen PASS, instead of all three specimens tested in each test series, shall be selected to be used for evaluation of the requirements of 23.1.2. The one specimen PASS that is selected shall be chosen at random from each of the respective series of three specimens for each test.

20.3.3 Any change in the design, construction, or material of a compliant PASS shall necessitate new inspection and testing to verify compliance to all applicable requirements of Chapters 20 through 24 of this standard that the certification organization determines can be affected by such change. This recertification shall be conducted before labeling the modified PASS as being compliant with this standard.

20.3.4 The certification organization shall not allow any modifications, pretreatment, conditioning, or other such special processes of the PASS or any PASS component, prior to the product's submission for evaluation and testing by the certification organization. The certification organization shall only accept, from the manufacturer for evaluation and testing for certification, PASS or PASS components that are the same in every respect to the actual final product or component. Other than as specifically permitted by this standard, the certification organization shall not allow the substitution, repair, or modification of any PASS or any PASS component during testing.

20.3.5* All testing and inspection shall be performed utilizing the power source(s) specified on the PASS in accordance with 21.1.7(6).

Table 20.3.2(a) Test Matrix for Stand-Alone PASS and Removable Integrated PASS

Test Order	Specimens 1–3	Specimens 4–6	Specimens 7–9	Specimens 10–12	Specimens 13–15	Specimens 16–18	Specimens 19–21	Specimens 22–24
1	Sound pressure (Section 24.2), specimens 1–3	Shock sensitivity (Section 24.7), specimens 4–6	Electronic temperature stress — elevated (24.3.5), specimens 7–9	Water drainage (Section 24.11), specimens 10–12	Case integrity (Section 24.6), specimens 13–15	Vibration test (Section 24.9), specimens 16–18	Tumble vibration (Section 24.17), specimens 19–21	Prealarm and alarm signal frequencies (Section 24.15), specimens 22–24
2	Alarm signal muffle (Section 24.18), specimens 1–3	Impact acceleration — ambient (Section 24.8), specimen 4	Electronic temperature stress — low (24.3.6), specimens 7–9	Corrosion (Section 24.4), specimens 10–12	Retention system (Section 24.10), specimens 13–15		Point-to-point RF attenuation test (Section 24.19), specimens 19–21	
3		Impact acceleration — cold (Section 24.8), specimen 5	Electronic temperature stress — shock (24.3.7), specimens 7–9	Product label durability (Section 24.16), specimens 10–12	High temperature functionality (Section 24.12), specimens 13–15		Loss-of-signal alarm test (Section 24.20), specimens 19–21	
4	Heat/flame test 1 (24.13.5.8), specimen 1	Impact acceleration — elevated (Section 24.8), specimen 6	Product label durability (Section 24.16), specimens 7–9				RF interference test (Section 24.21), specimens 19–21	
5	Heat/flame test 2 (24.13.5.9), specimen 2		Heat and immersion leakage (Section 24.5), specimens 7–9				RF Multipath Test (Section 24.22) specimens 19–21	
6	Heat/flame test 3 (24.13.5.10), specimen 3		Product label durability (Section 24.16), specimens 7–9				RF Multi-hop Test (Section 24.23) specimens 19–21	

Table 20.3.2(b) Test Matrix for Nonremovable Integrated PASS

Test Order	Specimens 1–3	Specimens 4–6	Specimens 7–9	Specimens 10–12	Specimens 13–15	Specimens 16–18	Specimens 19–21
1	Sound pressure (Section 24.2), specimens 1–3	Shock sensitivity (Section 24.7), specimens 4–6	Electronic temperature stress — elevated (24.3.5), specimens 7–9	Water drainage (Section 24.11), specimens 10–12	Case integrity (Section 24.6), specimens 13–15	Tumble vibration (Section 24.17), specimens 16–18	Prealarm and alarm signal frequencies (Section 24.15), specimens 19–21
2	Alarm signal muffle (Section 24.18), specimens 1–3	Vibration test (Section 24.9), specimens 4–6	Electronic temperature stress — low (24.3.6), specimens 7–9	Corrosion (Section 24.4), specimens 10–12	High temperature functionality (Section 24.12), specimens 13–15	Point-to-point RF attenuation test (Section 24.19), specimens 16–18	
3			Electronic temperature stress — shock (24.3.7, specimens 7–9	Product label durability (Section 24.16), specimens 10–12		Loss-of-signal alarm test (Section 24.20), specimens 16–18	
4	Heat/flame test 1 (24.13.5.8), specimen 1		Product label durability (Section 24.16), specimens 7–9			RF interference test (Section 24.21), specimens 16–18	
5	Heat/flame test 2 (24.13.5.9), specimen 2		Heat and immersion leakage (Section 24.5), specimens 7–9			RF Multipath Test (Section 24.22) specimens 16–18	
6	Heat/flame test 3 (24.13.5.10), specimen 3		Product label durability (Section 24.16), specimens 7–9			RF Multi-hop Test (Section 24.23) specimens 16–18	

20.4 Annual Verification.

20.4.1 After initial certification to this edition of NFPA 1970 (NFPA 1982), compliant PASS shall be tested annually for verification within 12 months from the previous certification or annual verification.

20.4.2 Annual verification shall occur each year of the four years following initial certification. If there is no revision to this edition of NFPA 1970 (NFPA 1982) by the fifth year following initial certification, compliant PASS shall be required to undergo full certification testing as specified in 20.3.3 in the fifth year.

20.4.3 Unless otherwise indicated, only one test specimen shall be required for each test specified in Table 20.3.2(a) or Table 20.3.2(b), as applicable for the type of PASS being tested.

20.4.4 Where there is more than one test for a single test specimen PASS required by Table 20.3.2(a) or Table 20.3.2(b), the order of testing shall be from top to bottom of the test specimen column as shown in the tables.

Chapter 21 Labeling and Information (NFPA 1982)

21.1 Product Labeling Requirements.

21.1.1 Each PASS shall have a product label(s) permanently and conspicuously attached. In all cases, the PASS shall bear at least one product label with the marking requirements specified in 21.1.5 through 21.1.8.

21.1.1.1 Where various components of PASS are not mounted or contained in a single location, case, or enclosure, additional product labels shall be permanently and conspicuously attached to major dispersed components.

21.1.1.2 The text of the product labels for dispersed PASS components shall be permitted to be limited to the marking requirements specified in 21.1.5 and 21.1.6.

21.1.2 Multiple label pieces shall be permitted in order to carry all statements and information required to be on the product label.

21.1.3 All worded portions of the required product label(s) shall be printed at least in English.

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

21.1.5* The certification organization's label, symbol, or identifying mark shall be attached to the product label or shall be part of the product label. The label, symbol, or identifying mark shall be at least 6 mm (¼ in.) in height and shall be placed in a conspicuous location.

21.1.6 The statement in 21.1.6.1 shall be printed on the product label(s) and placed on the product. All letters shall be at least 1.5 mm (1⁄32 in.) in height. This label is not restricted to one line.

21.1.6.1 The label shall read as follows:

CERTIFIED MODEL NFPA 1970 (1982), 2025 EDITION. DO NOT REMOVE THIS LABEL.

21.1.6.2 PASS devices certified to previous editions of NFPA 1982 that have been upgraded to meet Chapters 20 through 24 of this edition of NFPA 1970 shall have the following statement printed. All letters shall be at least 1.5 mm (1⁄16 in.) in height. The label shall not be required to be restricted to one line. The original NFPA required labeling shall not be removed or covered by the upgraded label.

UPGRADED TO NFPA 1970 (1982), 2025 EDITION.

21.1.7 At least the following information shall also be legibly printed on the product label(s) and placed on each PASS in a user-accessible location, and all letters shall be at least 2 mm (1⁄3 in.) in height:

(1) Manufacturer name, identification, or designation
(2) Country of manufacture
(3) Model name, number, or design
(4) Identification/lot/serial number
(5) Month and year of manufacture, not coded
(6) Recommended power source type and size if user replaceable

21.1.8 All product labels also shall meet the requirements specified in Section 23.12, Product Label Durability.

21.1.9 The base station component of an RF PASS system shall identify the maximum number of RF PASS alarm signals that the base station can process. This number shall be clearly printed on the product label.

21.1.10 The base station and RF PASS units shall contain the appropriate product label specified by FCC guidelines, if any, for the radio system technology used.

21.2 User Information.

21.2.1 The PASS manufacturer shall provide with each PASS at least the user information that is specified in 21.2.4.

21.2.2 The PASS manufacturer shall attach the required user information or packaging containing the user information, or links to digital user information, to the PASS in such a manner that it is not possible to initially use the PASS without being aware of the information.

21.2.3 The required user information or packaging containing the user information, or links to digital user information, shall be attached to the PASS so that a deliberate action is necessary to remove it. The PASS manufacturer shall provide notice that the user information is to be removed only by the end user.

21.2.4 The PASS manufacturer shall provide at least the following instructions and information with each PASS:

(1) Pre-use information as follows:
  (a) Safety considerations
  (b) Limitations of PASS
  (c) Marking recommendations and restrictions
  (d) Warranty information
(2) Preparation for use as follows:
  (a) Preferred mounting position and orientation for optimal performance
  (b) Training instructions
  (c) Recommended storage practices
(3) Inspection frequency and details
(4) Proper use
(5) Maintenance and cleaning as follows:
  (a) Cleaning instructions and precautions
  (b) Power source testing and replacement
  (c) Adjustments, if applicable
  (d) Maintenance criteria
  (e) Painting
  (f) Decontamination procedures
(6) Retirement criteria and considerations
(7) Procedure for reporting PASS problems to the manufacturer and to the certification organization

21.2.5 Equipment certified for use in hazardous locations shall be provided with at least the following information in user instructions or training materials:

(1) For PASS that is part of a nonincendive system, indication of the PASS accessories that comprise the nonincendive system in accordance with this standard
(2) For PASS that is part of an intrinsically safe system, indication of the PASS accessories that comprise the intrinsically safe system in accordance with this standard

Chapter 22 Design Requirements (NFPA 1982)

22.1 General Design Requirements for PASS.

22.1.1 PASS shall have at least the applicable design requirements specified in this section where inspected and evaluated by the certification organization as specified in Section 20.3, Inspection and Testing.

22.1.2 In all instances, the design of PASS shall provide for the safety and security of the functioning of the PASS.

22.1.2.1 PASS that is designed as a self-contained, independent device contained in a single case, housing, or enclosure and that is not an integral part or parts of any item or multiple items of protective clothing, protective equipment, or both shall be designated as “stand-alone PASS.”

22.1.2.2 PASS that is designed with dispersed components as part or parts of any item or multiple items of protective clothing, protective equipment, or both and the dispersed components are not mounted, grouped, or contained in a single location nor in a single case, housing, or enclosure, but with multiple cases, housings, or enclosures, shall be designated as “integrated PASS.”

22.1.2.3 Where integrated PASS is designed and intended to be readily removed from the item or multiple items of protective clothing, protective equipment, or both, so that it can also be used independently, such integrated PASS shall be designated as “removable integrated PASS.”

22.1.2.4 Where integrated PASS is not designed and not intended to be readily removed from the item or multiple items of protective clothing, protective equipment, or both so that it cannot be used independently, such integrated PASS shall be designated as “nonremovable integrated PASS.”

22.1.2.5 Where the PASS device is equipped with an RF PASS in addition to emitting an alarm signal, it shall also transmit and receive other alarm signals through the use of a modulated radio-frequency carrier. The RF PASS system shall consist of a wireless RF transceiver contained within or linked to the RF PASS, and a base station RF transceiver that might be self-contained or designed to operate in conjunction with a portable computer. The base station unit shall be capable of battery operation for up to 1 hour under alarm conditions. The use of repeaters is not precluded.

22.1.2.5.1 The base station shall be designed to emit a visual alarm when the alarm signal described in 22.4.3 is activated by the RF PASS unit, when the evacuation alarm is initiated, and/or when the loss-of-signal alarm is triggered.

22.1.2.5.2 Both the RF PASS unit and base station shall comply with FCC regulations for radio-frequency transmissions for the transmission format chosen by the manufacturer.

22.1.2.5.3 Antennas and/or other peripheral electronic components designed for use with RF PASS shall not interfere with or impede firefighting operations.

22.1.2.5.4 Software used in conjunction with RF PASS and base stations shall be updated as necessary within 6 months by the manufacturer for newly released versions of the computer operating system for which the software was designed.

22.1.3* PASS shall incorporate data logging in nonvolatile memory and, at a minimum, the following events shall be identified and recorded with the data log and shall also have a date and time stamp for each event in the data log:

(1) When the PASS is turned on
(2) When the PASS activates any alarm or prealarm
(3) When the PASS alarm is activated by the user
(4) When the PASS alarm was reset
(5) When the PASS was turned off
(6) When the PASS low power source warning signal activates

22.1.3.1 The data logging information shall be downloadable by the emergency services organization.

22.1.3.2 The data logging shall have a minimum capacity of logging 2000 events.

22.1.3.3 Data logging shall be permitted to be carried out via RF signals transmitted by an RF PASS and received by the base station.

22.1.4* Where PASS designated as stand-alone PASS or as integrated PASS are secured by a retention system in a wearing position, in accordance with the manufacturer’s instructions, the retention system shall not affect the proper function of the mode selection device or devices specified in Section 22.2, Mode Selection Design Requirements for PASS, and shall not affect the performance of the PASS when tested to the performance requirements specified in Chapter 23.

22.1.5* PASS power source(s) shall be isolated from the operating components to prevent damage to the components.

22.1.6 All PASS hardware finishes shall be free of all rough spots, burrs, and sharp edges.

22.1.7 All sewing thread used in the construction of PASS shall be made of inherently flame-resistant fiber.

22.2 Mode Selection Design Requirements for PASS.

22.2.1 PASS shall allow for operation in at least three modes: (1) off, (2) alarm, (3) sensing.

22.2.2 The mode selection device(s) shall be designed to provide automatic activation from the off mode to the sensing mode without the user setting the mode selection device.

22.2.2.1 Such automatic activation shall include, but not be limited to, being linked to activation of SCBA, being linked to removal from storage or transportation positions, by pull-away tether to a fixed position, or by remote activation.

22.2.2.2 Such automatic activation shall be designed so that when PASS is automatically activated it shall be able to be manually switched from the sensing mode to the alarm mode with the mode selection device but shall not be able to be switched to the off mode until the automatic activation means is also intentionally deactivated.

22.2.2.3 Base station units for RF PASS shall indicate on a visual display the presence of all RF PASS units that are in sensing mode.

22.2.3 All mode selection devices shall be protected against accidental change of operation and impact damage.

22.2.4 All mode selection devices shall be rated for a service life of not fewer than 50,000 cycles.

22.2.5 All mode selection devices shall be capable of being switched to the alarm or sensing mode by a single gloved hand.

The fingers of gloves utilized for this function test shall have a thickness of 2.5 mm to 4 mm (3⁄32 in. to 5⁄32 in.).

22.2.6 Only one action shall be required to switch the mode selection device(s) from any mode to alarm mode.

22.2.7 When PASS is sounding the alarm signal, it shall require at least two separate and distinct manual actions to silence the alarm signal.

22.2.7.1 Any action to silence the alarm signal and the actual silencing of the alarm signal shall not permit PASS to remain in the off mode.

22.2.7.2 The silencing of the alarm signal shall automatically reset PASS to the sensing mode.

22.2.7.3 Base station units for RF PASS shall indicate on a visual display the presence of all RF PASS units that are in alarm mode.

22.2.8 PASS shall be provided with a light source capable of providing a visual indication of mode status as well as an audible source capable of providing an aural indication of a change in the mode selection when switching from off to sensing, off to alarm, and alarm to sensing.

22.2.8.1 Base station units for RF PASS shall utilize a different visual display to indicate sensing and alarm modes.

22.3 Motion Sensing Design Requirements for PASS.

22.3.1 PASS shall incorporate motion sensing that shall detect motion and lack of motion of the person on whom the PASS is deployed and cause the activation of the sequence that leads to the sounding of the alarm signal when lack of motion is detected for the specified time.

22.3.2 PASS shall sound the alarm signal specified in 22.4.3 when the PASS does not sense movement for 30 seconds, +5/−0 seconds.

22.3.2.1 The base station associated with RF PASS shall receive the alarm signal within 30 seconds +5/–0 seconds of its initiation on the RF PASS, unless RF communication has been lost.

22.3.3 The alarm signal shall be preceded by a prealarm signal as specified in 22.4.2.

22.3.4 PASS motion sensing shall function regardless of the angle of deployment of the PASS.

22.3.5 PASS shall be designed so that any failure of the motion sensing function shall cause the PASS to sound the alarm signal as specified in 22.4.3 within 30 seconds +5/–0 seconds of such failure. The PASS manufacturer shall submit a failure modes and effects analysis (FMEA) to the certification organization for verification of this requirement.

22.3.6 For RF PASS, the evacuation alarm shall be received within 30 seconds +5/–0 seconds of its transmission by the base station unless RF communication has been lost.

22.3.7 Failure Mode and Effects Analysis (FMEA) for Personal Alert Safety Systems.

22.3.7.1* An FMEA shall be applied throughout the development process.

22.3.7.2 The FMEA shall address PASS and shall identify and prioritize those critical failures that could have a serious effect on the safety and reliability of a PASS in the anticipated operating environments.

22.3.7.3 The FMEA shall tabulate potential failure modes and their effects on the performance of a PASS. The failure mode shall describe how the system might fail.

22.3.7.4* The PASS manufacturer shall use the FMEA to address the reduction of risk of random and systematic failures of PASS by using as low as reasonably practical (ALARP) region activities, shown in Figure 22.3.7.4. The PASS manufacturer shall include the risk priority number (RPN) corresponding to the upper limit of the ALARP region in the FMEA report.

22.3.7.5 Where a PASS RPN as determined by the manufacturer is above the upper limit of the ALARP region as determined by the manufacturer, one or more of the practices specified in 22.3.7.5.1 shall be permitted.

22.3.7.5.1 Verification of the manufacturer's design and testing practices shall include documentation of at least temperature, vibration, and wetness exposure data, hours of operation, and management of change information.

22.3.7.6 The FMEA report shall be provided to the certification organization.

22.4 Signal Design Requirements for PASS.

22.4.1 Operational Signal.

22.4.1.1 PASS shall emit an audible "operational signal" within 1 second of completing the required action to set PASS to the sensing mode, indicating to the user that the device is functioning properly.

22.4.1.2 When PASS is in the off mode and the power source is at or below the level specified in 22.4.4.1, the operational signal shall not sound when PASS is switched to the sensing mode.

22.4.2 Prealarm Signal.

22.4.2.1 The PASS shall have at least an audible primary "prealarm signal." The audible primary prealarm signal shall be a distinct and different sound from the alarm signal.

22.4.2.2 PASS shall be permitted to incorporate a supplementary prealarm signal or signals in addition to the audible primary prealarm signal to enhance the ability of the user to detect and identify the prealarm status. Supplementary prealarm signals shall be variable in a continuous pattern or shall be recurrent.

22.4.2.2.1 The supplementary prealarm signal shall alert senses other than hearing.

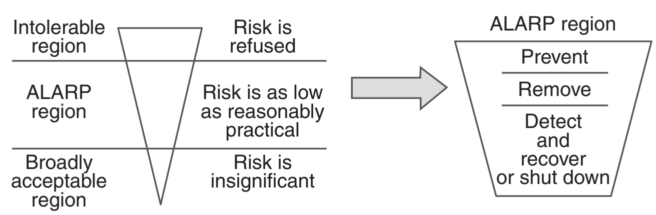


FIGURE 22.3.7.4 ALARP Region Activities. [1801:Figure 6.3.4]

22.4.2.2.2 When activated, the supplementary prealarm signal shall not diminish the performance of the audible primary prealarm signal below the requirements of this standard.

22.4.2.2.3 The design of the supplementary prealarm signal shall be such that failure of the supplementary prealarm signal shall not affect the activation or operation of the audible primary prealarm signal.

22.4.2.3 PASS shall sound the prealarm signal(s) 11.245 seconds +2.755/–0 seconds prior to the sounding of the alarm signal.

22.4.2.4 During the prealarm signal(s) sounding, all other audible PASS signals, other than the alarm signal, shall be rendered inactive.

22.4.2.5 PASS shall be designed to have at least a motion-induced cancellation of functioning of the prealarm signal(s) prior to the sounding of the alarm signal.

22.4.2.6 Cancellation of the sounding of the audible primary prealarm signal and cancellation of functioning of the supplementary prealarm signal(s) shall not require the use of the user's hand(s).

22.4.2.7 PASS shall reset to the sensing mode upon cancellation of the prealarm signal.

22.4.2.8 Audible Primary Prealarm Signal. The PASS annunciator shall be driven by a prealarm sequence consisting of the following three steps:

(1) Step 1: A Type-1 tone pair, repeated in sequence as follows with each tone duration being 500 ms ± 20 ms:
  (a) Tone 1..Tone 2..Tone 1..<silence 500 ms ± 20 ms>
  (b) Tone 1..Tone 2..Tone 1..<silence 500 ms ± 20 ms> immediately followed by Step 2.
(2) Step 2: A Type 2 tone pair, repeated in sequence as follows with each tone duration being 250 ms ± 10 ms:
  (a) Tone 3..Tone 4..Tone 3..<silence 250 ms ± 10 ms>
  (b) Tone 3..Tone 4..Tone 3..<silence 250 ms ± 10 ms>
  (c) Tone 3..Tone 4..Tone 3..<silence 250 ms ± 10 ms>
  (d) Tone 3..Tone 4..Tone 3..<silence 250 ms ± 10 ms> immediately followed by Step 3.
(3) Step 3: A Type 3 tone pair, repeated in sequence as follows with each tone duration being 125 ± 10 ms:
  (a) Tone 5..Tone 6..Tone 5..Tone 6..Tone 5..Tone 6..Tone 5..<silence 125 ms ± 10 ms>
  (b) Tone 5..Tone 6..Tone 5..Tone 6..Tone 5..Tone 6..Tone 5..<silence 125 ms ± 10 ms>
  (c) Tone 5..Tone 6..Tone 5..Tone 6..Tone 5..Tone 6..Tone 5..<silence 125 ms ± 10 ms>
  (d) Tone 5..Tone 6..Tone 5..Tone 6..Tone 5..Tone 6..Tone 5.

22.4.2.8.1 Tone pair definitions: The frequency of all tones shall be between 1000 Hz and 4000 Hz, with the second tone of each pair (Tone 2, Tone 4, and Tone 6) being 250 Hz + 250/–50 Hz higher than the first tone (Tone 1, Tone 3, and Tone 5) of the pair. It shall be permitted for each step's tone pair to be the same two tones or for them to rise to higher tones. If rising tone pairs are deployed, the frequency gap between Tone 2 and Tone 3 and between Tone 4 and Tone 5 shall be 250 Hz + 250/–50 Hz.

22.4.3 Alarm Signal.

22.4.3.1 PASS shall sound the alarm signal when switched to the alarm signal mode.

22.4.3.2 For RF PASS, while in the sensing mode, the PASS shall sound an audible evacuation or other alarm within 35 seconds of the evacuation or other alarm being initiated on the base station, unless the RF PASS is in alarm mode or the unit is out of range. Upon resetting the alarm condition, the RF PASS shall sound the evacuation or other alarm within 35 seconds. While the RF PASS is in alarm mode, no other audible alarms shall override or impede the alarm signal. For RF PASS with integrated repeating capability, the alarm shall be received within 35 seconds after two repeater hops, as specified by Section 24.22.

22.4.3.3 During the alarm signal sounding, all other audible PASS signals shall be rendered inactive.

22.4.3.3.1 For RF PASS, during the alarm signal sounding, all other audible PASS signals shall be rendered inactive.

22.4.3.4 The alarm signal shall have a duration of at least 1 hour at the PASS.

22.4.3.4.1 For RF PASS, the alarm signal shall have a duration of at least 1 hour at the base station.

22.4.3.5 The alarm signal, once activated, shall not be deactivated by the motion detector.

22.4.3.6 Any action to silence the alarm signal and the actual silencing of the alarm signal shall not permit the PASS to remain in the off mode.

22.4.3.7 The PASS annunciator shall be driven by an alarm sequence consisting of the following eight steps:

(1) A Type 1 sweep
(2) A silent interval of 300 ms ± 100 ms
(3) A Type 2 sweep, repeated a total of 4 times with a silent interval of 10 ms ± 5 ms between each sweep
(4) A silent interval of 300 ms ± 100 ms
(5) A Type 1 warble
(6) A Type 2 warble
(7) A Type 1 warble
(8) A silent interval of 600 ms ± 100 ms

22.4.3.7.1 Following Step 8, the alarm sound shall repeat beginning immediately with Step 1.

22.4.3.7.2 Type 1 Sweep. The Type 1 sweep is a 1 second ± 50 ms frequency sweep with a minimum of 100 increasing frequency steps. The start frequency and end frequency shall be in the range of 2000 Hz to 4000 Hz and the end frequency must be a minimum of 500 Hz greater than the start frequency.

22.4.3.7.3 Type 2 Sweep. The Type 2 sweep is a 250 ms ± 12.5 ms frequency sweep with a minimum of 25 increasing frequency steps. The start frequency and end frequency shall be in the range of 2000 Hz to 4000 Hz and the end frequency must be a minimum of 500 Hz greater than the start frequency.

22.4.3.7.4 Type 1 Warble. The Type 1 warble is a 400 ms ± 20 ms sound that alternates between Tone A and Tone B every 10 ms ± 5 ms.

22.4.3.7.5 Type 2 Warble. The Type 2 warble is a 200 ms ± 10 ms sound that alternates between Tone B and Tone C every 10 ms ± 5 ms.

22.4.3.7.6 Tones A, B, and C shall be between 2000 Hz and 4000 Hz.

22.4.3.7.6.1 Tone A. Tone A shall be a frequency between 2300 Hz and 4000 Hz.

22.4.3.7.6.2 Tone B. Tone B shall be a frequency 100 Hz to 200 Hz below Tone A.

22.4.3.7.6.3 Tone C. Tone C shall be a frequency 200 Hz to 300 Hz below Tone B.

22.4.4 Low Power Source Warning Signal.

22.4.4.1 While in the sensing mode, PASS shall emit a recurrent audible low power source warning signal when the power source voltage or power source percent capacity remaining is depleted to the level that will maintain the alarm signal level at a minimum of 92 dBA for a minimum of 1 hour.

22.4.4.2 The power source shall be discharged at a rate that is equal to the operational mode that uses maximum power consumption. The rate and a discharge method shall be provided to the certification organization by the manufacturer and must include consideration of all special conditions, optional features, and external accessories, including, but not limited to, the PASS alarm signal, RF PASS communications, and integrated SCBA supplementary voice communications.

22.4.4.3 The low power source warning signal sound shall be distinct and different from the prealarm signal(s) and the alarm signal.

22.4.4.4 The low power source warning signal shall have an interval of not greater than 30 seconds.

22.4.4.5 While in the off mode and with the power source voltage or power source percent remaining at or below the level specified in 22.4.4.1, the system that causes the activation of the low power source warning signal shall cancel the operational signal so that it shall not sound when the PASS is switched to the sensing mode.

22.4.5 Loss-of-Signal Alarm (RF PASS).

22.4.5.1 For RF PASS, when loss of RF communication is detected, the base station shall emit a recurrent visual loss-of-signal alarm and the RF PASS unit shall emit a recurrent visual loss-of-signal alarm within 60 seconds of loss of RF communication. The visual alarm shall recur at a period of no more than 20 seconds. Loss of communication might be due to, but not be limited to, the portable unit being out of range or the presence of an RF interferer.

22.4.5.2 The loss-of-signal alarm shall consist of a visual alarm, distinct from the remote distress alarm and the evacuation signal.

22.4.5.3 The base station and the RF PASS shall monitor for loss of RF communication periodically when the RF PASS is in sensing mode at a period not to exceed 60 seconds.

22.5* Hazardous Location Requirements.

22.5.1 General. PASS devices and PASS device accessories involving electrical circuitry shall only use circuitry that meets the requirements of this standard for one of the following types of explosion protection:

(1) Nonincendive equipment, stand-alone type (i.e., individual pieces of equipment separately certified for Class I and II, Division 2 and Class III applications, without any external electrical interconnection means, and intended for stand-alone use)
(2) Nonincendive system (i.e., multiple pieces of nonincendive equipment certified together for Class I and II, Division 2 and Class III applications, with electrical interconnection means, and intended for dedicated system use)
(3) Intrinsically safe apparatus, stand-alone type (i.e., individual pieces of apparatus separately certified for Class I and II, Division 1 and Class III applications, without any external electrical interconnection means, and intended for stand-alone use)
(4) Intrinsically safe system (i.e., multiple pieces of intrinsically safe apparatus certified together for Class I and II, Division 1 and Class III applications, with electrical interconnection means, and intended for dedicated system use)

22.5.2 Nonincendive Equipment and Systems.

22.5.2.1* General. PASS devices and PASS device accessories involving electrical circuitry shall, at a minimum, be suitable for use in Class I, Division 2, Groups C and D; Class II, Division 2, Groups F and G; and Class III, Division 1 and Division 2 hazardous (classified) locations, with a temperature class within the range of T3 through T6 inclusive, in accordance with UL 121201, *Nonincendive Electrical Equipment for Use in Class I and II, Division 2 and Class III, Divisions 1 and 2 Hazardous (Classified) Locations.*

22.5.2.2 Interconnection of Nonincendive Systems. PASS devices that are certified as part of a nonincendive system shall only be interconnected with PASS device accessories also certified as part of the same nonincendive system (i.e., specific PASS devices that are certified together with specific SCBAs as part of a single nonincendive system).

22.5.3 Intrinsically Safe Apparatus and Systems.

22.5.3.1* General. PASS devices and PASS device accessories involving electrical circuitry shall be permitted to be certified for use in Class I, Division 1, Groups C and D; Class II, Division 1, Groups E, F, and G; and Class III, Divisions 1 and 2 hazardous (classified) locations, with a temperature class within the range of T3 through T6 inclusive, in accordance with UL 913, *Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, and III, Division 1 Hazardous (Classified) Locations.*

22.5.3.2 Interconnection of Intrinsically Safe Systems. PASS devices that are certified as part of an intrinsically safe system shall only be interconnected with PASS device accessories also certified as part of the same intrinsically safe system (i.e., specific PASS devices that are certified together with specific SCBAs as part of a single intrinsically safe system).

Chapter 23 Performance Requirements (NFPA 1982)

23.1 Audible Signals.

23.1.1 Audible Primary Prealarm Signal.

23.1.1.1 PASS shall be tested for the sound pressure level of the audible primary prealarm signal as specified in Section 24.2. The sound pressure level of the Type 1 tone pair shall be a minimum of 60 dBA. The sound pressure level of the Type 2 tone pair shall be a minimum of 75 dBA and a minimum of 3 dBA greater than the Type 1 tone pair. The sound pressure level of the Type 3 tone pair shall be a minimum of 90 dBA and shall be a minimum of 3 dBA greater than the Type 2 tone pair.

23.1.1.2* PASS shall be tested for primary prealarm signal frequency as specified in Section 24.14, shall have at least an audible signal, and shall have the primary prealarm as specified in 22.4.2.8.

23.1.2 PASS Alarm Signal.

23.1.2.1 PASS shall be tested for the sound pressure level of the alarm signal as specified in Section 24.2, and shall not have the alarm signal, once activated, be deactivated by the motion detector; shall have the alarm signal sound pressure level not be less than 92 dBA; and shall have PASS function as specified in 22.4.3.

23.1.2.2 PASS shall be tested for frequency content as specified in Section 24.14, and shall have the alarm signals as specified in 22.4.3.7.

23.1.3 PASS Low Power Warning Signal. PASS shall be tested for the sound pressure level of the *low power source warning signal* as specified in Section 24.2, and shall have a sound pressure level between 75 dBA and 95 dBA; shall have the low power source warning signal continue to sound for not less than 1 hour; and shall have the PASS function as specified in 22.4.4.

23.2 Electronic Temperature Stress. PASS shall be tested for resistance to electronic temperature stress as specified in Section 24.3, Electronic Temperature Stress Test, and shall be evaluated for proper functioning of signals as specified in 22.4.2.3 and 22.4.3.2, shall meet the proper alarm signal sound pressure level as specified in 23.1.2.1, and shall have the data logging functions specified in 22.1.3(1) through 22.1.3(6) operating properly.

23.3 Corrosion Resistance. PASS shall be tested for resistance to corrosion as specified in Section 24.4, Corrosion Resistance Test, and shall be evaluated for proper functioning of signals as specified in 22.4.2.3 and 22.4.3.2, shall meet the proper alarm signal sound pressure level as specified in 23.1.2.1, and shall have the data logging functions specified in 22.1.3(1) through 22.1.3(6) operating properly.

23.4 Immersion Leakage Resistance.

23.4.1 PASS shall be tested for resistance to leakage as specified in Section 24.5, Heat and Immersion Leakage Test, and for 24.5.5, Test Procedure 1, PASS shall be evaluated for proper functioning of signals as specified in 22.4.2.3 and 22.4.3.2, shall meet the proper alarm signal sound pressure level as specified in 23.1.2.1, shall have no water in its power source compartment(s), and shall have the data logging functions specified in 22.1.3(1) through 22.1.3(6) operating properly.

23.4.2 PASS shall be tested for resistance to leakage as specified in Section 24.5, Heat and Immersion Leakage Test; and for 24.5.6, Test Procedure 2, PASS shall have no water in the electronics compartment(s).

23.5 Case Integrity. PASS cases, housings, or enclosures shall be tested for integrity as specified in Section 24.6, Case Integrity Test; shall be evaluated for proper functioning of signals as specified in 22.4.2.3 and 22.4.3.2; shall meet the proper alarm signal sound pressure level as specified in 23.1.2.1; shall support the test weight without affecting case integrity or causing visible damage; and shall have the data logging functions specified in 22.1.3(1) through 22.1.3(6) operating properly.

23.6 Shock Sensitivity. PASS shall be tested for signal cancellation sensitivity as specified in Section 24.7, Shock Sensitivity Test, and the prealarm signal shall not cancel.

23.7 Impact and Vibration Resistance.

23.7.1 PASS shall be tested for resistance to impact as specified in Section 24.8, Impact Acceleration Resistance Test, and shall be evaluated for proper functioning of signals as specified in 22.4.2.3 and 22.4.3.2; shall meet the proper alarm signal sound pressure level as specified in 23.1.2.1; and shall have the data logging functions specified in 22.1.3(1) through 22.1.3(6) operating properly.

23.7.2 PASS shall be tested for resistance to vibration as specified in Section 24.9, Vibration Resistance Test, and shall be evaluated for proper functioning of signals as specified in 22.4.2.3 and 22.4.3.2; shall meet the proper alarm signal sound pressure level as specified in 23.1.2.1; and shall have the data logging functions specified in 22.1.3(1) through 22.1.3(6) operating properly.

23.7.3 PASS shall be tested for resistance to vibration as specified in Section 24.16, Tumble–Vibration Test, and shall be evaluated for proper functioning of signals as specified in 22.4.2.3 and 22.4.3.2; shall meet the proper alarm signal sound pressure level as specified in 23.1.2.1; and shall have the data logging functions specified in 22.1.3(1) through 22.1.3(6) operating properly.

23.8 Retention System. PASS shall be tested for durability of the retention system as specified in Section 24.10, Retention System Test, and the retention system shall withstand the applied force without separating.

23.9 Water Drainage. PASS shall be tested for water drainage as specified in Section 24.11, Water Drainage Test, and the alarm signal sound pressure level shall be at least 92 dBA.

23.10 Heat Resistance. PASS shall be tested for resistance to heat as specified in Section 24.12, High Temperature Functionality Test, and shall not melt, drip, or ignite.

23.10.1 PASS shall be evaluated for proper functioning of signals as specified in 22.4.2.3 and 22.4.3.2.

23.10.2 The sound pressure level shall not be less than 92 dBA.

23.10.3 The data logging functions specified in 22.1.3(1) through 22.1.3(5) shall operate properly.

23.11 Heat and Flame Resistance.

23.11.1 PASS shall be tested for resistance to heat and flame as specified in Section 24.13, Heat and Flame Test, Test Procedure 1, and shall not have the afterflame exceed 2.2 seconds; shall have nothing fall off the PASS; shall not have the PASS fall from its mounted position; and the PASS shall function as follows:

(1) The alarm signal shall sound and continue to sound as specified in 22.4.3.
(2) The alarm signal shall meet the sound pressure levels as specified 23.1.2.1.
(3) At least two separate and distinct manual actions shall be required to change the mode selection device from alarm to sensing in order to silence the alarm as specified in 22.2.7.
(4) The data logging functions specified in 22.1.3(1) through 22.1.3(6) shall operate properly.

23.11.2 PASS shall be tested for resistance to heat and flame as specified in Section 24.13, Heat and Flame Test, Test Procedure 2, and shall not have the afterflame exceed 2.2 seconds; shall have nothing fall off the PASS; shall not have the PASS fall from its mounted position; and the PASS shall function as follows:

(1) PASS shall emit the operational signal as specified in 22.4.1.
(2) PASS shall cycle from sensing to prealarm as specified in Section 22.3, Motion Sensing Design Requirements for PASS.
(3) The primary prealarm signal shall sound as specified in 22.4.2.
(4) PASS shall cycle from prealarm to alarm as specified in Section 22.3, Motion Sensing Design Requirements for PASS.
(5) The alarm signal shall sound as specified in 22.4.3.
(6) At least two separate and distinct manual actions shall be required to change the mode selection device from alarm to sensing in order to silence the alarm as specified in 22.2.7.
(7) The primary prealarm signal sound pressure level shall be as specified in 23.1.1.1, and supplementary prealarm signals shall function as designed.
(8) The alarm signal sound pressure level shall be as specified in 23.1.2.1.
(9) The data logging functions specified in 22.1.3 through 22.1.3(6) shall operate properly.

23.11.3 PASS shall be tested for resistance to heat and flame as specified in Section 24.13, Heat and Flame Test, Test Procedure 3, and shall not have the afterflame exceed 2.2 seconds, shall have nothing fall off the PASS; shall not have the PASS fall from its mounted position; and the PASS shall function as follows:

(1) PASS shall emit the operational signal as specified in 22.4.1.
(2) The mode selection device shall be capable of being switched from sensing to alarm as specified in 22.2.5 and 22.2.6.
(3) The alarm signal shall sound as specified in 22.4.3.
(4) At least two separate and distinct manual actions shall be required to change the mode selection device from alarm to sensing in order to silence the alarm as specified in 22.2.7.
(5) The primary prealarm signal sound pressure level shall be as specified in 23.1.1.1, and supplementary prealarm signals shall function as designed.
(6) The alarm signal sound pressure level shall be as specified in 23.1.2.1.
(7) The data logging functions specified in 22.1.3(1) through 22.1.3(6) shall operate properly.

23.12 Product Label Durability. PASS with product labels attached shall be tested for durability and legibility as specified in Section 24.15, Product Label Durability Test, and the product labels shall remain attached to the PASS and shall be legible to the unaided eye.

23.13 Alarm Signal Muffle Test. PASS shall be tested for resistance to sound pressure level deadening or muffling as specified in Section 24.17, PASS Alarm Signal Muffle Test, and the sound pressure level shall not be less than 92 dBA.

23.14* Radio System Tests — Point-to-Point RF Attenuation Test. RF PASS shall be tested for reliable wireless transmission and reception of alarm signals under a fixed amount of path loss (attenuation) as specified in Section 24.18, Radio System Tests for RF PASS — Point-to-Point RF Attenuation Test.

23.14.1 The base station shall automatically emit a visual alarm in response to an alarm signal received from the RF PASS within the time specified in 22.3.2.1 of alarm initiation under the radio channel conditions specified in Section 24.18.

23.14.2 The RF PASS shall automatically emit an audible alarm within the time specified in 22.3.6 of evacuation alarm initiation on the base station under the radio channel conditions specified in Section 24.18.

23.15 Radio System Tests — Loss-of-Signal Alarm Test. RF PASS shall be tested for initiation of a visual alarm signal when RF communication is lost as specified in Section 24.19, Radio System Tests for Optional RF PASS — Loss-of-Signal Alarm Test.

23.15.1 The base station shall automatically initiate the loss-of-signal alarm in response to loss of RF communication with the RF PASS within 60 seconds under the radio channel conditions specified in Section 24.19, Radio System Tests for Optional RF PASS — Loss-of-Signal Alarm Test.

23.15.2 The RF PASS shall automatically initiate the loss-of-signal alarm within 60 seconds of loss of RF communication with the base station under the radio channel conditions specified in Section 24.19, Radio System Test for Optional RF PASS — Loss-of-Signal Alarm Test.

23.16 Radio System Tests — RF Interference Test. RF PASS shall be tested for wireless transmission and reception of alarm signals under a fixed amount of external in-band RF interference as specified in Section 24.20, Radio System Tests for RF PASS — RF Interference Test.

23.16.1 The base station shall automatically emit a visual alarm in response to an alarm signal received from the RF PASS within the time specified in 22.3.2.1 of alarm initiation under the radio channel conditions specified in Section 24.20.

23.16.2 The RF PASS shall automatically emit an audible alarm within the time specified in 22.3.6 of evacuation alarm initiation on the base station under the radio channel conditions specified in Section 24.20.

23.17 Radio System Tests — Multipath Test. RF PASS shall be tested for reliable wireless transmission and reception of alarm signals under a statistical condition of multipath reflections as specified in Section 24.21, Radio System Tests for RF PASS — Multipath Test.

23.17.1 The base station shall automatically emit an audible alarm in response to an alarm signal received from the RF PASS within the time specified in 22.3.2.1 of alarm activation under the radio channel conditions specified in Section 24.21.

23.17.2 The RF PASS shall automatically emit an audible alarm within the time specified in 22.3.6 of evacuation alarm transmission by the base station under the radio channel conditions specified in Section 24.21.

23.18 Radio System Tests — Multihop RF Test. RF PASS with repeating capability shall be tested for reliable wireless transmission and reception of alarm signals under a fixed amount of path loss (i.e., attenuation) and through two repeaters as specified in Section 24.22.

23.18.1 The RF PASS shall automatically emit an audible alarm within the time specified in Section 22.3 of evacuation alarm initiation on the base station under the radio channel conditions specified in Section 24.22.

23.18.2 The base station shall automatically emit an audible alarm in response to an alarm signal received from the RF PASS within the time specified in 22.3.2.1 of alarm activation under the radio channel conditions specified in Section 24.22.

Chapter 24 Test Methods (NFPA 1982)

24.1 Sample Preparation.

24.1.1 Application.

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

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

24.1.2 Room Temperature Conditioning Procedure.

24.1.2.1 Samples shall be conditioned at a temperature of 22°C ± 3°C (72°F ± 5°F) and relative humidity (RH) of 50 percent ± 25 percent for at least 4 hours.

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

24.1.3 Cold Temperature Conditioning Procedure.

24.1.3.1 Specimens shall be exposed to a temperature of −20°C +0/−3°C (−4°F +0/−5°F) for at least 4 hours.

24.1.3.2 Testing shall begin within 30 seconds of the specimens being removed from the conditioning.

24.1.4 Elevated Temperature Conditioning Procedure.

24.1.4.1 Specimens shall be exposed to a temperature of 71°C +1/−0°C (160°F +2/−0°F) for at least 4 hours.

24.1.4.2 Testing shall begin within 30 seconds of the specimens being removed from the conditioning.

24.2 Sound Pressure Level Tests.

24.2.1 Application.

24.2.1.1 This test method shall apply to all PASS.

24.2.1.2 Modifications to this test method for testing prealarm signals shall be as specified in 24.2.9.

24.2.1.3 Modifications to this test method for testing alarm signals shall be as specified in 24.2.8.

24.2.1.4 Modifications to this test method for testing low power source warning signals shall be as specified in 24.2.10.

24.2.2 Samples.

24.2.2.1 Samples shall be complete PASS.

24.2.2.2 Samples shall be conditioned as specified in 24.1.2.

24.2.3 Specimens.

24.2.3.1 Specimens for testing shall be complete PASS.

24.2.3.2 A minimum of three specimens shall be tested.

24.2.4 Apparatus.

24.2.4.1 Where the audio test manikin is specified, the test manikin shall be a Central Display, Inc., Model MA32 medium-size manikin or equivalent as shown in Figure 24.2.4.1.

24.2.4.2 The test chamber shall be as specified in ANSI/ASA S1.13, *Measurement of Sound Pressure Levels in Air.*

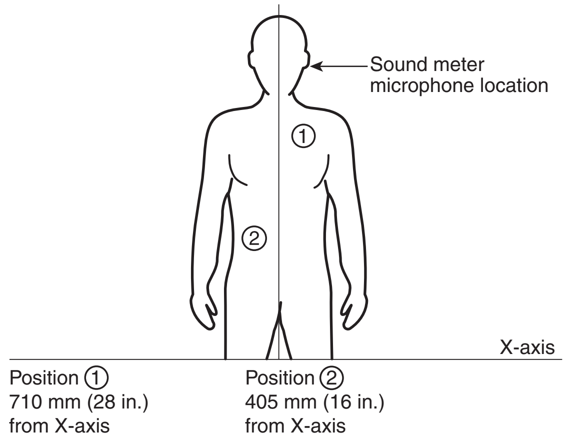


FIGURE 24.2.4.1 Audio Test Manikin.

24.2.4.3 The sound level meter shall meet the requirements of ANSI/ASA S1.4, *Specification for Sound Level Meters*, Type 1.

24.2.5 Procedure.

24.2.5.1 Specimens shall be tested for sound pressure levels of the signals in accordance with ANSI/ASA S1.13, *Measurement of Sound Pressure Levels in Air.*

24.2.5.2 The laboratory measurement defined in ANSI/ASA S1.13, *Measurement of Sound Pressure Levels in Air,* shall be used for these tests.

24.2.5.3 All sound pressure level measurements shall be made with the sound level meter set to A-weighting with a fast response time (LAF). The max-hold function (if available) shall be permitted to be used to hold the maximum value observed by the meter for the specified period of time.

24.2.5.4 All sound pressure levels shall be measured in a spherical radius at a distance of 1 m +2.5 /−0 cm (3.3 ft +1/−0 in.) in from the specimen's annunciator.

24.2.6 Report.

24.2.6.1 The alarm signal sound pressure level after testing as specified in 24.2.8 shall be measured, recorded, and reported.

24.2.6.2 The prealarm signal sound pressure level after testing as specified in 24.2.9 shall be measured, recorded, and reported.

24.2.6.3 The low power source warning signal sound pressure level after testing as specified in 24.2.10 shall be measured, recorded, and reported.

24.2.7 Interpretation.

24.2.7.1 Pass or fail performance shall be determined for each specimen.

24.2.7.2 One or more specimens failing any portion of this test shall constitute failing performance.

24.2.8 Specific Requirements for Testing Alarm Signals.

24.2.8.1 The specimen shall be mounted on the audio test manikin in the preferred mounting position and orientation for optimal performance as specified by the manufacturer.

24.2.8.2 Before starting the test, the specimen's power source shall be discharged to the voltage level or percent capacity remaining value at which the PASS first emits the low power source warning signal specified in 22.4.4.

24.2.8.3 The power source shall be discharged as specified in 22.4.4.2.

24.2.8.4 The sound pressure level for the alarm signal shall be measured at 60 minutes +1/−0 minutes after the start of the test. Five measurements, each for a minimum duration of 6 seconds, shall be taken. The maximum sound pressure value shall be recorded for each measurement. The lowest of the five measurements shall be discarded and the remaining four shall be the sound pressure values.

24.2.8.5 The sound pressure values for the PASS alarm signal shall be recorded, evaluated, and reported to determine pass or fail performance.

24.2.9 Specific Requirements for Testing Prealarm Signals.

24.2.9.1 The specimen shall be mounted on the audio test manikin in the preferred mounting position and orientation for optimal performance as specified by the manufacturer.

24.2.9.2 Before the test is started, the specimen's power source shall be discharged to the voltage level or percent capacity remaining value at which the PASS first emits the low power source warning signal specified in 22.4.4.

24.2.9.3 The power source shall be discharged as specified in 22.4.4.2.

24.2.9.4 The sound pressure level for the prealarm signal shall be measured for the duration of the prealarm.

24.2.9.5 The prealarm signal sound pressure level shall be recorded, evaluated, and reported for the entire duration to determine pass or fail performance.

24.2.10 Specific Requirements for Testing Low Power Source Warning Signal.

24.2.10.1 Specimens shall be mounted on the audio test manikin in the preferred mounting position and orientation for optimal performance as specified by the PASS manufacturer.

24.2.10.2 Before the test is started, the specimen's power source shall be discharged to the voltage level or percent capacity remaining value at which the specimen first emits the low power source warning signal specified in 22.4.4.

24.2.10.3 The power source shall be discharged as specified in 22.4.4.2.

24.2.10.4 The sound pressure level for the low power source warning signal shall be measured at 60 minutes +1/−0 minutes after the start of the test. Five measurements, each for a minimum duration of 6 seconds, shall be taken. The maximum sound pressure value shall be recorded for each measurement. The lowest of the five measurements shall be discarded and the remaining four shall be the sound pressure values.

24.2.10.5 The low power source warning signal sound pressure level shall be recorded, evaluated, and reported for the entire duration to determine pass or fail performance.

24.3 Electronic Temperature Stress Test.

24.3.1 Application. This test method shall apply to all PASS.

24.3.2 Samples.

24.3.2.1 Samples shall be complete PASS.

24.3.2.2 Samples shall be conditioned as specified in 24.1.2.

24.3.3 Specimens.

24.3.3.1 Specimens for testing shall be complete PASS.

24.3.3.2 A minimum of three specimens shall be tested.

24.3.4 Procedure.

24.3.4.1 Each specimen shall be subjected to a series of three temperature stress tests identified as 24.3.5, Test Procedure 1, for elevated temperature, 24.3.6, Test Procedure 2, for low operating temperature, and 24.3.7, Test Procedure 3, for temperature shock.

24.3.4.2 The same three specimens shall be used for all three test series. Each specimen tested shall be complete with power source.

24.3.4.3 The test chamber or cabinet shall be capable of maintaining the required conditions specified in 24.3.5, 24.3.6, and 24.3.7 throughout the envelope of air surrounding the specimen being tested, and these conditions shall be continuously monitored.

24.3.4.4 Following each test procedure, the specimen shall be allowed to stabilize at ambient conditions prior to proceeding to the next test procedure.

24.3.5 Test Procedure 1.

24.3.5.1 Specimens shall be placed in the test apparatus that has been stabilized at 49°C +3/−0°C (120°F +5/−0°F).

24.3.5.2 After 6 hours, the temperature shall be raised within 1 hour to 71°C +3/−0°C (160°F +5/−0°F) and maintained for 4 hours.

24.3.5.3 The temperature shall then be decreased within 1 hour to 49°C +3/−0°C (120°F +5/−0°F).

24.3.5.4 This cycle shall be repeated twice.

24.3.5.5 After the second cycle, the temperature shall be raised to 71°C +3/−0°C (160°F +5/−0°F) for 4 hours.

24.3.5.6 Specimens shall be removed following the specified conditioning, and testing shall begin within 30 seconds of removal from conditioning.

24.3.5.7 Specimens shall be operated according to the manufacturer's instructions to determine the proper functioning as specified in 22.4.2.3 and 22.4.3.2.

24.3.5.8 The alarm signal sound pressure level shall be measured as specified in 23.1.2 to determine pass or fail performance.

24.3.5.9 Specimens shall be operated according to the manufacturer's instructions to determine the functionality of data logging as specified in 22.1.3 and the logs shall be examined for continuous functioning of the specimen to determine pass or fail performance.

24.3.6 Test Procedure 2.

24.3.6.1 Specimens shall be placed in the test apparatus that has been stabilized at −20°C +0/−3°C (−4°F +0/−5°F) and maintained for a minimum of 4 hours.

24.3.6.2 Specimens shall be removed following the specified conditioning, and testing shall begin within 30 seconds of removal from conditioning.

24.3.6.3 Specimens shall be operated according to the manufacturer's instructions to determine the proper functioning as specified in 22.4.2.3 and 22.4.3.2.

24.3.6.4 The alarm signal sound pressure level shall be measured as specified in 23.1.2 to determine pass or fail performance.

24.3.6.5 Specimens shall be operated according to the manufacturer's instructions to determine the functionality of data logging as specified in 22.1.3 and the logs shall be examined for continuous functioning of the specimen to determine pass or fail performance.

24.3.7 Test Procedure 3.

24.3.7.1 Specimens shall be placed in the test apparatus that has been stabilized at −20°C +0/−3°C (−4°F +0/−5°F) cold condition for 4 hours.

24.3.7.2 Specimens shall be removed from the cold condition and shall be placed within 5 minutes into another test apparatus that has been stabilized at 71°C +3/−0°C (160°F +5/−0°F) hot condition for 4 hours.

24.3.7.3 The cold-to-hot cycle shall be repeated twice.

24.3.7.4 Specimens shall be removed following the specified conditioning, and testing shall begin within 30 seconds of removal from conditioning.

24.3.7.5 Specimens shall be operated according to the manufacturer's instructions to determine the proper functioning as specified in 22.4.2.3 and 22.4.3.2.

24.3.7.6 The alarm signal sound pressure level shall be measured as specified in 23.1.2 to determine pass or fail performance.

24.3.7.7 Specimens shall be operated according to the manufacturer's instructions to determine the functionality of data logging as specified in 22.1.3 and the logs shall be examined for continuous functioning of the specimen to determine pass or fail performance.

24.3.8 Report.

24.3.8.1 The specimen alarm signal sound pressure level shall be measured, recorded, and reported.

24.3.8.2 The functioning of the specimens shall be recorded and reported.

24.3.9 Interpretation.

24.3.9.1 Pass or fail performance shall be determined for each specimen.

24.3.9.2 One or more specimens failing this test shall constitute failing performance.

24.4 Corrosion Resistance Test.

24.4.1 Application. This test method shall apply to all PASS.

24.4.2 Samples.

24.4.2.1 Samples shall be complete PASS.

24.4.2.2 Samples shall be conditioned as specified in 24.1.2.

24.4.3 Specimens.

24.4.3.1 Specimens for testing shall be complete PASS.

24.4.3.2 A minimum of three specimens shall be tested.

24.4.4 Procedure.

24.4.4.1 Specimens shall be tested in accordance with ASTM B117, *Standard Practice for Operating Salt Spray (Fog) Apparatus*, the salt spray shall be 5 percent saline solution, and the test exposure shall be for 48 hours +30/−0 minutes.

24.4.4.2 The chamber shall be stabilized at a temperature of 35°C +3/−0°C (95°F +5/−0°F).

24.4.4.3 Specimens shall be placed in the chamber as if worn by a user, in a wearing position specified by the manufacturer.

24.4.4.4 At the conclusion of the salt spray period, the specimen shall be stored in an environment of 22°C ± 3°C (72°F ± 5°F) at 50 percent ± 5 percent RH for a minimum of 48 hours.

24.4.4.5 Following the conditioning period, specimens shall be tested within 30 seconds of removal from conditioning.

24.4.4.6 Specimens shall be operated according to the manufacturer's instructions to determine the proper functioning as specified in 22.4.2.3 and 22.4.3.2.

24.4.4.7 The alarm signal sound pressure level shall be measured as specified in 23.1.2 to determine pass or fail performance.

24.4.4.8 Specimens shall be operated according to the manufacturer's instructions to determine the functionality of data logging as specified in 22.1.3 and the logs shall be examined for continuous functioning of the specimen to determine pass or fail performance.

24.4.5 Report.

24.4.5.1 The specimen alarm signal sound pressure level shall be measured, recorded, and reported.

24.4.5.2 The functioning of the specimens shall be recorded and reported.

24.4.6 Interpretation.

24.4.6.1 Pass or fail performance shall be determined for each specimen.

24.4.6.2 One or more specimens failing this test shall constitute failing performance.

24.5 Heat and Immersion Leakage Test.

24.5.1 Application. This test method shall apply to all PASS.

24.5.2 Samples.

24.5.2.1 Samples shall be complete PASS.

24.5.2.2 Samples shall be conditioned as specified in 24.1.2.

24.5.3 Specimens.

24.5.3.1 Specimens for testing shall be complete PASS.

24.5.3.2 A minimum of three specimens shall be tested.

24.5.4 Apparatus.

24.5.4.1 A test oven having minimum dimensions of 915 mm depth × 915 mm width × 1220 mm height (36 in. depth × 36 in. width × 48 in. height) shall be provided.

24.5.4.1.1 The test oven shall have an airflow rate of 38 m/min to 76 m/min (125 ft/min to 250 ft/min) at the standard temperature and pressure of 21°C (70°F) at 1 atmosphere measured at the center point of the oven.

24.5.4.1.2 A test thermocouple shall be positioned so that it is level with the horizontal centerline of a mounted specimen.

24.5.4.2 A test water container capable of covering the uppermost point of the specimen with a depth of 1.5 m (4.9 ft) of water shall be provided.

24.5.4.2.1 The water container shall maintain the PASS at that depth.

24.5.4.2.2 The water temperature shall be 18°C ± 10°C (64°F ± 18°F).

24.5.5 Test Procedure 1.

24.5.5.1 Specimens shall be placed in the test oven that has been preheated to 177°C +5/−0°C (350°F +10/−0°F). Test exposure time of 15 minutes shall begin.

24.5.5.2 After the test exposure time of 15 minutes, the specimens shall be removed from the oven and within 30 seconds shall be immersed in the test water container for 15 minutes. After 15 minutes, the specimens shall be removed from the test water container and shall be wiped dry.

24.5.5.3 Specimens shall be subject to 24.5.5.1 and 24.5.5.2 for six complete cycles.

24.5.5.4 After the sixth cycle, the power source compartment of the specimens shall be opened and shall be inspected for water leakage to determine pass or fail performance. Where the PASS does not fail this portion of the test, the power source shall be replaced.

24.5.5.5 After the sixth cycle, the specimens shall be operated according to the manufacturer's instructions to determine the proper functioning as specified in Section 22.4, Signal Design Requirements for PASS.

24.5.5.6 After the sixth cycle, the specimens' alarm signal sound pressure level shall be measured as specified in 23.1.2.1 to determine pass or fail performance.

24.5.5.7 Specimens shall be operated according to the manufacturer's instructions to determine the functionality of data logging as specified in 22.1.3 and the logs shall be examined for continuous functioning of the specimen to determine pass or fail performance.

24.5.6 Test Procedure 2.

24.5.6.1 Following test procedure 1, the specimens shall be re-immersed in the test water container for an additional 5 minutes +30/−0 seconds. The power source compartment(s) shall be open, and the power source shall not be installed.

24.5.6.2 After the 5-minute immersion, the specimens shall be removed from the test water container and shall be wiped dry.

24.5.6.3 The electronic compartment(s) of the specimens shall be opened and inspected for water leakage to determine pass or fail performance.

24.5.7 Report.

24.5.7.1 For test procedure 1, the specimen alarm signal sound pressure level shall be measured, recorded, and reported.

24.5.7.2 For test procedure 1, the functioning of the specimens shall be recorded and reported.

24.5.7.3 Following each test procedure, any water leakage shall be reported and recorded.

24.5.8 Interpretation.

24.5.8.1 Pass or fail performance shall be determined for each specimen.

24.5.8.2 One or more specimens failing any portion of this test shall constitute failing performance.

24.6 Case Integrity Test.

24.6.1 Application. This test method shall apply to all PASS.

24.6.2 Samples.

24.6.2.1 Samples shall be complete PASS.

24.6.2.2 Samples shall be conditioned as specified in 24.1.2.

24.6.3 Specimens.

24.6.3.1 Specimens for testing shall be complete PASS.

24.6.3.2 A minimum of three specimens for PASS that meet the criteria specified in 22.1.2.1 shall be tested.

24.6.3.3 A minimum of three specimens shall be tested for each containment case, housing, and enclosure for PASS that meet the criteria specified in 22.1.2.2, 22.1.2.3, or 22.1.2.4.

24.6.4 Procedure.

24.6.4.1 Specimens shall be subjected to a test weight of 200 kg +2/−0 kg (442 lb +4.4/−0 lb).

24.6.4.2 The test weight shall be placed on each surface of the specimen case, housing, or enclosure.

24.6.4.3 The test weight shall be placed so as to avoid impact loading.

24.6.4.4 The test weight shall remain on each surface of the specimen case for 1 minute +15/−0 seconds.

24.6.4.5 After removal of the test weight, each surface of the specimen case, housing, and enclosure shall be examined for damage.

24.6.4.6 Signal testing shall begin within 30 seconds following the final inspection of the case, housing, and enclosure.

24.6.4.7 Specimens shall be operated according to the manufacturer's instructions to determine the proper functioning as specified in 22.4.2.3 and 22.4.3.2.

24.6.4.8 The specimens' alarm signal sound pressure level shall be measured as specified in 23.1.2 to determine pass or fail performance.

24.6.4.9 Specimens shall be operated according to the manufacturer's instructions to determine the functionality of data logging as specified in 22.1.3 and the logs shall be examined for continuous functioning of the specimen to determine pass or fail performance.

24.6.5 Report.

24.6.5.1 The specimen alarm signal sound pressure level shall be measured, recorded, and reported.

24.6.5.2 The functioning of the specimens shall be recorded and reported.

24.6.5.3 Any visible damage to the specimen case shall be recorded and reported.

24.6.6 Interpretation.

24.6.6.1 Pass or fail performance shall be determined for each specimen.

24.6.6.2 One or more specimens failing this test shall constitute failing performance.

24.7 Shock Sensitivity Test.

24.7.1 Application. This test method shall apply to all PASS.

24.7.2 Samples.

24.7.2.1 Samples shall be complete PASS.

24.7.2.2 Samples shall be conditioned as specified in 24.1.2.

24.7.3 Specimens.

24.7.3.1 Specimens for testing shall be complete PASS.

24.7.3.2 A minimum of three specimens shall be tested.

24.7.4 Apparatus.

24.7.4.1 A granite surface place with minimum dimensions of 305 mm width × 305 mm length × 75 mm thickness (12 in. × 12 in. × 3 in.) shall be used as the test surface.

24.7.4.2 A 10 mm (3⁄8 in.) I.D. × 150 mm (6 in.) long tube shall be used as a guide for the ball drop.

24.7.4.3 A stainless steel test ball measuring 8 mm (5⁄16 in.) O.D. shall be used.

24.7.5 Procedure.

24.7.5.1 Specimens shall be subjected to one test series conducted on each test orientation as specified in Figure 24.7.5.1. A single test series shall consist of the test ball being dropped three times.

24.7.5.2 Specimens shall be placed in direct contact on the granite test surface and secured in such a manner to prevent movement of the specimen during the test. The method of securing the specimen shall not interfere with the surface being tested.

24.7.5.3 Specimens shall be placed in the sensing mode. The testing shall be conducted during the sounding of the prealarm signal.

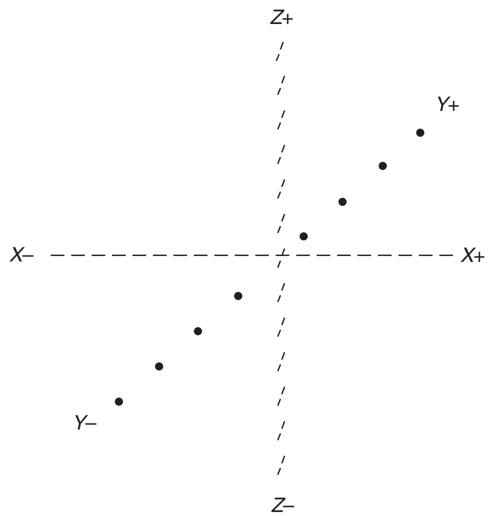


FIGURE 24.7.5.1 Test Orientation.

24.7.5.4 The guide tube shall be positioned in a vertical orientation over the center of the surface of the specimen, with the long axis perpendicular within ±2 degrees. The bottom of the tube shall be within 3 mm (1⁄8 in.) of the surface of the specimen but shall not touch the specimen.

24.7.5.5 The stainless steel test ball shall be held at the top of the tube, then dropped through the tube and allowed to fall on the surface of the specimen.

24.7.5.6 The sounding of the specimen prealarm signal shall be monitored to determine pass or fail performance.

24.7.6 Report.

24.7.6.1 The sounding of the prealarm signal during testing shall be recorded and reported.

24.7.6.2 Any cancellation of the prealarm signal during testing shall be recorded and reported.

24.7.7 Interpretation.

24.7.7.1 Pass or fail performance shall be determined for each specimen.

24.7.7.2 Cancellation of the prealarm signal as a result of the ball drop shall constitute failure.

24.7.7.3 One or more specimens failing any portion of this test shall constitute failing performance.

24.8 Impact Acceleration Resistance Test.

24.8.1 Application.

24.8.1.1 This test method shall apply to stand-alone and removable integrated PASS.

24.8.1.2 This test method shall not apply to nonremovable integrated PASS.

24.8.2 Samples.

24.8.2.1 Samples shall be complete PASS.

24.8.2.2 Samples shall be conditioned as specified in 24.1.2.

24.8.3 Specimens.

24.8.3.1 Specimens for testing shall be complete PASS.

24.8.3.2 A minimum of three specimens shall be tested.

24.8.3.3 Specimens of removable integrated PASS shall have the PASS removed from the integrated attachment so that the PASS alone is tested.

24.8.4 Procedure.

24.8.4.1 Three specimens shall be subjected to a series of impact–acceleration tests.

24.8.4.1.1 One specimen shall be conditioned as specified in 24.1.2.

24.8.4.1.2 One specimen shall be conditioned as specified in 24.1.3.

24.8.4.1.3 One specimen shall be conditioned as specified in 24.1.4.

24.8.4.2 Each specimen tested shall be complete with power supply.

24.8.4.3 After conditioning, specimens shall be switched to the sensing mode. Testing shall begin within 30 seconds of removal from conditioning.

24.8.4.4 For each conditioning, the specimens shall be dropped a total of eight times from a distance of 3 m +0.1/−0 m (118 in. +4/−0 in.) onto a concrete surface so that impact is on each face, on one corner, and one edge of the specimen. The specimens shall not be permitted to bounce a second time.

24.8.4.5 Following each drop, the specimen shall remain motionless and shall sound the prealarm signal and the alarm signal from the sensing mode to evaluate proper functioning as specified in Section 22.3, Motion Sensing Design Requirements for PASS, for determining pass or fail performance, after which the alarm signal shall be stopped and the specimen reset to sensing mode for the next drop.

24.8.4.6 The entire single series of drops shall be completed within 10 minutes of removal from conditioning.

24.8.4.7 Following the entire single series of drops, the specimen's alarm signal testing shall begin within 30 seconds.

24.8.4.8 Specimens shall be operated according to the manufacturer's instructions to determine the proper functioning as specified in 22.4.2.3 and 22.4.3.2.

24.8.4.9 The alarm signal sound pressure level shall be measured as specified in 23.1.2 to determine pass or fail performance.

24.8.4.10 Specimens shall be operated according to the manufacturer's instructions to determine the functionality of data logging as specified in 22.1.3 and the logs shall be examined for continuous functioning of the specimen to determine pass or fail performance.

24.8.5 Report.

24.8.5.1 The specimen alarm signal sound pressure level shall be measured, recorded, and reported.

24.8.5.2 The functioning of the specimens shall be recorded and reported.

24.8.6 Interpretation.

24.8.6.1 Pass or fail performance shall be determined for each specimen.

24.8.6.2 One or more specimens failing this test shall constitute failing performance.

24.9 Vibration Resistance Test.

24.9.1 Application. This test method shall apply to all PASS.

24.9.2 Samples.

24.9.2.1 Samples shall be complete PASS.

24.9.2.2 Samples shall be conditioned as specified in 24.1.2.

24.9.3 Specimens.

24.9.3.1 Specimens for testing shall be complete PASS.

24.9.3.2 A minimum of three specimens shall be tested.

24.9.3.3 Integrated PASS shall be tested with the PASS in the integrated configuration.

24.9.4 Apparatus.

24.9.4.1 Specimens shall be tested on a typical package tester within the compartments specified in 24.9.4.2.

24.9.4.2 Compartments shall be configured as specified in Figure 24.9.4.2(a) and Figure 24.9.4.2(b).

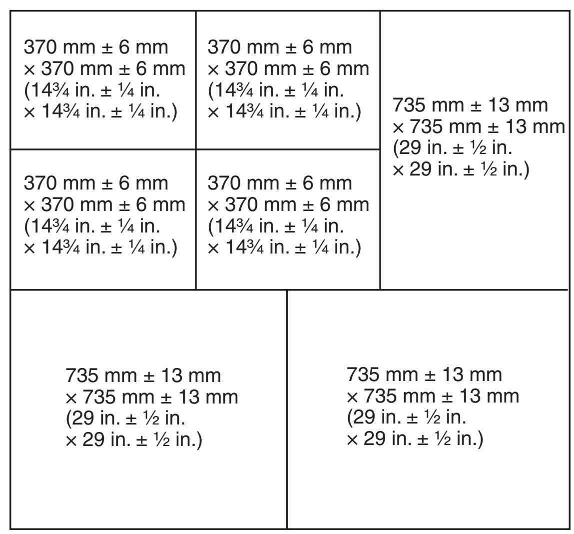


FIGURE 24.9.4.2(a) Vibration Table Compartments: Top View (Not to scale).

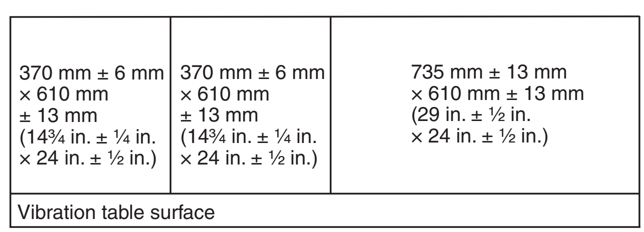


FIGURE 24.9.4.2(b) Vibration Table Compartments: Side View (Not to scale).

24.9.4.3 The sides and the base of the compartments shall be constructed of nominal 6 mm (¼ in.) stainless steel, and the top of the compartments shall remain open.

24.9.4.4 There shall be no burrs, sharp edges, surface discontinuities, or fasteners on the internal surfaces of the holding boxes.

24.9.4.5 The large compartments shall be utilized for integrated PASS.

24.9.4.6 The small compartments shall be utilized for stand-alone PASS.

24.9.5 Procedure.

24.9.5.1 The integrated PASS or the stand-alone PASS shall be placed unrestrained in the compartments specified in 24.9.4.5 or 24.9.4.6 as applicable, and all adjustments, where present, shall be fully extended.

24.9.5.2 No tie-downs shall be allowed to be made to the specimens.

24.9.5.3 The basic movement of the bed of the test table shall be a 25 mm (1 in.) orbital path, such as can be obtained on a standard package tester operating in synchronous mode at 250 rpm ± 5 rpm.

24.9.5.4 The test duration shall be 3 hours +5/−0 minutes.

24.9.5.5 Specimens shall be operated according to the manufacturer's instructions to determine the proper functioning as specified in 22.4.2.3 and 22.4.3.2.

24.9.5.6 The alarm signal sound pressure level shall be measured as specified in 23.1.2 to determine pass or fail performance.

24.9.5.7 Specimens shall be operated according to the manufacturer's instructions to determine the functionality of data logging as specified in 22.1.3 and the logs shall be examined for continuous functioning of the specimen to determine pass or fail performance.

24.9.6 Report.

24.9.6.1 The specimen alarm signal sound pressure level shall be measured, recorded, and reported.

24.9.6.2 The functioning of the specimens shall be recorded and reported.

24.9.7 Interpretation.

24.9.7.1 Pass or fail performance shall be determined for each specimen.

24.9.7.2 One or more specimens failing this test shall constitute failing performance.

24.10 Retention System Test.

24.10.1 Application.

24.10.1.1 This test method shall apply to stand-alone and removable integrated PASS with a retention system.

24.10.1.2 This test method shall not apply to nonremovable integrated PASS.

24.10.2 Samples.

24.10.2.1 Samples shall be complete PASS.

24.10.2.2 Samples shall be conditioned as specified in 24.1.2.

24.10.3 Specimens.

24.10.3.1 Specimens for testing shall be complete PASS.

24.10.3.2 A minimum of three specimens shall be tested.

24.10.4 Procedure.

24.10.4.1* Prior to testing, specimens shall have the retention system attachment method cycled 500 times.

24.10.4.2 Specimens shall be placed in a test stand capable of applying a load to the retention system.

24.10.4.3 A base load of 45 N +3/−0 N (10 lbf +0.7/−0 lbf) shall be applied to the retention system.

24.10.4.4 A force shall then be steadily applied from the base load of 45 N (10 lbf) at a rate between 9 N/sec (2 lbf/sec) and 45 N/sec (10 lbf/sec). The force shall be applied perpendicular to the plane of the specimen as it is intended to be worn, in accordance with the manufacturer's instructions.

24.10.4.5 The force shall be applied until 445 N +9/−0 N (100 lbf +2/−0 lbf) is attained, and then the force shall be released.

24.10.4.6 Specimens shall then be inspected for retention system separation.

24.10.5 Report. Any separation of the retention system shall be recorded and reported.

24.10.6 Interpretation.

24.10.6.1 Pass or fail performance shall be determined for each specimen.

24.10.6.2 One or more specimens failing this test shall constitute failing performance.

24.11 Water Drainage Test.

24.11.1 Application. This test method shall apply to all PASS.

24.11.2 Samples.

24.11.2.1 Samples shall be complete PASS.

24.11.2.2 Samples shall be conditioned as specified in 24.1.2.

24.11.3 Specimens.

24.11.3.1 Specimens for testing shall be complete PASS.

24.11.3.2 A minimum of three specimens shall be tested.

24.11.4 Procedure.

24.11.4.1 Specimens shall be subjected to three water drainage tests.

24.11.4.1.1 The first test shall have the specimens positioned with the annunciator oriented in the position it is intended to be worn, in accordance with the manufacturer's instructions.

24.11.4.1.2 The second test shall have the specimens positioned with the annunciator oriented horizontally and facing up.

24.11.4.1.3 A third test shall have the specimen positioned where the annunciator is oriented in a position that will retain the greatest volume of water.

24.11.4.2 Water shall be introduced into all openings, indentations, and grilles of the specimens until water overflows from each such opening, indentation, and grille.

24.11.4.3 The filling method shall ensure that no air bubbles remain in any of the openings, indentations, and grilles.

24.11.4.4 Specimens shall then be placed in the alarm mode and allowed to sound the alarm signal for at least 65 seconds without the specimen being moved.

24.11.4.5 The alarm signal sound pressure level shall be measured as specified in 23.1.2 for the duration of the test.

24.11.4.6 The alarm signal sound pressure level shall be measured and recorded at the 60 second +5/−0 seconds, mark to determine pass or fail performance.

24.11.5 Report. The specimen alarm signal sound pressure level shall be measured, recorded, and reported.

24.11.6 Interpretation.

24.11.6.1 Pass or fail performance shall be determined for each specimen.

24.11.6.2 One or more specimens failing this test shall constitute failing performance.

24.12 High Temperature Functionality Test.

24.12.1 Application. This test method shall apply to all PASS.

24.12.2 Samples.

24.12.2.1 Samples shall be complete PASS.

24.12.2.2 Samples shall be conditioned as specified in 24.1.2.

24.12.3 Specimens.

24.12.3.1 Specimens for testing shall be complete PASS.

24.12.3.2 A minimum of three specimens shall be tested.

24.12.3.3 Integrated PASS shall be tested with the PASS in the integrated configuration.

24.12.4 Apparatus.

24.12.4.1 The thermal exposure test oven shall be as specified in ISO 17493, *Clothing and equipment for protection against heat — Test method for convective heat resistance using a hot air circulating oven.* The test oven shall be capable of maintaining temperatures up to 260°C +6/−0°C (500°F +10/−0°F) and shall be capable of maintaining the required conditions specified in 24.12.5.1, and these conditions shall be continuously monitored.

24.12.4.2 A test fixture shall be constructed using an aramid belt that is at least 50 mm (2 in.) wide and fastened to mounting posts spaced 305 mm +25/−0 mm (12 in. +1/−0 in.) apart. The test fixture shall be designed to allow the specimens to be attached to the belt by the retention system according to the PASS manufacturer's instructions.

24.12.4.3 An alternative text fixture shall be designed to allow an integrated PASS to be attached in the same configuration as a PASS integrated with SCBA mounting assembly attaches to the PASS.

24.12.4.4 Integrated PASS, other than SCBA integrated PASS, shall be tested in the "as designed" configuration and shall not be altered, separated, or cut apart from what it is integrated with.

24.12.4.5 The test fixtures shall be designed such that with the specimen attached, no portion of the specimen shall touch any oven surface. The test fixtures shall also not degrade the oven recovery time.

24.12.4.6 The sound test chamber shall be as specified in ANSI/ASA S1.13, *Measurement of Sound Pressure Levels in Air.*

24.12.5 Procedure.

24.12.5.1 The thermal exposure test temperature shall be set to 260°C +6/−0°C (500°F +10/−0°F). The oven shall be allowed to stabilize at the test temperature for a minimum of 30 minutes.

24.12.5.2 Specimens shall be attached to a test fixture in the "as worn" position.

24.12.5.3 Specimens shall be set to the sensing mode.

24.12.5.4 The test fixture with the specimen attached shall be placed in the test oven perpendicular to the airflow of the oven.

24.12.5.5 There shall be no obstructions between the specimen and the airflow. The test fixture shall position the specimen equidistant from all interior oven surfaces.

24.12.5.6 The test oven door shall not remain open more than 15 seconds. The air circulation shall be shut off while the door is open and turned on when the door is closed.

24.12.5.7 The total test oven recovery time shall not exceed 60 seconds. The thermocouple reading shall remain at 260°C +5/−0°C (500°F +10/−0°F) for the duration of the test.

24.12.5.8 Specimens, mounted as specified, shall be exposed in the test oven for 5 minutes +15/−0 seconds. The test exposure time shall begin when the test thermocouple recovers to 260°C +5/−0°C (500°F +10/−0°F).

24.12.5.9 Provisions shall be made to prevent the PASS device from going from sensing mode to alarm mode for the duration of the thermal exposure.

24.12.5.10 After the specified thermal exposure period, the specimen shall be removed from the thermal exposure test oven and within 30 seconds placed in the sound test chamber specified in 24.12.4.6.

24.12.5.11 The specimen shall remain motionless and be allowed to cycle from sensing mode to alarm mode. When the PASS cycles into the alarm mode, within 30 seconds the sound pressure value for the alarm signal shall be measured in a spherical radius at a distance of 1 m +2.5/−0 cm (3.3 ft +1/−0 in.) from the specimen's annunciator.

24.12.5.12 Following the sound pressure level measurement, the specimen shall be operated according to the manufacturer's instructions to determine the proper functioning as specified in 22.4.2.3 and 22.4.3.2 to determine pass or fail performance.

24.12.5.13 Specimens shall be operated according to the manufacturer's instructions to determine the functionality of data logging as specified in 22.1.3 and the logs shall be examined for continuous functioning of the specimen to determine pass or fail performance.

24.12.5.14 Specimens shall be examined for melting, dripping, or ignition to determine pass or fail performance.

24.12.6 Report.

24.12.6.1 The alarm signal sound pressure level measured after exposure to high temperature environment shall be recorded and reported.

24.12.6.2 The functioning of the specimens shall be recorded and reported.

24.12.7 Interpretation.

24.12.7.1 Pass or fail performance shall be determined for each specimen.

24.12.7.2 Failing performance of one or more specimens shall constitute failing performance for this test.

24.13 Heat and Flame Test.

24.13.1 Application. This test method shall apply to all PASS.

24.13.2 Samples.

24.13.2.1 Samples shall be complete PASS.

24.13.2.2 Samples shall be conditioned as specified in 24.1.2.

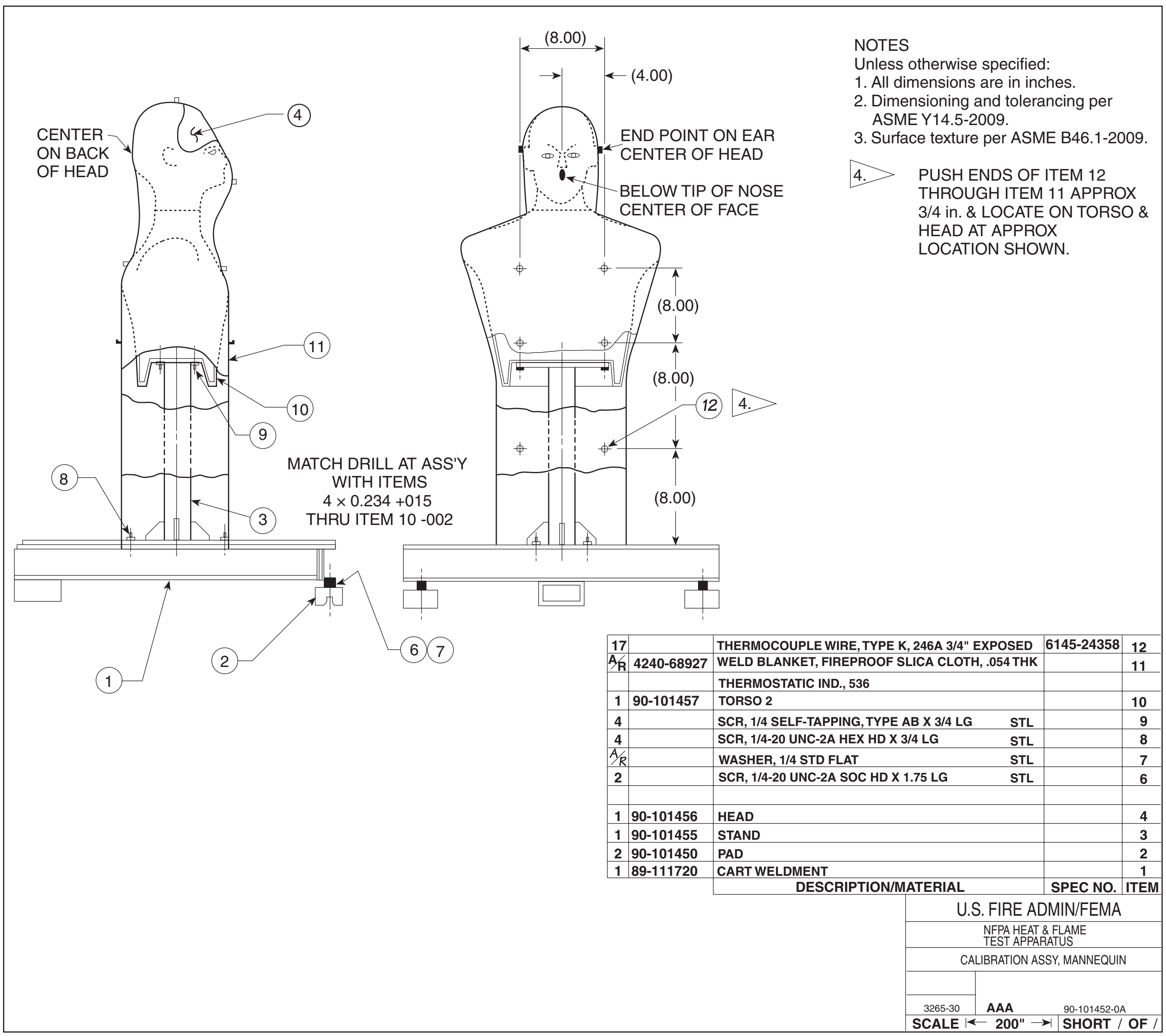
24.13.3 Specimens.

24.13.3.1 Specimens for testing shall be complete PASS.

24.13.3.2 A minimum of three specimens shall be tested.

24.13.4 Apparatus.

24.13.4.1 A calibration manikin meeting the requirements specified in Figure 24.13.4.1 shall be provided.



		DESCRIPTION/MATERIAL	SPEC NO.	ITEM
17		THERMOCOUPLE WIRE, TYPE K, 246A 3/4" EXPOSED	6145-24358	12
A/R	4240-68927	WELD BLANKET, FIREPROOF SLICA CLOTH, .054 THK		11
		THERMOSTATIC IND., 536		
1	90-101457	TORSO 2		10
4		SCR, 1/4 SELF-TAPPING, TYPE AB X 3/4 LG STL		9
4		SCR, 1/4-20 UNC-2A HEX HD X 3/4 LG STL		8
A/R		WASHER, 1/4 STD FLAT STL		7
2		SCR, 1/4-20 UNC-2A SOC HD X 1.75 LG STL		6
1	90-101456	HEAD		4
1	90-101455	STAND		3
2	90-101450	PAD		2
1	89-111720	CART WELDMENT		1

FIGURE 24.13.4.1 Calibration Manikin.

24.13.4.2 A heat and flame test manikin meeting the requirements specified in Figure 24.13.4.2 shall be provided.

24.13.4.3* Both the calibration manikin specified in 24.13.4.1 and the heat and flame test manikin specified in 24.13.4.2 shall have a protective covering.

24.13.4.3.1 The protective covering shall be a weld blanket made of fireproof silica cloth of a minimum weight of 18 oz/sq yd.

24.13.4.3.2 The protective covering shall be designed and constructed to provide coverage over the surface of the manikin.

24.13.4.3.3 Where additional insulation is needed to protect the manikin electronics, an additional thermal liner underlayer shall be permitted.

24.13.4.4 The complete protective covering shall be discarded and shall not be used where the damage to any portion indicates the covering can no longer provide thermal protection for the test manikin.

24.13.4.5 The test headform shall be covered with an undyed aramid hood for protection of the headform during testing. The protective hood shall meet the structural firefighting protective hood requirements specified in Chapters 4 through 9 of this standard.

24.13.4.6 The heat and flame test apparatus shall be as specified in Figure 24.13.4.6(a) and Figure 24.13.4.6(b).

24.13.4.7 The test oven shall be a horizontal forced circulating air oven with an internal velocity of 61 m/min, ±15 m/min (200 linear ft/min, ±49 linear ft/min). The test oven shall have minimum dimensions of 915 mm depth × 915 mm width × 1220 mm height (36 in. depth × 36 in. width × 48 in. height).

24.13.5 Procedure.

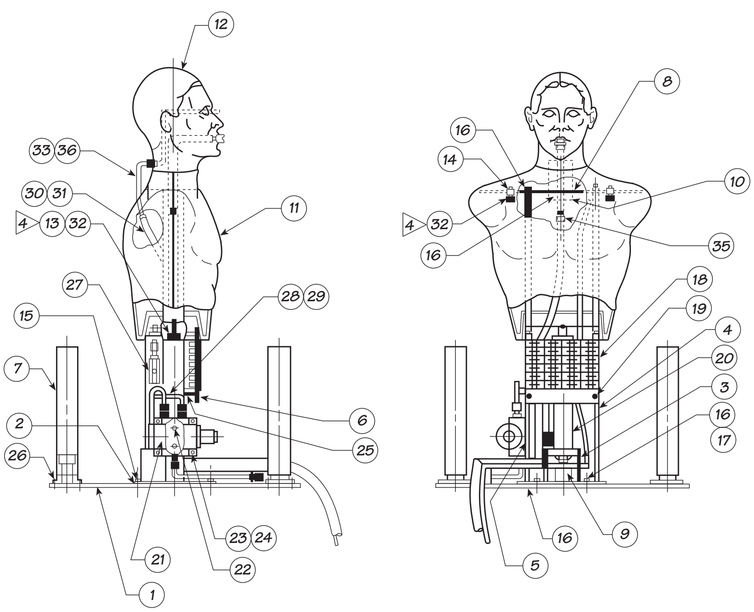
24.13.5.1 For calibration prior to the heat and flame test, the calibration manikin specified in Figure 24.13.4.1 shall be exposed to direct flame contact for 10 seconds using the heat and flame test apparatus.

24.13.5.1.1 All peak temperature readings shall be within a temperature range of 815°C to 1150°C (1500°F to 2102°F).

24.13.5.1.2 The average mean of all peak temperature readings shall be no higher than 950°C (1742°F).

24.13.5.2 The test oven recovery time, after the door is closed, shall not exceed 1 minute.

24.13.5.3 Specimens shall be attached to the front or rear of the test manikin by the retention system, in accordance with the manufacturer's instructions, by means of a loop, belt, SCBA strap, or other means, on the outside or over the manikin protective clothing.

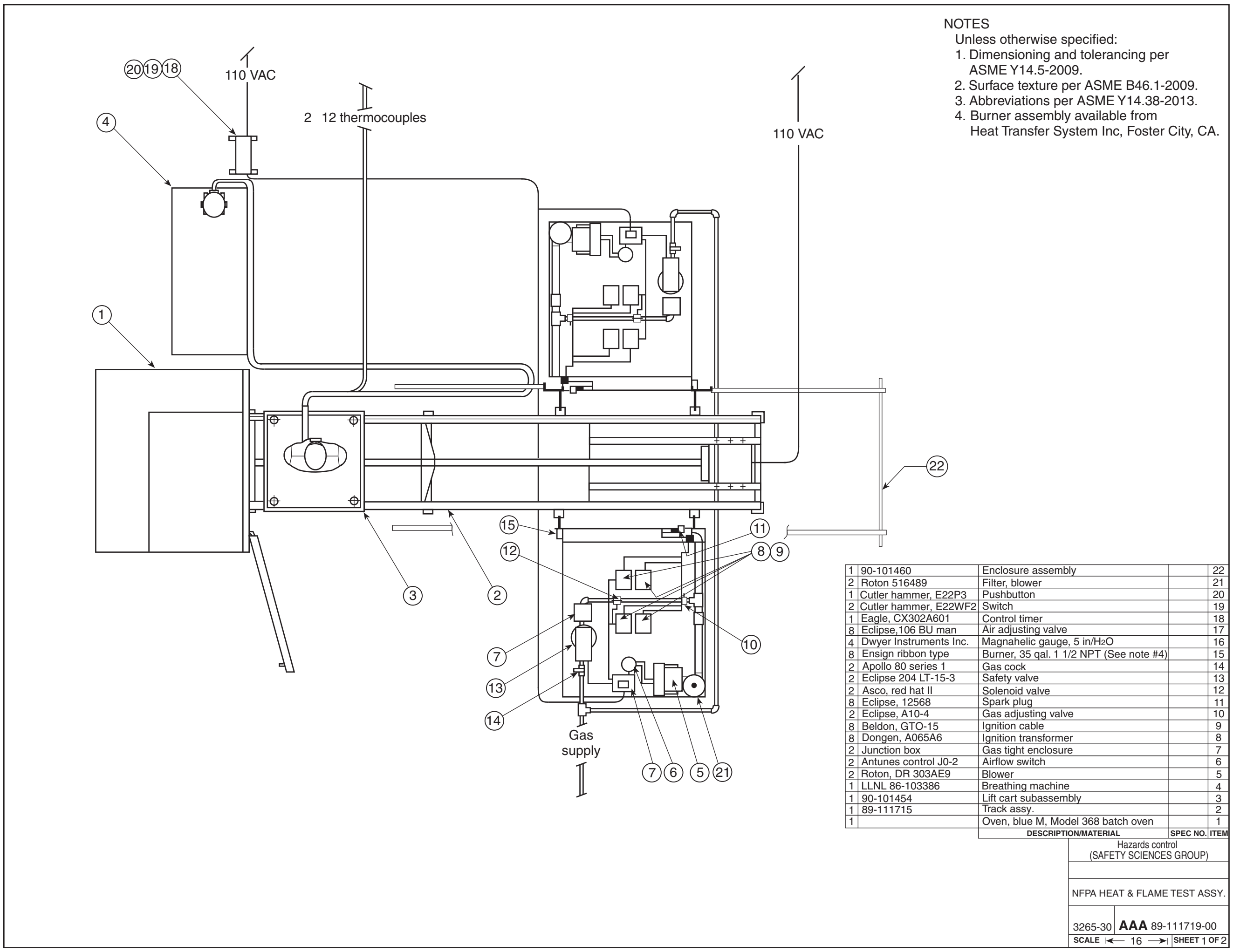


NOTES
Unless otherwise specified:
1. All dimensions are in inches.
2. Dimensioning and tolerancing per ASME Y14.5-2009.
3. Surface texture per ASME B46.1-2009.
4 $4 \times 0.197\ ^{+.010}_{-.002}$ THRU ITEM II, MATCH DRILL FROM ITEMS 13 & 14 FOR ITEM 32.

		DESCRIPTION/MATERIAL		SPEC NO.	ITEM
A/R		TUBE, S/STL, 1/4 O.D.			36
1		CLAMP, AEROSEAL, O 1/2			35
1	SWAGELOK-400-6	UNION, 1/4 TUBE	CRES		33
12		SCR, #8-32 UNC-2A RD HD X 3/8 LG	CRES		32
1		CLAMP, AEROSEAL, O 1/2	CRES		31
A/R		TUBE, PVC REINFORCED 1/4 I.D.		9330-51405	30
5	SWAGELOK-600-1-2	MALE CONNECTOR, 3/8 TUBE X 1/8 NPT	CRES		29
A/R		TUBE, 0.375 X .035 W.	CRES	4710-14193	28
1	ARO CORP	SNUBBER			27
12		SCR, 1/4-20 UNC-2A SOC HD X 1.00 LG	STL		26
4		STANDOFF, #6-32 THD, X 1.00 LG	ALUM	5975-53447	25
4		NUT, HEX, #10-32 UNF-28 STD	STL		24
4		SCR, #10-32 UNF-2A SOC HD X 1.50 LG	STL		23
4		SCR, #10-32 UNF-2A FLT HD X 1.00 LG	STL		22
1	ARO CORP MODEL K21355120A	VALVE			21
1	ARO CORP 0418-1003-080	CYLINDER , AIR, 1 1/8 BORE			20
4		SCR, #6-32 UNC-2A RD HD X 1 1/2 LG	STL		19
4	MARLIN CORP. 1032-6	CONNECTOR, T.C., 6 JACK, 2 HOLE, TYPE K		5935-58196	18
		NUT, HEX, 1/4-20 UNC-2B STD	STL		17
12		SCR, 1/4-20 UNC-2A FLT HD X .75 LG	STL		16
4		SCR, 1/4-20 UNC-2A SOC HD X .50 LG	STL		15
4	90-101459	BRACKET			14
2	90-101473 A	TIE STRAP			13
1	90-101456	HEAD			12
1	90-10146 OR 90-101458	TORSO I OR TORSO II			11
1	89-113884	COLLAR-MOUNT			10
1	89-113883	SHAFT END			9
1	89-111724	MOUNT PLATE, MANNEQUIN			8
4	89-113882	GUIDE VERTICAL			7
1	89-113881	T.C. PANEL			6
1	89-113880	VALVE PLATE			5
2	89-113878	FRAME BAR			4
1	89-113877	MOUNT-AIR CYL.			3
1	89-113876	BASE MOUNT			2
1	89-113879	LIFT PLATE			1

MAJOR UNIT HAZARD CONTROL (SAFETY SCIENCE GROUP)
SUBASSY. NFPA HEAT & FLAME TEST APPARATUS
DETAIL MANNEQUIN ASSY
SHOWN ON AAA 3265-30
DRAWING NO AAA 90-101453-0A
SCALE ← 8.00 → SHEET OF

FIGURE 24.13.4.2 Heat and Flame Test Manikin.



1	90-101460	Enclosure assembly		22
2	Roton 516489	Filter, blower		21
1	Cutler hammer, E22P3	Pushbutton		20
2	Cutler hammer, E22WF2	Switch		19
1	Eagle, CX302A601	Control timer		18
8	Eclipse,106 BU man	Air adjusting valve		17
4	Dwyer Instruments Inc.	Magnahelic gauge, 5 in/H_2O		16
8	Ensign ribbon type	Burner, 35 qal. 1 1/2 NPT (See note #4)		15
2	Apollo 80 series 1	Gas cock		14
2	Eclipse 204 LT-15-3	Safety valve		13
2	Asco, red hat II	Solenoid valve		12
8	Eclipse, 12568	Spark plug		11
2	Eclipse, A10-4	Gas adjusting valve		10
8	Beldon, GTO-15	Ignition cable		9
8	Dongen, A065A6	Ignition transformer		8
2	Junction box	Gas tight enclosure		7
2	Antunes control J0-2	Airflow switch		6
2	Roton, DR 303AE9	Blower		5
1	LLNL 86-103386	Breathing machine		4
1	90-101454	Lift cart subassembly		3
1	89-111715	Track assy.		2
1		Oven, blue M, Model 368 batch oven		1
		DESCRIPTION/MATERIAL	SPEC NO.	ITEM

FIGURE 24.13.4.6(a) Heat and Flame Test Apparatus: Top View.

24.13.5.3.1 Specimens shall be attached to the manikin in accordance with the PASS manufacturer's instructions.

24.13.5.3.2 For integrated PASS, the specimens shall be mounted on the test manikin in accordance with the PASS manufacturer's instructions to simulate the correct wearing position.

24.13.5.4 Specimens shall be subjected to three different series of the heat and flame test identified in this section as test procedure 1, test procedure 2, and test procedure 3. Different specimens shall be used for each of the three test series.

24.13.5.5 For all three test procedures, specimens mounted on the test manikin shall first be placed in the test oven, which has been preheated to 95°C ± 2°C (203°F ± 4°F) for 15 minutes +15/−0 seconds. The test exposure time of 15 minutes shall begin after the door is closed and the oven temperature recovers to 95°C (203°F).

24.13.5.6 At the completion of the 15-minute +15/−0 seconds exposure, the oven door shall be opened and the specimens, mounted on the test manikin, shall be moved out of the oven and into the center of the burner array.

24.13.5.7 The specimens shall then be exposed to direct flame contact for 10 seconds +0.25 /−0 seconds. This exposure shall begin within 20 seconds of removal of the specimen from the test oven.

24.13.5.8 For test procedure 1, the specimen mode selection device shall be set in the alarm mode and then exposed to the flame and drop sequences. Specimens shall be observed for the sounding of the alarm signal to determine pass or fail performance as specified in 23.11.1(1).

24.13.5.9 For test procedure 2, the specimen mode selection device shall be set in the sensing mode and then exposed to the flame and drop sequences. Specimens shall be observed for the sounding of the operational signal to determine pass or fail performance as specified in 23.11.1(1).

24.13.5.10 For test procedure 3, the specimen mode selection device shall be set in the sensing mode and then exposed to the flame and drop sequences. Specimens shall be observed for the sounding of the operational signal to determine pass or fail performance as specified in 23.11.3(1).

24.13.5.11 After the mode selection device has been set to the applicable setting for test procedure 1, test procedure 2, or test

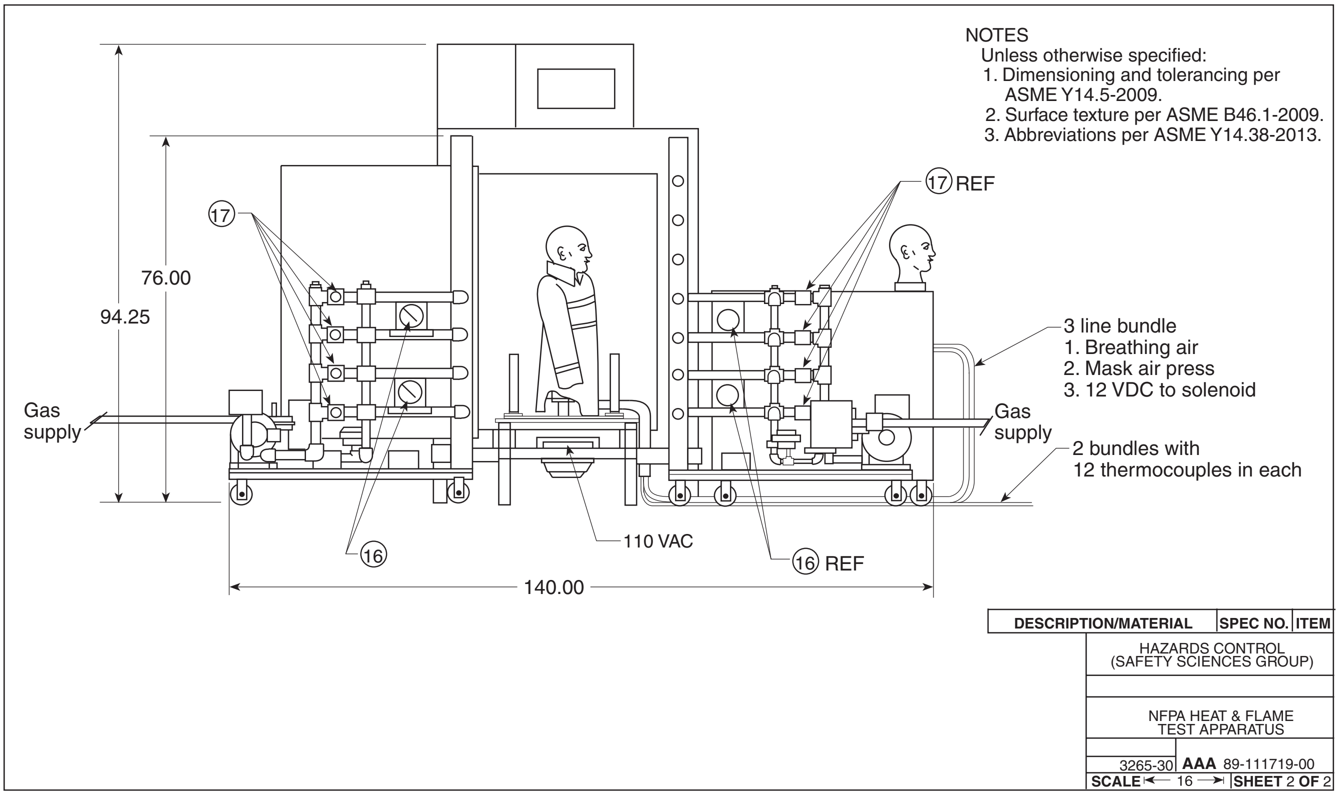


FIGURE 24.13.4.6(b) Heat and Flame Test Apparatus: Side View.

procedure 3, as indicated in 24.13.5.8, 24.13.5.9, or 24.13.5.10, respectively, the specimens in all three test procedures shall then be exposed to direct flame contact for 10 seconds +0.25 / −0 seconds. The exposure shall begin within 20 seconds of removal of the specimens from the test oven.

24.13.5.12 For all three test procedures, specimens shall be observed for any afterflame, and the afterflame duration shall be recorded to determine pass or fail performance as specified in 23.11.1, 23.11.2, and 23.11.3.

24.13.5.13 For test procedure 1, specimens shall be observed for the continued sounding of the alarm signal to determine pass or fail performance as specified in 23.11.1(1).

24.13.5.14 For all three test procedures, within 20 seconds of completion of the direct flame exposure, specimens mounted on the test manikin shall be raised 150 mm +6/−0 mm (6 in. +0.25/−0 in.) and dropped freely.

24.13.5.15 For all three test procedures, specimens shall be observed to determine pass or fail performance and that nothing has fallen off the PASS and that the PASS has not fallen from its mounted position.

24.13.5.16 Specimens shall be operated according to the manufacturer's instructions to determine the proper functioning for data logging as specified in 22.1.3 to determine pass or fail performance as specified in 23.11.1(4), 23.11.2(9), and 23.11.3(7).

24.13.5.17 For test procedure 1, following the drop sequence, specimens shall be observed for the continued sounding of the alarm signal to determine pass or fail performance as specified in 23.11.1(1).

24.13.5.17.1 The specimen mode selection device then shall be set to off.

24.13.5.17.2 Specimens shall be observed for the proper functioning of the mode selection device to determine pass or fail performance as specified in 23.11.1(3).

24.13.5.18 For test procedure 2, following the flame and drop sequences, specimens shall remain motionless and allowed to cycle to the prealarm signal and then to the alarm signal.

24.13.5.18.1 Following the sounding of the alarm signal, the mode selection device shall be set to off.

24.13.5.18.2 Specimens shall be observed for the proper cycling to determine pass or fail performance as specified in 23.11.2(2) and 23.11.2(4).

24.13.5.18.3 Specimens shall be observed for the activation and operation of the primary prealarm signal and the alarm signal to determine pass or fail performance as specified in 23.11.2(3) and 23.11.2(8).

24.13.5.18.4 Supplementary prealarm signal(s), where provided, shall be evaluated for proper operation.

24.13.5.18.5 Specimens shall be observed for the proper functioning of the mode selection device to determine pass or fail performance as specified in 23.11.2(6).

24.13.5.19 For test procedure 3, following the flame and drop sequences, the specimen mode selection device shall be set to alarm.

24.13.5.19.1 Where specimens begin to operate the prealarm signal(s) prior to being set to alarm, the specimen shall be jarred to cancel the prealarm signal(s) before setting to alarm.

24.13.5.19.2 Following the sounding of the alarm signal, the mode selection device shall be set to off.

24.13.5.19.3 Specimens shall be observed for the proper functioning of the mode selection device while switching to alarm to determine pass or fail performance as specified in 23.11.3(2).

24.13.5.19.4 Specimens shall be observed for the sounding of the alarm signal to determine pass or fail performance as specified in 23.11.3(3).

24.13.5.19.5 Specimens shall be observed to determine the proper functioning of the mode selection device while switching to off to determine pass or fail performance as specified in 23.11.3(4).

24.13.5.20 For all three test procedures, specimens shall be operated according to the manufacturer's instructions to determine the proper functioning as specified in 22.4.2.3 and 22.4.3.2.

24.13.5.21 The alarm signal sound pressure level shall be measured as specified in 23.1.2.1 to determine pass or fail performance.

24.13.6 Report.

24.13.6.1 Observations of any afterflame shall be recorded and reported for each specimen.

24.13.6.2 Observations of the functioning of the mode selection while the specimen is being activated shall be evaluated, recorded, and reported for each specimen.

24.13.6.3 Observations of the sounding of the operational signal shall be evaluated, recorded, and reported for each specimen.

24.13.6.4 Observations of the functioning of the mode selection device while being switched to the sensing mode shall be evaluated, recorded, and reported for each specimen.

24.13.6.5 Observations of the activation and sounding of the primary prealarm signal shall be evaluated, recorded, and reported for each specimen.

24.13.6.6 Observations of the activation and sounding of any supplementary prealarm signal(s), where provided, shall be evaluated, recorded, and reported for each specimen.

24.13.6.7 Observations of the functioning of the mode selection device while switching to alarm shall be evaluated, recorded, and reported for each specimen.

24.13.6.8 Observations of the sounding of the alarm signal and the continued sounding of the alarm signal shall be evaluated, recorded, and reported for each specimen.

24.13.6.9 Observations of the functioning of the mode selection device while switching to off shall be evaluated, recorded, and reported for each specimen.

24.13.6.10 Specimens shall be observed to determine the functionality of data logging as specified in 22.1.3, and the logs shall be examined for continuous functioning of the specimen to determine pass or fail performance.

24.13.6.11 The specimen alarm signal sound pressure level shall be measured, recorded, and reported.

24.13.7 Interpretation.

24.13.7.1 Pass or fail performance shall be determined for each specimen.

24.13.7.2 One or more specimens failing this test or a portion of this test shall constitute failing performance.

24.14 Prealarm and Alarm Signal Frequency Test.

24.14.1 Application. This test shall apply to the prealarm and alarm signals of all PASS.

24.14.2 Samples.

24.14.2.1 Samples shall be complete PASS with suitable modifications to provide access to the digital pulse wave that controls the driver circuit for the audible annunciator.

24.14.2.2 Samples shall be conditioned as specified in 24.1.2.

24.14.3 Specimens.

24.14.3.1 Specimens for testing shall be complete PASS.

24.14.3.2 A minimum of three specimens shall be tested.

24.14.4 Apparatus. A sampling digital oscilloscope or time-interval counter connected to the digital pulse wave shall be used to measure the frequencies of the prealarm and alarm signals. The sampling digital oscilloscope or time-interval counter shall have a minimum time resolution of 50 nanoseconds.

24.14.5 Procedure. The prealarm and alarm signals shall be activated, and the signal frequencies shall be measured. Frequency measurements shall be based on the period of individual cycles of the digital pulse wave.

24.14.6 Report.

24.14.6.1 The prealarm and alarm signal frequencies shall be recorded and reported.

24.14.6.2 The prealarm and alarm signals shall be recorded at a minimum time resolution of 50 nanoseconds, verified that it meets the requirements of 22.4.2.8 and 22.4.3.7, and reported.

24.14.7 Interpretation.

24.14.7.1 Pass or fail performance shall be determined for each specimen for the prealarm and alarm signals.

24.14.7.2 One or more specimens failing this test shall constitute failing performance.

24.15 Product Label Durability Test.

24.15.1 Application. This test method shall apply to all PASS product labels.

24.15.2 Samples.

24.15.2.1 Samples shall be complete PASS with all product labels attached.

24.15.2.2 Samples shall be conditioned as specified in 24.1.2.

24.15.3 Specimens.

24.15.3.1 Specimens for testing shall be complete PASS with all product labels attached.

24.15.3.2 A minimum of three specimens shall be tested.

24.15.3.3 At least three specimens shall be subjected to all three test procedures.

24.15.4 Apparatus.

24.15.4.1 A test chamber or cabinet shall be provided and shall be capable of maintaining the required conditions specified in 24.15.5, 24.15.6, and 24.15.7 throughout the envelope of air surrounding the specimen being tested.

24.15.4.2 The conditions in the chamber or cabinet shall be continuously monitored.

24.15.5 Test Procedure 1.

24.15.5.1 Specimens shall be subjected to the elevated temperature environmental conditioning specified in 24.3.5.1 through 24.3.5.5, excluding 24.3.5.6 through 24.3.5.9.

24.15.5.2 Specimens shall be removed following the specified conditioning, and evaluation shall begin within 30 seconds of removal from conditioning.

24.15.5.3 The product labels shall be permitted to be wiped clean with an untreated cloth prior to being examined.

24.15.5.4 Specimen product labels shall be examined at a distance of 305 mm +25/−0 mm (12 in. +1/−0 in.) by the unaided eye with 20/20 vision or with vision corrected to 20/20.

24.15.6 Test Procedure 2.

24.15.6.1 Specimens shall be subjected to the low-temperature environmental conditioning specified in 24.3.6.1, excluding 24.3.6.2 through 24.3.6.5.

24.15.6.2 Specimens shall be removed following the specified conditioning, and evaluation shall begin within 30 seconds of removal from conditioning.

24.15.6.3 The product labels shall be permitted to be wiped clean with an untreated cloth prior to being examined.

24.15.6.4 Specimen product labels shall be examined at a distance of 305 mm +25/−0 mm (12 in. +1/−0 in.) by the unaided eye with 20/20 vision or with vision corrected to 20/20.

24.15.7 Test Procedure 3.

24.15.7.1 Specimens shall be subjected to the temperature shock environmental conditioning specified in 24.3.7.1 through 24.3.7.4 and excluding 24.3.7.5 through 24.3.7.7.

24.15.7.2 Specimens shall be removed following the specified conditioning, and evaluation shall begin within 30 seconds of removal from conditioning.

24.15.7.3 The product labels shall be permitted to be wiped clean with an untreated cloth prior to being examined.

24.15.7.4 Specimen product labels shall be examined at a distance of 305 mm +25/−0 mm (12 in. +1/−0 in.) by the unaided eye with 20/20 vision or with vision corrected to 20/20.

24.15.8 Report. The legibility of each specimen product label shall be recorded and reported.

24.15.9 Interpretation.

24.15.9.1 Pass or fail performance shall be determined for each specimen.

24.15.9.2 Any one specimen failing the test shall constitute failing performance.

24.16 Tumble–Vibration Test.

24.16.1 Application. This test method shall apply to all PASS.

24.16.2 Samples.

24.16.2.1 Samples shall be complete PASS.

24.16.2.2 Samples shall be conditioned as specified in 24.1.2.

24.16.2.3 Integrated PASS, other than SCBA integrated PASS, shall be tested in the “as designed” configuration and shall not be altered, separated, or cut apart from what it is integrated with.

24.16.3 Specimens.

24.16.3.1 Specimens for testing shall be complete PASS.

24.16.3.2 A minimum of three specimens shall be tested.

24.16.4 Apparatus. The tumble test apparatus shall be as specified in Figure 24.16.4.

24.16.5 Procedure.

24.16.5.1 The test specimens shall be placed unrestrained in the tumbling apparatus. Only one specimen shall be tested at a time.

24.16.5.2 The tumbling apparatus shall be run at a speed of 15 rpm ± 1 rpm.

24.16.5.3 The test shall be run for a duration of 3 hours +5/−0 minutes.

24.16.5.4 Specimens shall be operated according to the manufacturer’s instruction to determine the proper functioning as specified in 23.1.3 to determine pass or fail performance.

24.16.5.5 Upon completion of the test duration, specimens shall be operated according to the manufacturer’s instructions to determine the functionality for data logging as specified in 22.1.3 and the logs shall be examined for continuous functioning of the specimen to determine pass or fail performance.

24.16.5.6 The alarm signal sound pressure level shall be measured as specified in 23.1.3 to determine pass or fail performance.

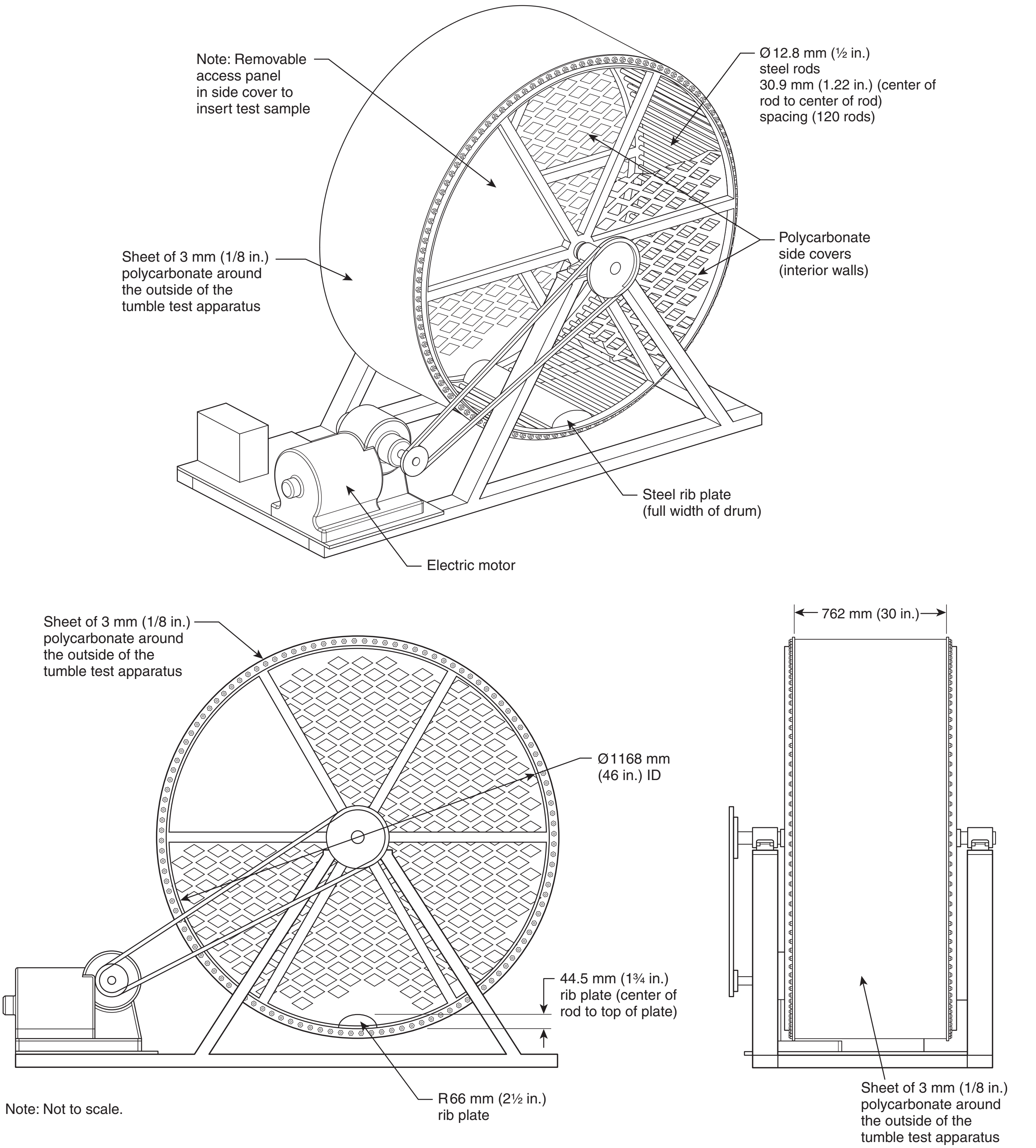


FIGURE 24.16.4 Tumble Test Apparatus.

24.16.6 Report.

24.16.6.1 The specimen alarm signal sound pressure level shall be measured, recorded, and reported.

24.16.6.2 The functioning of the specimens shall be recorded and reported.

24.16.7 Interpretation.

24.16.7.1 Pass or fail performance shall be determined for each specimen.

24.16.7.2 Any one specimen failing the test shall constitute failing performance.

24.17 PASS Alarm Signal Muffle Test.

24.17.1 Application. This test method shall apply to all PASS.

24.17.2 Samples.

24.17.2.1 Samples for testing shall be complete PASS.

24.17.2.2 Samples shall be conditioned as specified in 24.1.2.

24.17.3 Specimens.

24.17.3.1 Specimens for testing shall be complete PASS.

24.17.3.2 At least three specimens shall be tested.

24.17.4 Apparatus.

24.17.4.1 The test chamber shall be as specified in ANSI/ASA S1.13, *Measurement of Sound Pressure Levels in Air.*

24.17.4.2 Testing shall be conducted in a test chamber that absorbs a minimum of 90 percent of all sound from 500 Hz to 5000 Hz.

24.17.4.3 Test subjects shall wear a structural firefighting protective ensemble that includes the coat, trousers, helmet, hood, gloves, and footwear that are certified as compliant with Chapters 4 through 9 of this standard.

24.17.4.4 Test subjects shall also wear an SCBA that is certified as compliant with Chapters 15 through 19 of this standard.

24.17.5 Procedure.

24.17.5.1 Specimens shall be tested at an ambient temperature of 22°C ± 3°C (72°F ± 5°F) and RH of 50 percent ± 25 percent.

24.17.5.2 Specimens shall be tested for sound pressure levels of the primary alarm signals in accordance with ANSI/ASA S1.13, *Measurement of Sound Pressure Levels in Air.*

24.17.5.3 All sound pressure level measurements shall be made with the sound level meter set to A-weighting with a fast response time (LAF). The maximum-hold function (if available) shall be permitted to be used to hold the maximum value observed by the meter for the specified period of time. The test subject shall don the following:

(1) The protective ensemble specified in 24.17.4.3
(2) The specimen PASS per the manufacturers' instructions

24.17.5.4 The test subject shall assume each of the following five testing positions, shall place the specimen PASS into the alarm mode, and shall remain in each position, unmoving, until the sound pressure levels have been measured and recorded:

(1) Face down with arms fully extended out to the sides
(2) Supine left as far as possible, arms down along sides
(3) Supine right as far as possible, arms down along sides
(4) Fetal, knees drawn to chest as far as possible, arms around legs, and lying on right side
(5) Fetal, knees drawn to chest as far as possible, arms around legs, and lying on left side

24.17.5.5 The sound pressure value for the alarm signal shall be measured in a spherical radius at a distance of 1 m +2.5/−0 cm (3.3 ft +1/−0 in.) from the specimen's annunciator.

24.17.6 Report. The alarm signal sound pressure levels shall be measured, recorded, and reported.

24.17.7 Interpretation.

24.17.7.1 Pass or fail performance shall be determined for each specimen.

24.17.7.2 One or more specimens failing any portion of this test shall constitute failing performance.

24.18 Radio System Tests for RF PASS — Point-to-Point RF Attenuation Test.

24.18.1 Application. This test method shall apply to all RF PASS systems.

24.18.1.1 The RF PASS shall be tested in conjunction with the model of base station with which it is intended to be deployed. If a portable computer is utilized in the base station, radio system tests shall be conducted using the manufacturer's supplied portable computer. The portable computer, if used, shall be placed into the test chamber with the base station.

24.18.1.2 The base station, base station computer, and any other electronic equipment associated with the RF PASS system shall operate on battery power for the duration of the RF system tests.

24.18.2 Samples.

24.18.2.1 Samples shall be complete RF PASS systems.

24.18.2.2 Samples shall be conditioned as specified in 24.1.2.

24.18.3 Specimens

24.18.3.1 Specimens for testing shall be complete RF PASS consisting of an RF PASS and the base station designed for use with it, provided by the manufacturer.

24.18.3.2 A single RF PASS and a single base station shall be used in each test. Three different sets of units (portable + base station) shall be tested.

24.18.3.3 All point-to-point RF attenuation tests shall be conducted using specimens 19–21 in Table 20.3.2(a) if the specimens are stand-alone or removable integrated PASS and specimens 16–18 in Table 20.3.2(b) if the specimens are nonremovable integrated PASS.

24.18.4 Test Apparatus

24.18.4.1* The point-to-point RF attenuation test shall be conducted as shown in Figure 24.18.4.1 in the following two configurations:

(1) With the base station acting as the receiver and the RF PASS transmitting an alarm signal
(2) With the RF PASS acting as a receiver and the base station transmitting an evacuation alarm

24.18.4.2 For both configurations, the total attenuation (including cables, connectors, free-space path loss, antenna loss, and external added attenuation) between the base station and the RF PASS shall correspond to 100 dB ± 3 dB. The total attenuation shall be calculated using the methods described in 24.18.5.2.

24.18.4.3 The point-to-point RF attenuation test shall be conducted with no added radio interference.

24.18.4.4 Anechoic Chambers.

24.18.4.4.1* Overall usable interior height of an anechoic chamber shall be no less than 40 in. (102 cm) between the antenna and tabletop or 55 in. These specifications shall not preclude the use of a larger anechoic chamber, including one large enough to contain operation personnel if the RF isolation conditions in 24.18.4.4.2 and field uniformity conditions in 24.18.5.2.1 are satisfied.

24.18.4.4.2 Each chamber shall provide at least 100 dB shielding from the test platform tabletop to the outside of the chamber at the frequency of operation of the RF PASS, with the bulkhead ports specified in 24.18.4.4.8 in place. This will RF isolate the device and base station from each other.

24.18.4.4.3 The chambers shall provide RF attenuation of a minimum of 25 dB normal incidence, at the frequency of operation of the RF PASS, provided by RF absorbing material. Performance specifications provided by the manufacturer shall satisfy this requirement.

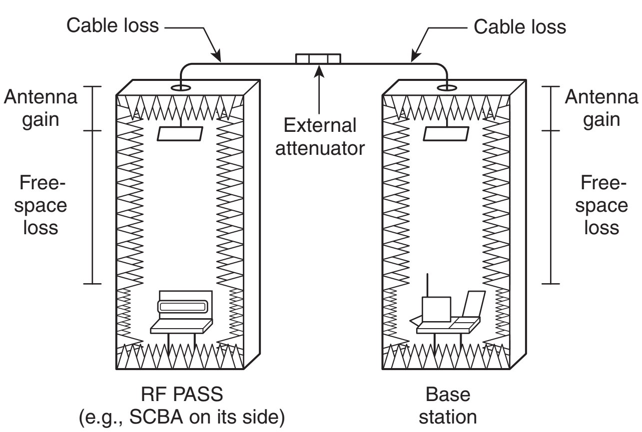


FIGURE 24.18.4.1 Apparatus Used for Point-to-Point RF Attenuation Test.

24.18.4.4.4 Minimum door size shall be 18 in. (46 cm) × 12 in. (30.5 cm).

24.18.4.4.5 The width and depth of the chambers shall be large enough to allow insertion, placement, and rotation of complete SCBAs. Usable space shall be a minimum of 24 in. (61 cm) width × 24 in. (61 cm) depth × 10 in. (30.5 cm) height at the height of the table. Usable interior width and depth shall be permitted to be smaller at other heights within the chamber.

24.18.4.4.6 Each chamber shall include a nonconducting antenna mount that shall ensure the usable interior height specified in 24.18.4.4.1.

24.18.4.4.7 Each chamber shall include a nonconducting table top a minimum 12 in. (30.5 cm) square, 15 in. (38 cm) high.

24.18.4.4.8 Each chamber shall include a side bulkhead located on the right side of the chamber when facing it, no higher than 18 in. (46 cm) from the bottom of the chamber onto which one type N or SMA bulkhead adapter is connected.

24.18.4.5 Antennas.

24.18.4.5.1 Circularly polarized patch antennas shall be used to minimize the dependence of the test on the orientation within the chamber of the RF PASS and base station.

24.18.4.5.2 Four antennas are required for the path loss calibration step; two shall be used during the test.

24.18.4.5.3 Cables that are connected to the antennas shall be no longer than 24 in. (61 cm) to minimize errors in estimating the antenna gain during the calibration step, unless a three-antenna calibration is used to determine the antenna gain, in which case the cable shall be the same as that used during the three-antenna calibration.

24.18.4.6 Cables.

24.18.4.6.1 Cables shall be high-quality shielded coaxial cables with type N or SMA connectors.

24.18.4.6.2 If cables are permanently left in place at the top of each chamber to make changing antennas easier, these cables shall be accounted for in the path loss calibration step.

24.18.4.6.3 Appropriate torque wrenches for the cable connectors shall be used to torque cable connectors to manufacturer's specifications.

24.18.4.7 Test Equipment.

24.18.4.7.1 The following test equipment shall be utilized in the point-to-point attenuation test:

(1) A three-axis field probe with optical fiber cabling to characterize the field uniformity of the chamber/antenna combination
(2) A spectrum analyzer to calibrate the path loss
(3) A variable attenuator (or combination of fixed and variable) to set the path loss
(4) A signal generator capable of generating a continuous-wave signal in each frequency of operation of the RF PASS
(5) An external power amplifier designed to work in the frequency of operation of the RF PASS

24.18.5 Procedure.

24.18.5.1 Procedure for Field Uniformity Calibration.

24.18.5.1.1 Each anechoic chamber shall be calibrated individually, using the same antenna and interior coaxial cables that shall be used during the RF PASS test. The configuration shall be as shown in Figure 24.18.5.1.1.

24.18.5.1.2 The antenna used for the RF PASS test shall be mounted to the antenna mount specified in 24.18.4.4.6. A coaxial cable shall connect the antenna to the interior bulkhead adapter of the chamber.

24.18.5.1.3 A coaxial cable shall connect the exterior side of the bulkhead adapter of the chamber to a signal generator. The signal generator shall be set to the frequency of operation of the RF PASS. The power level setting shall provide a reading on the field probe.

24.18.5.1.4 The field probe shall be connected to its receiver through a chamber bulkhead.

24.18.5.1.5 The total electric field shall be sequentially measured and recorded at the 25 points specified in Figure 24.18.5.1.5.

24.18.5.1.6* The power level at each of the 25 points shall be calculated relative to the minimum total power measured at one of the 25 points. The minimum total power, *P*, shall be determined by calculating the total power at each of the measurement points, and then selecting the minimum value of those calculations as follows:

[24.18.5.1.6a]

$$P_k^i\left(dB\right)_{relative} = 20 \times \log_{10}\left(\frac{E_k^i}{\text{minimum}\left(E_{total}^i\right)}\right)$$

where:
i = 1, 2, 3 ... 25 (the measured points)
k = x, y, z, or "*total*," and

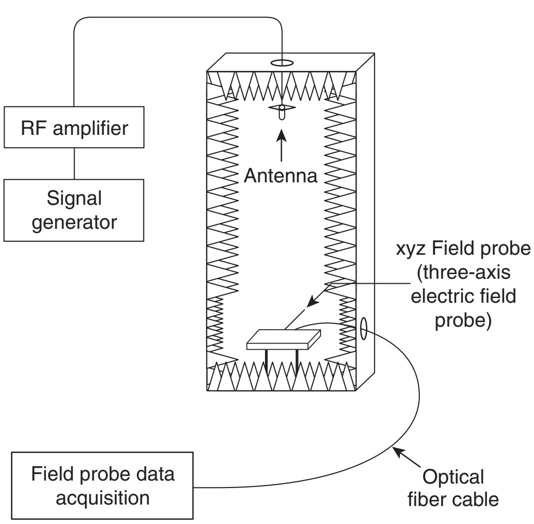


FIGURE 24.18.5.1.1 Configuration for Testing the Electric Field Uniformity Using a Signal Generator and a Three-Axis Electric Field Probe.

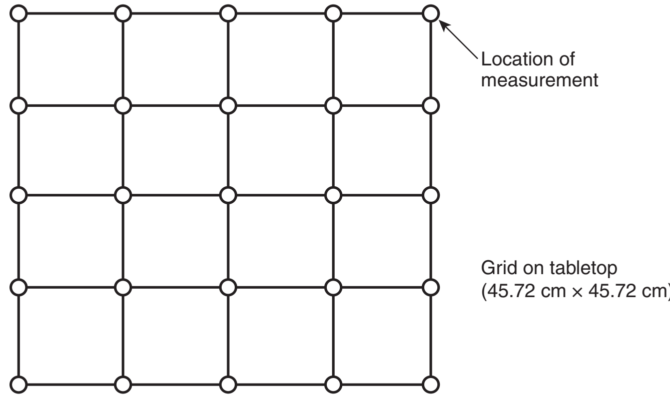


FIGURE 24.18.5.1.5 The Measurement Pattern for Checking the Electric Field Uniformity on the Table Surface.

[24.18.5.1.6b]

$$E_{total}^i = \sqrt[2]{\left(E_x^i\right)^2 + \left(E_y^i\right)^2 + \left(E_z^i\right)^2}$$

24.18.5.1.7 Seventy five percent of the measured points in 24.18.5.1.5 shall not exceed the minimum measured total power results by more than 3 dB.

24.18.5.2 Procedure for Configuring Chambers with the Target Attenuation. This procedure shall be carried out for each set of chambers, antennas, and cables.

24.18.5.2.1 The chambers shall be configured as shown in Figure 24.18.5.2.1.

24.18.5.2.2 Two calibration antennas, as shown in Figure 24.18.5.2.1, shall be inserted into the test chambers on the same tabletops where the RF PASS components shall be placed during the attenuation test. The gain of these antennas shall be obtained from the manufacturer's specifications or by use of a technique such as a three-antenna method.

24.18.5.2.3 One calibration antenna shall be connected to the signal generator, and the other to the spectrum analyzer through bulkhead adapters in the body of the test chambers. The cables connecting the antennas to the bulkhead adapters shall be of a length that limits power loss to less than 2 dB.

24.18.5.2.4 The power loss in the cables connecting the signal generator and spectrum analyzer to the bulkheads of the chambers shall be determined through measurement.

24.18.5.2.5 The system path loss shall be measured between the two measurement reference planes specified in Figure 24.18.5.2.1 with the external attenuator set to 0 dB. The power loss between the measurement reference planes shall be a positive quantity that is measured and recorded as "measured path loss, 0 dB." Measurements shall be collected over the frequency of operation of the RF PASS system that is being tested. The resolution bandwidth of the spectrum analyzer shall be less than or equal to 1 kHz.

24.18.5.2.6 The calibrated path loss, 0 dB shall be calculated as measured path loss, 0 dB + gain of calibration antennas, where gain of calibration antennas is the sum of the specified gain of each calibration antenna in decibels.

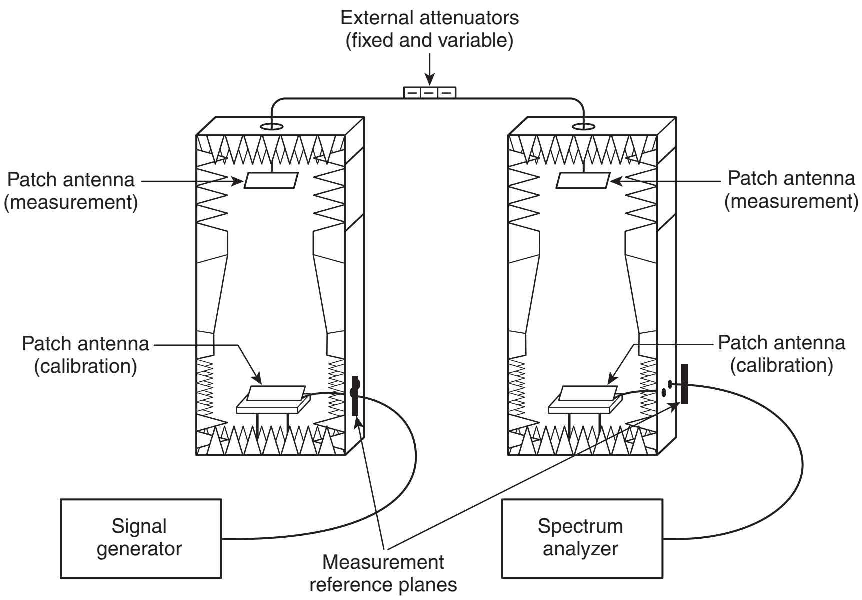


FIGURE 24.18.5.2.1 Configuration for Calibration of Target Path Loss, Consisting of the Summation (in dB) of the Various Fixed Elements in the Propagation Path, Plus the External Attenuators. (In the calibration step, the external attenuator is adjusted until the target path loss is obtained.)

24.18.5.2.7 The external attenuator to achieve the total attenuation from table to table shall be calculated as total attenuation — calibrated path loss, 0 dB, where total attenuation is 100 dB ± 3 dB for the point-to-point RF attenuation test.

24.18.5.3 Procedure for Point-to-Point RF Attenuation Test.

24.18.5.3.1 Alarm Signal Test. The test shall be conducted with the base station acting as the receiver and the RF PASS transmitting an alarm signal upon initiation of the alarm signal.

24.18.5.3.1.1 The total attenuation, including cables, connectors, free-space path loss, antenna loss, and external added attenuation, between the base station and the RF PASS shall correspond to 100 dB ± 3 dB using the calibration procedure specified in 24.18.5.2.

24.18.5.3.1.2 A wireless link shall be established between the base station and the RF PASS before closing the chambers' doors.

24.18.5.3.1.3 The alarm signal test shall be conducted twice.

(A) The RF PASS system shall be tested with the RF PASS perpendicular to the surface of the tabletop and the base station antenna parallel to the surface of the tabletop.

(B) The RF PASS system shall be tested with the RF PASS parallel to the surface of the tabletop and the base station antenna parallel to the surface of the tabletop.

24.18.5.3.1.4 For each test, the chamber doors shall be closed and the duration of time between the initiation of the alarm signal until the reception of the alarm signal shall be recorded.

24.18.5.3.2 Evacuation Alarm Test. The test shall be conducted with the RF PASS acting as a receiver and the base station transmitting an evacuation alarm.

24.18.5.3.2.1 The total attenuation, including cables, connectors, free-space path loss, antenna loss, and external added attenuation, between the base station and the RF PASS shall correspond to 100 dB ± 3 dB using the calibration procedure specified in 24.18.5.2.

24.18.5.3.2.2 A wireless link shall be established between the base station and RF PASS before closing the chambers' doors.

24.18.5.3.2.3 The RF PASS shall be kept in motion so that the motion-sensing device shall not trigger the alarm signal. A mechanism to move the RF PASS shall be permitted to be used. Any mechanism employed to move the RF PASS shall not disturb the field uniformity of the chamber more than 3 dB as specified in 24.18.5.1.

24.18.5.3.2.4 The evacuation alarm test shall be conducted twice.

(A) The RF PASS system shall be tested with the RF PASS placed perpendicular to the surface of the tabletop and the base station antenna placed parallel to the surface of the tabletop.

(B) The RF PASS system shall be tested with the RF PASS placed parallel to the surface of the tabletop and the base station antenna placed parallel to the surface of the tabletop.

24.18.5.3.2.5 For each test, the chamber doors shall be closed and the evacuation alarm shall be initiated. A mechanism to initiate the evacuation alarm shall be permitted to be used. Any mechanism employed to initiate the evacuation alarm shall not disturb the field uniformity of the chamber by more than 3 dB as specified in 24.18.5.1.

24.18.5.3.2.6 For each test, the duration of time between the initiation of the evacuation alarm and the reception of the alarm RF PASS shall be recorded.

24.18.6 Report.

24.18.6.1 All quantities shall be reported to the nearest decibel.

24.18.6.2 The operator shall record and report the results of all the tests and test parameters specified in 24.18.5, including the values of:

(1) Total attenuation associated with the test environment
(2) Maximum difference in field uniformity within an area covering the center 30 cm × 30 cm of the test chamber, as measured in 24.18.5.1
(3) Value of measured path loss when the external attenuator is set to 0 dB denoted as calibrated path loss, 0 dB, in 24.18.5.2.6
(4) Value of external attenuators used
(5) Frequency of operation (the minimum and maximum operating frequencies utilized)

24.18.7 Interpretation.

24.18.7.1 Pass or fail performance shall be determined for each specimen.

24.18.7.2 One or more specimens failing this test shall constitute failing performance.

24.19 Radio System Tests for RF PASS — Loss-of-Signal Alarm Test.

24.19.1 Application. This test method shall apply to all RF PASS systems.

24.19.2 Samples.

24.19.2.1 Samples shall be complete RF PASS systems.

24.19.2.2 Samples shall be conditioned as specified in 24.1.2.

24.19.3 Specimens.

24.19.3.1 Specimens for testing shall be complete RF PASS consisting of an RF PASS and the base station designed for use with it, provided by the manufacturer.

24.19.3.2 A single RF PASS and a single base station shall be used in each test. Three different sets of units (portable + base station) shall be tested.

24.19.3.3 The RF PASS shall be tested in conjunction with the model of base station with which it is intended to be deployed.

24.19.3.3.1 If a portable computer is utilized in the base station, radio system tests shall be conducted using the manufacturer's supplied portable computer.

24.19.3.3.1.1 The radiating element of the base station (i.e., the antenna) shall be placed into the test chamber.

24.19.3.3.2 If the base station is placed outside the test chamber, a coaxial cable shall connect the antenna to the base station through either a bulkhead connector or through the bulkhead feed-through.

24.19.3.3.3 If the base station is placed inside the test chamber, the base station shall connect to the host computer using a shielded data cable via the bulkhead feed-through.

24.19.3.4 The base station, base station computer, and any other electronic equipment associated with the RF PASS system shall operate on battery power for the duration of the RF system tests.

24.19.3.5 The loss-of-signal alarm test shall be conducted using specimens 19–21 in Table 20.3.2(a) if the specimens are stand-alone or removable integrated PASS and specimens 16–18 in Table 20.3.2(b) if the specimens are nonremovable integrated PASS.

24.19.4 Test Apparatus.

24.19.4.1 The test apparatus described in 24.18.4 for the point-to-point RF attenuation test shall be used.

24.19.5 Procedure.

24.19.5.1* The loss-of-signal alarm test shall be conducted with the RF PASS placed in one test chamber and the base station placed in a second chamber.

24.19.5.2 The path loss used in the loss-of-signal alarm test shall be implemented by disconnecting the coaxial cables that were connected to the attenuator in the point-to-point RF attenuation test. These cables shall be as specified in Figure 24.18.4.1.

24.19.5.3 The orientation of the RF PASS and the base station is not critical.

24.19.5.4 An RF link shall be established between the RF PASS and base station with the doors to the test chambers open. When the link has been established, the doors shall be closed.

24.19.5.5 Upon closing the second door, the duration until the loss-of-signal alarm from each of the RF PASS and the base station shall be noted.

24.19.6 Report. The operator shall note the results of the three tests specified in 24.19.5.5, including the duration before the loss-of-signal alarm sounds at the RF PASS and base station, and the frequency of operation.

24.19.7 Interpretation.

24.19.7.1 Pass or fail performance shall be determined for each specimen.

24.19.7.2 One or more specimens failing this test shall constitute failing performance.

24.20 Radio System Tests for RF PASS — RF Interference Test.

24.20.1 Application. This test method shall apply to all RF PASS systems that operate using unlicensed frequencies in the 902–928 MHz and 2.400–2.4835 GHz ISM bands. RF PASS systems operating with a licensed frequency shall be exempt from the requirements of this test.

24.20.1.1 The RF PASS shall be tested in conjunction with the model of base station with which it is intended to be deployed. If a portable computer is utilized in the base station, radio system tests shall be conducted using the manufacturer's supplied portable computer. The portable computer, if used, shall be placed into the test chamber with the base station.

24.20.1.2 The base station, base station computer, and any other electronic equipment associated with the RF PASS system shall operate on battery power for the duration of the RF interference test.

24.20.1.3 The total attenuation, including cables, connectors, free-space path loss, antenna loss, and external added attenuation, between the base station and the RF PASS shall correspond to 100 dB ± 3 dB using the method described in 24.18.5.2.

24.20.1.4 The RF interference test shall be conducted with the base station acting as the receiver and the RF PASS transmitting an alarm signal in the presence of RF interference.

24.20.1.5 The RF interference test does not preclude the use of repeaters in the field.

24.20.2 Samples.

24.20.2.1 Samples shall be complete RF PASS systems.

24.20.2.2 Samples shall be conditioned as specified in 24.1.2.

24.20.3 Specimens.

24.20.3.1 Specimens for testing shall be complete RF PASS consisting of an RF PASS and the base station designed for use with it, provided by the manufacturer.

24.20.3.2 A single RF PASS and a single base station that have passed the point-to-point RF attenuation test described in Section 9.3.7 and the loss-of-signal alarm test described in Section 24.19 shall be tested.

24.20.3.3 All RF interference tests shall be conducted using Specimens 19–21 in Table 20.3.2(a) if the specimens are standalone or removable integrated PASS and specimens 16–18 in Table 20.3.2(b) if the specimens are nonremovable integrated PASS.

24.20.4 Test Apparatus.

24.20.4.1 The RF interference test shall be conducted with apparatus that meets the guidelines in 24.20.2 through 24.20.4.4, as illustrated in Figure 24.20.4.1.

24.20.4.2 Test Chambers. The two test chambers shall be configured as shown in Figure 24.18.4.1. The anechoic chambers, antennas, and cables used in the RF Interference Test are the same as those described in 24.18.4.

24.20.4.3 Power Combiner. A power combiner shall be used to combine the signal from the base station with the interfering signal, as shown in Figure 24.20.4.1. The power combiner shall have two input ports and one output port, shall use Type N or SMA connectors, and shall have a minimum isolation between the input ports of 20 dB.

24.20.4.4 Interferer. A programmable signal generator or a commercial wireless device capable of emitting the common wireless protocols specified in Table 24.20.4.4 shall be used. The signal generator or the commercial wireless device shall be programmed to provide the parameters specified in Table 24.20.4.4 for the frequency of operation of the RF PASS system.

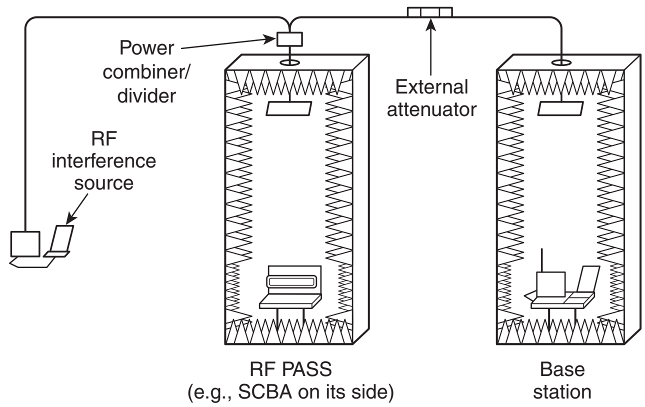


FIGURE 24.20.4.1 Apparatus Used for RF Interference Test. Two anechoic chambers provide shielding between the RF PASS and the base station. The chambers are linked by a known amount of attenuation, representing a specified path loss. An interfering RF signal is introduced into the test chambers by use of a power combiner.

24.20.4.4.1 The 900 MHz interferer shall be a programmable signal generator or a wireless development board controlled by a computer as illustrated in Figure 24.20.4.4.1. The interferer shall be capable of producing the equivalent channel usage requirements in Table 24.20.4.4. The interferer shall hop over 51 channels in the 902 MHz to 928 MHz band, at a hop duration of 40 ms ± 2 ms. The interferer shall utilize an RF data rate of 38 kB/sec ± 2 kB/sec and a serial data rate of 38 kB/sec ± 2 kB/sec. Data are transmitted with filtered non-return-to-zero (NRZ) encoding modulated onto a carrier with binary frequency shift keying (FSK).

24.20.4.4.2 The 2.4 GHz interferer shall consist of a programmable signal generator or two wireless access points as illustrated in Figure 24.20.4.4.1, capable of producing the equivalent channel usage requirement as specified in Table 24.20.4.4. The two access points shall be connected to the input ports of a power combiner with no less than 20 dB of isolation between the input ports. The output of the power combiner shall be connected to the input of the power combiner on the test

Table 24.20.4.4 Definition of Interference Sources for RF Interference Test

Frequency Range	Transmission Format or Modulation Scheme	Subcarrier or Channel Bandwidth	Output Power and FCC Part	Channel Usage by Interference Source
902 MHz–928 MHz	Direct sequence spread spectrum (DSSS) or frequency hopping spread spectrum (FHSS)	100 kHz subcarrier	1 W peak power (30 dBm) into antenna (w/ max 6 dBi gain), 47 CFR, FCC Part 15.247*	25% over the 30 second test interval; 25% ± 10% within any 5 second subinterval
2.4 GHz–2.472 GHz	Direct sequence spread spectrum (DSSS) or frequency hopping spread spectrum (FHSS)	22 MHz (IEEE 802.11 channels)	63 mW peak power (18 dBm) into antenna, 47 CFR, FCC Part 15 *(See example 2 for determination of correction factor.)*	25% over the 30 second test interval; 25% ± 10% within any 5 second subinterval

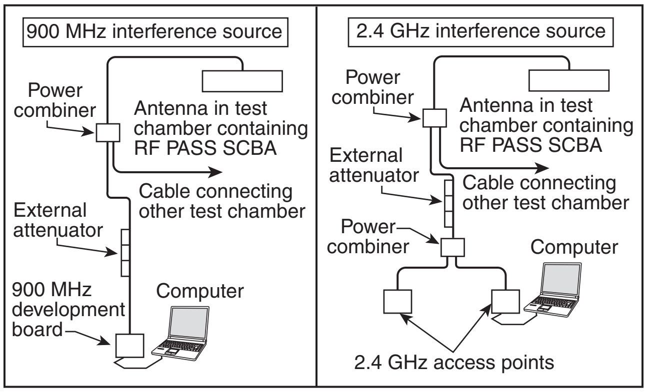


FIGURE 24.20.4.4.1 Apparatus Used for Creating the 900 MHz and 2.46 GHz Band Interference.

chamber containing the RF PASS. The programmable signal generator or wireless access points shall be set to establish a 1 MB/sec wireless distribution or bridging channel between two access points. A computer connected to the Ethernet port on one of the access points continuously sends an "echo request" to the Ethernet interface of the other access point with a packet size of 28 kB/sec, using the internet control message protocol (ICMP). The receiving access point shall reply with an "echo response."

24.20.4.4.3 The physical distance between the transmit antenna and the center of the testing platform supporting the PASS shall be 1.25 m ± 0.1 m.

24.20.4.4.4 The interference signal path loss in dB shall be calculated as cable losses plus power combiner insertion losses plus external attenuator losses minus interference signal amplification minus antenna gain in the test chamber. The value shall be 0 dB ± 2 dB, the interference shall be either attenuated or amplified so that the calculated value equals 0 dB ± 2 dB.

24.20.5 Procedure.

24.20.5.1 Prior to conducting the RF interference test, each anechoic chamber shall be characterized using the techniques described in 24.18.5.1.

24.20.5.2 The total attenuation, including cables, connectors, free-space path loss, antenna loss, power combiner, and external added attenuation, between the base station and the RF PASS shall correspond to 100 dB ± 3 dB. The total attenuation shall be calculated using the calibration procedure described in 24.18.5.2.

24.20.5.3 The signal from the RF interferer shall be coupled into the test chamber in which the RF PASS is located. Coupling shall be through a coaxial cable to a two-input power combiner having a minimum of 20 dB isolation between input ports. The other input port of the power combiner shall be connected to the coaxial cable that connects the base station test chamber to the RF PASS test chamber, as specified in 24.18.5.2.

24.20.5.4 A wireless link shall be established between the base station and device before closing the chambers' doors.

24.20.5.5 The chamber doors shall be closed.

24.20.5.6 The interferer shall be turned on.

24.20.5.7 The duration until the reception of the alarm signal shall be recorded.

24.20.5.8 The RF PASS system shall be tested with the RF PASS placed in two orientations (vertically and horizontally) and the base station placed in one orientation (horizontally).

24.20.6 Report.

24.20.6.1 All quantities shall be reported to the nearest decibel.

24.20.6.2 The operator shall record and report the results of all tests and test parameters specified in 24.20.5 including the values of:

(1) Total attenuation associated with the test environment
(2) Maximum difference in field uniformity within an area covering the center 30 cm × 30 cm of the test chamber, as specified in 24.18.5.1
(3) Calibrated path loss, 0 dB specified in 24.18.5.2.6
(4) External attenuators used
(5) Frequency of operation (the minimum and maximum operating frequencies utilized by the RF PASS system under test)
(6) Model, typical loss and isolation of power combiner, from manufacturer's specifications
(7) Model of the interferer
(8) Interferer parameters, as specified in Table 24.20.4.4
(9) Interference signal path loss, as specified in 24.20.4.4.4

24.20.7 Interpretation.

24.20.7.1 Pass or fail performance shall be determined for each specimen.

24.20.7.2 One or more specimens failing this test shall constitute failing performance.

24.21 Radio System Tests for RF PASS — Multipath Test.

24.21.1 Application. This test method shall apply to all RF PASS systems.

24.21.1.1 The RF PASS shall be tested in conjunction with the model of base station with which it is intended to be deployed. If a portable computer is utilized in the base station, radio system tests shall be conducted using the manufacturer's supplied portable computer. The portable computer, if used, shall be placed into the test chamber with the base station.

24.21.1.2 The base station, base station computer, and any other electronic equipment associated with the RF PASS system shall operate on battery power for the duration of the RF system tests.

24.21.2 Samples.

24.21.2.1 Samples shall be complete RF PASS systems.

24.21.2.2 Samples shall be conditioned as specified in 24.1.2.

24.21.3 Specimens.

24.21.3.1 Specimens for testing shall be complete RF PASS systems consisting of an RF PASS and the base station designed for use with it, provided by the manufacturer.

24.21.3.2 A single RF PASS and a single base station shall be used in each test. Three different sets of units (portable base station) shall be tested.

24.21.3.3 All multipath tests shall be conducted using specimens 19–21 in Table 20.3.2(a) if the specimens are stand-alone or removable integrated PASS and specimens 16–18 in Table 20.3.2(b) if the specimens are nonremovable integrated PASS.

24.21.4 Test Apparatus.

24.21.4.1 The multipath test shall be conducted as shown in Figure 24.21.4.1 in the following two configurations:

(1) With the base station acting as the receiver and the RF PASS transmitting an alarm signal
(2) With the RF PASS acting as a receiver and the base station transmitting an evacuation alarm

24.21.4.2 For both configurations, the total attenuation (including cables, connectors, free-space path loss, antenna loss, and external added attenuation) between the base station and the RF PASS shall correspond to 100 dB ± 3 dB. The total attenuation shall be calculated using the method specified in 24.21.5.3.

24.21.4.3* Anechoic Chamber. This test chamber shall be configured as the base station chamber shown in Figure 24.18.4.1.

24.21.4.4 Reverberation Chamber.

24.21.4.4.1 Overall usable interior dimensions of the reverberation chamber shall be such that the distance between the antenna and the DUT is a minimum of one-half the free space wavelength, and the distance between the DUT and any chamber wall surface is a minimum of one-half the free space wavelength. The free space wavelength shall be computed at the lowest intended frequency of DUT operation. These specifications shall not preclude the use of a larger reverberation chamber.

24.21.4.4.2 To isolate the device and base station from each other, the reverberation chamber shall provide at least 100 dB shielding from the test platform tabletop to the outside of the chamber at the frequency of operation of the RF PASS, with the bulkhead ports specified in 24.18.4.4.8 in place.

24.21.4.4.3 The reverberation chamber shall meet specifications as specified in IEC 61000-4-21, *Testing and measurement techniques — Reverberation chamber test methods*. Performance specifications provided by the manufacturer shall satisfy this requirement.

24.21.4.4.4 Minimum reverberation chamber door size shall be 18 in. (46 cm) × 12 in. (30.5 cm).

24.21.4.4.5 The width and depth of the reverberation chamber shall be large enough to allow insertion, placement, and rotation of complete SCBAs. Usable space shall be a minimum of 24 in. (61 cm) width × 24 in. (61 cm) depth × 10 in. (30.5 cm) height at the height of the table. Usable interior width and depth shall be permitted to be smaller at other heights within the chamber.

24.21.4.4.6 The reverberation chamber shall include a nonconducting antenna mount that shall ensure the usable interior height specified in 24.21.4.4.1.

24.21.4.4.7 The reverberation chamber shall include a nonconducting tabletop with minimum dimensions of 12 in. (30.5 cm) square, 15 in. (38 cm) high.

24.21.4.5 Antennas. The antennas shall be as specified in 24.18.4.5.

24.21.4.6 Cables. The cables shall be as specified in 24.18.4.6.

24.21.4.7 Test Equipment. The test equipment shall be as specified in 24.18.4.7.

24.21.5 Procedure.

24.21.5.1 Procedure for Field Uniformity Calibration in Anechoic Chamber. The procedure specified in 24.18.5.1 shall be followed to calibrate the field uniformity in the anechoic chamber.

24.21.5.2 Procedure for Field Calibration in Reverberation Chamber. The procedure specified in IEC 61000-4-21, clause 8, and IEC 61000-4-21, annex B, shall be followed to calibrate the field uniformity and verify the loading in the reverberation chamber. The field uniformity shall be ±3 dB standard deviation for frequencies above 400 MHz.

24.21.5.3 Procedure for Configuring Chambers with Target Attenuation. This procedure shall be carried out for each set of chambers, antennas, and cables. An average value shall be obtained using independent tuner paddle locations as specified in 24.21.5.3.2.

24.21.5.3.1 The chambers shall be configured as shown in Figure 24.21.5.3.1.

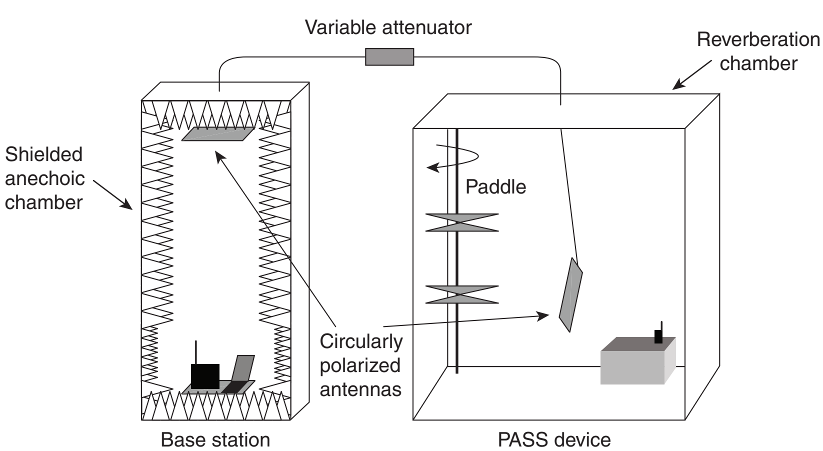


FIGURE 24.21.4.1 Setup for the Multipath Test.

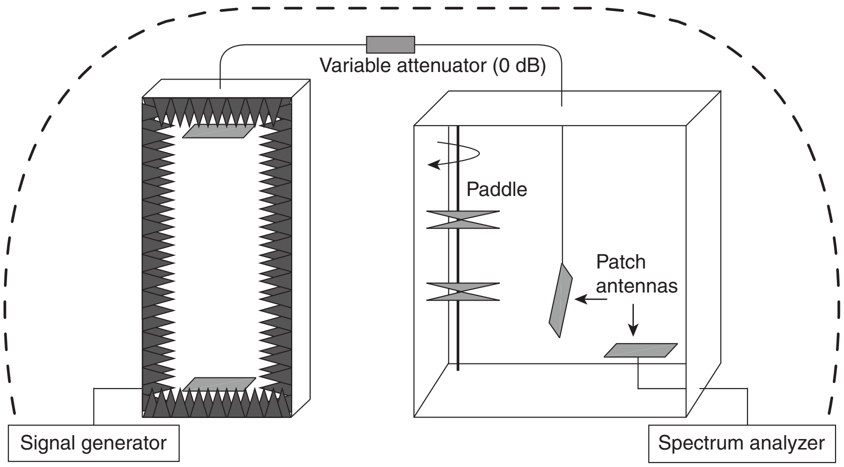


FIGURE 24.21.5.3.1 Configuration for Calibration of System Path Loss.

24.21.5.3.2 The procedure specified in 24.18.5.2 shall be followed to obtain a sample value for the final average. The paddle shall be stationary in the reverberation chamber for each sample measurement. The paddle shall be moved to a unique location for each sample measurement. One hundred (100) samples shall be obtained and averaged to determine the system path loss.

24.21.5.3.3 The procedure specified in 24.21.5.3.2 shall be used to obtain a total attenuation value of 100 dB ± 3 dB for the multipath test.

24.21.5.4 Procedure for Multipath Test.

24.21.5.4.1 Alarm Signal Test. The test shall be conducted with the base station acting as the receiver and the RF PASS transmitting an alarm signal upon initiation of the alarm signal.

24.21.5.4.1.1 The total attenuation, including cables, connectors, free-space path loss, antenna loss, and external added attenuation, between the base station and the RF PASS shall correspond to 100 dB ± 3 dB using the calibration procedure specified in 24.21.5.3.

24.21.5.4.1.2 A wireless link shall be established between the base station and the RF PASS before closing the chambers' doors.

24.21.5.4.1.3 The alarm signal test shall be conducted twice, once in the configuration specified in 24.21.5.4.1.3(A) and once in the configuration specified in 24.21.5.4.1.3(B).

(A) The RF PASS system shall be tested with the RF PASS perpendicular to the surface of the tabletop and the base station antenna parallel to the surface of the tabletop.

(B) The RF PASS system shall be tested with the RF PASS parallel to the surface of the tabletop and the base station antenna parallel to the surface of the tabletop.

24.21.5.4.1.4 The paddle in the reverberation chamber shall continuously spin at 3 RPM.

24.21.5.4.1.5 For each test, the chamber doors shall be closed and the duration of time between the initiation of the alarm signal and the reception of the alarm signal shall be recorded.

24.21.5.4.2 Evacuation Alarm Test. The test shall be conducted with the RF PASS acting as a receiver and the base station transmitting an evacuation alarm.

24.21.5.4.2.1 The total attenuation, including cables, connectors, free-space path loss, antenna loss, and external added attenuation, between the base station and the RF PASS shall correspond to 100 dB ± 3 dB using the calibration procedure specified in 24.21.5.2.

24.21.5.4.2.2 A wireless link shall be established between the base station and RF PASS before closing the chambers' doors.

24.21.5.4.2.3 The RF PASS shall be kept in motion so that the motion-sensing device shall not trigger the alarm signal. A mechanism to move the RF PASS shall be permitted to be used. Any mechanism employed to move the RF PASS shall not disturb the field uniformity of the anechoic chamber more than 3 dB as specified in 24.21.5.1.

24.21.5.4.2.4 The evacuation alarm test shall be conducted twice, once in the configuration specified in 24.21.5.4.2.4(A) and once in the configuration specified in 24.21.5.4.2.4(B).

(A) The RF PASS system shall be tested with the RF PASS placed perpendicular to the surface of the tabletop and the base station antenna placed parallel to the surface of the tabletop.

(B) The RF PASS system shall be tested with the RF PASS placed parallel to the surface of the tabletop and the base station antenna placed parallel to the surface of the tabletop.

24.21.5.4.2.5 The paddle in the reverberation chamber shall continuously spin at 3 RPM.

24.21.5.4.2.6 For each test, the chamber doors shall be closed and the evacuation alarm shall be initiated. A mechanism to initiate the evacuation alarm shall be permitted to be used. Any mechanism employed to initiate the evacuation alarm shall not disturb the field uniformity of the anechoic chamber by more than 3 dB as specified in 24.21.5.1.

24.21.5.4.2.7 For each test, the duration of time between the initiation of the evacuation alarm and the reception of the alarm RF PASS shall be recorded.

24.21.6 Report.

24.21.6.1 All quantities shall be reported to the nearest decibel.

24.21.6.2 The operator shall record and report the results of all the tests and test parameters specified in 24.21.5, including the values of the following:

(1) Total attenuation associated with the test environment
(2) Maximum difference in field uniformity within an area covering the center 30 cm × 30 cm (12 in. × 12 in.) of the anechoic chamber, as measured in 24.21.5.1
(3) Value of reverberation chamber loss, including the number of samples upon which the estimated loss is based
(4) Value of measured path loss when the external attenuator is set to 0 dB denoted as calibrated path loss, 0 dB, in 24.21.5.3
(5) Value of external attenuators used
(6) Frequency of operation (the minimum and maximum operating frequencies utilized)

24.21.7 Interpretation.

24.21.7.1 Pass or fail performance shall be determined for each specimen.

24.21.7.2 One or more specimens failing this test shall constitute failing performance.

24.22 Radio System Tests for RF PASS — Multi-hop RF Test.

24.22.1 Application. This test method shall apply to all RF PASS with integrated repeating capability.

24.22.2 Samples.

24.22.2.1 Samples shall be complete RF PASS with integrated repeating capability.

24.22.2.2 Samples shall be conditioned as specified in 24.1.2.

24.22.3 Specimens.

24.22.3.1 Specimens for testing shall be complete RF PASS consisting of three RF PASS devices capable of relaying an RF PASS signal and a base station designed for use with them, provided by the manufacturer.

24.22.3.2 Two of the three RF PASS devices shall serve as repeater units capable of relaying an RF PASS signal, and one shall originate or terminate the alarm signal.

24.22.3.3 All multi-hop RF tests shall be conducted using specimens 19–21 in Table 20.3.2(a) if the specimens are standalone or removable integrated PASS and specimens 16–18 in Table 20.3.2(b) if the specimens are nonremovable integrated PASS.

24.22.4 Test Apparatus.

24.22.4.1 The multi-hop RF test shall be conducted as shown in Figure 24.22.4.1 in the following two configurations:

(1) With the base station acting as the receiver and the RF PASS under test transmitting an alarm signal
(2) With the RF PASS under test acting as a receiver and the base station transmitting an evacuation alarm

24.22.4.2 For both configurations, the total attenuation (including cables, connectors, free-space path loss, antenna loss, and external added attenuation) between two anechoic chambers shall correspond to 100 dB. The total attenuation between the anechoic and reverberation chamber shall correspond to 80 dB.

24.22.4.3 Anechoic Chambers. The anechoic chambers shall be as specified in 24.18.4.4.

24.22.4.4 Reverberation Chamber. The reverberation chamber shall be as specified in 24.21.4.4.

24.22.4.5 Antennas.

24.22.4.5.1 Circularly polarized antennas shall be used to minimize the dependence of the test on the orientation within the chamber of the RF PASS under test and base station.

24.22.4.5.2 Five circularly polarized antennas and one linearly polarized horn antenna shall be used during the calibration steps. Five circularly polarized antennas shall be used during the test.

24.22.4.5.3 Cables permanently connected to any antenna shall be no longer than 24 in. (61 cm) to minimize errors in estimating the antennas gain during the calibration step, unless a three-antenna calibration is used to determine the antenna

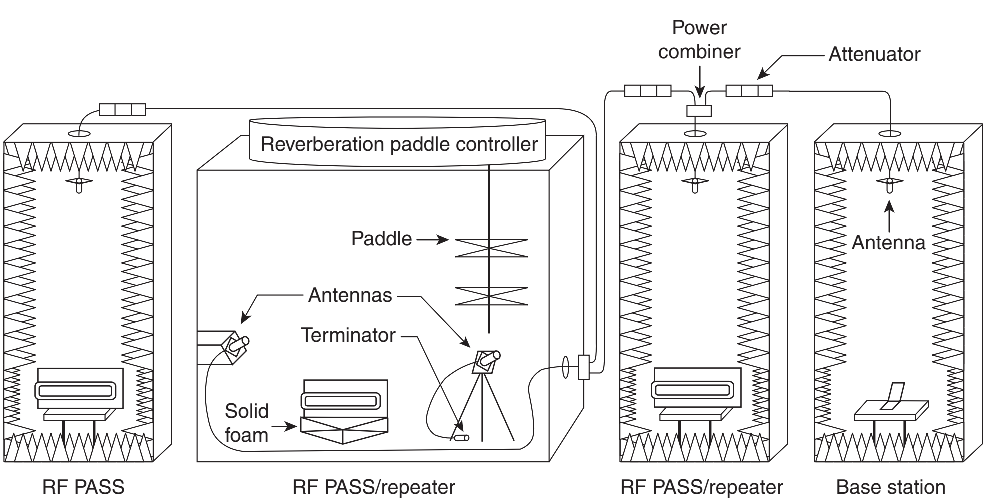


FIGURE 24.22.4.1 Apparatus Used for Multi-hop RF Test.

gain, in which case the cable shall be the same as that used during the three-antenna calibration.

24.22.4.6 Cables. The cables shall be as specified in 24.18.4.6.

24.22.4.7 Test Equipment. The test equipment shall be as specified in 24.18.4.7.

24.22.5 Procedure.

24.22.5.1 Procedure for Field Uniformity Calibration in Anechoic Chamber. The procedure for field uniformity calibration shall be as specified in 24.18.5.1.

24.22.5.2 Procedure for Field Calibration in Reverberation Chamber. The procedure for field calibration in the reverberation chamber shall be as specified in 24.21.5.2.

24.22.5.3 Procedure for Configuring one Anechoic Chamber Connected to one Reverberation Chamber with Target Attenuation. This procedure shall be carried out for the connection between an anechoic chamber and a reverberation chamber, antennas, and cables.

24.22.5.3.1 The chambers shall be configured as shown in Figure 24.22.5.3.1.

24.22.5.3.2 Two circularly polarized antennas shall be inserted into the reverberation chamber as shown in Figure 24.22.5.3.1. One dual ridged horn antenna as shown in Figure 24.22.5.3.1 shall be inserted into the anechoic chamber on the same tabletops where the RF PASS components shall be placed during the attenuation test. The gain of these antennas shall be obtained from the manufacturer's specifications or by use of a technique such as a three-antenna method.

24.22.5.3.3 One calibration antenna shall be connected to the signal generator, and the other to the spectrum analyzer through bulkhead adapters in the body of the test chambers. The cables connecting the antennas to the bulkhead adapters shall be of a length that limits power loss to less than 2 dB.

24.22.5.3.4 The power loss in the cables connecting the signal generator and spectrum analyzer to the bulkheads of the chambers shall be determined through measurement.

24.22.5.3.5 The reverberation chamber paddle shall be on and operating at 0.2 RPM and path loss measurements shall be collected every 3 seconds.

24.22.5.3.6 The path loss measurements shall be averaged. This value shall be regarded as the total path loss between the tabletop of the anechoic chamber and the reverberation chamber.

24.22.5.3.7 The system path loss shall be measured between the reference plane within the anechoic chamber and the reverberation chamber specified in Figure 24.22.5.3.1 with the external attenuator set to 0 dB. The power loss between the measurement reference planes shall be a positive quantity that is measured and recorded as "measured path loss, 0 dB." Measurements shall be collected over the frequency of operation of the RF PASS under test. The resolution bandwidth of the spectrum analyzer shall be less than or equal to 1 kHz.

24.22.5.3.8 The calibrated path loss, 0 dB shall be calculated as measured path loss, 0 dB gain of calibration antennas, where gain of calibration antennas is the sum of the specified gain of each calibration antenna in decibels.

24.22.5.3.9 The external attenuator to achieve the total attenuation from table to table shall be calculated as total attenuation — calibrated path loss, 0 dB, where total attenuation is 80 dB between the anechoic chamber and reverberation chamber for the multi-hop RF test.

24.22.5.4 Procedure for Configuring one Reverberation Chamber Connected to one Anechoic Chamber with Target Attenuation. This procedure shall be carried out for the connection between reverberation chamber and anechoic chamber, antennas, and cables.

24.22.5.4.1 The chambers shall be configured as shown in Figure 24.22.5.4.1.

24.22.5.4.2 Two circularly polarized antennas shall be inserted into the reverberation chamber as shown in Figure 24.22.5.3.1. One dual ridged horn antenna as shown in Figure 24.22.5.4.1 shall be inserted into the anechoic chamber on the same

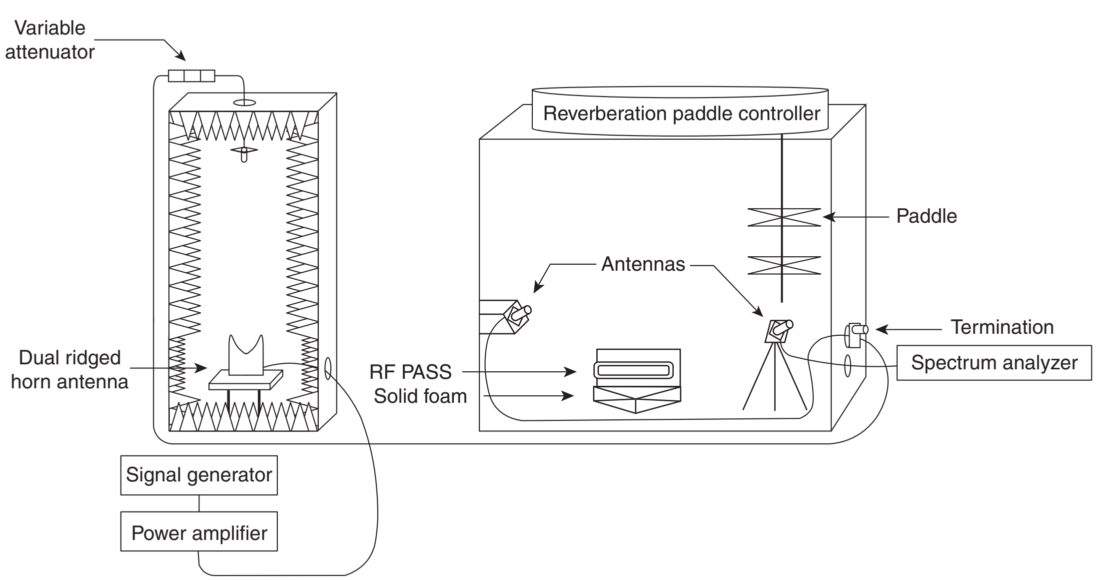


FIGURE 24.22.5.3.1 Configuration for Calibration of Target Path Loss Between Anechoic Chamber and Reverberation Chamber.

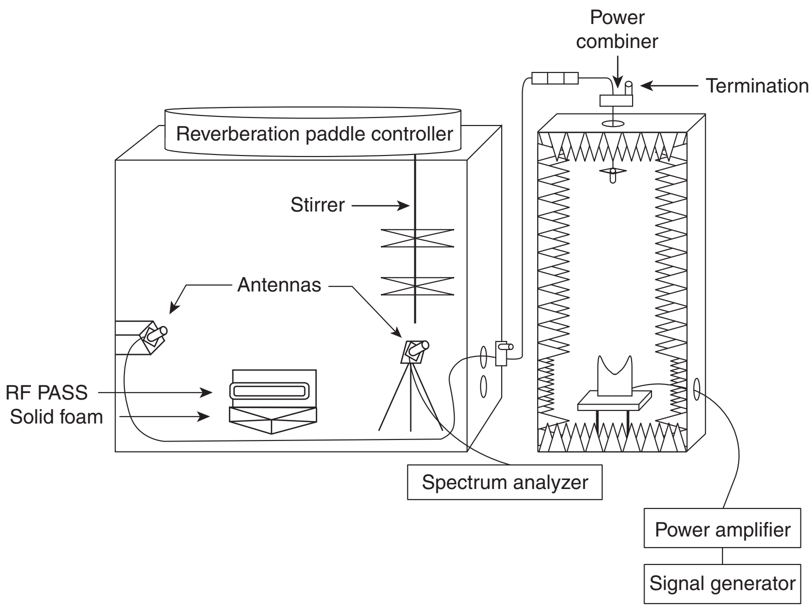


FIGURE 24.22.5.4.1 Configuration for Calibration of Target Path Loss Between Reverberation Chamber and Anechoic Chamber.

tabletops where the RF PASS components shall be placed during the attenuation test. The gain of these antennas shall be obtained from the manufacturer's specifications or by use of a technique such as a three-antenna method.

24.22.5.4.3 One calibration antenna shall be connected to the signal generator, and the other to the spectrum analyzer through bulkhead adapters in the body of the test chambers. The cables connecting the antennas to the bulkhead adapters shall be of a length that limits power loss to less than 2 dB.

24.22.5.4.4 The power loss in the cables connecting the signal generator and spectrum analyzer to the bulkheads of the chambers shall be determined through measurement.

24.22.5.4.5 The reverberation chamber paddle shall be on and operating at 0.2 RPM and path loss measurements shall be collected every 3 seconds.

24.22.5.4.6 The path loss measurements shall be averaged. This value shall be regarded as the total path loss between the reverberation chamber and the tabletop of the anechoic chamber.

24.22.5.4.7 The system path loss shall be measured between the reverberation chamber and the reference plane within the anechoic chamber specified in Figure 24.22.5.4.1 with the external attenuator set to 0 dB. The power loss between the measurement reference planes shall be a positive quantity that is measured and recorded as "measured path loss, 0 dB." Measurements shall be collected over the frequency of operation of the RF PASS under test. The resolution bandwidth of the spectrum analyzer shall be less than or equal to 1 kHz.

24.22.5.4.8 The calibrated path loss, 0 dB shall be calculated as measured path loss, 0 dB gain of calibration antennas, where gain of calibration antennas is the sum of the specified gain of each calibration antenna in decibels.

24.22.5.4.9 The external attenuator to achieve the total attenuation from table to table shall be calculated as total attenuation — calibrated path loss, 0 dB, where total attenuation is 80 dB between the anechoic chamber and reverberation chamber for the multi-hop RF test.

24.22.5.5 Procedure for Configuring Two Anechoic Chambers with Target Attenuation. This procedure shall be carried out for the pair of anechoic chambers, antennas, and cables.

24.22.5.5.1 The chambers shall be configured as shown in Figure 24.22.5.5.1.

24.22.5.5.2 Two dual ridged horn antennas, as shown in Figure 24.22.5.5.1 shall be inserted into the anechoic chambers on the same tabletops where the RF PASS components shall be placed during the attenuation test. The gain of these antennas shall be obtained from the manufacturer's specifications or by use of a technique such as a three-antenna method.

24.22.5.5.3 One calibration antenna shall be connected to the signal generator, and the other to the spectrum analyzer through bulkhead adapters in the body of the test chambers. The cables connecting the antennas to the bulkhead adapters shall be of a length that limits power loss to less than 2 dB.

24.22.5.5.4 The power loss in the cables connecting the signal generator and spectrum analyzer to the bulkheads of the chambers shall be determined through measurement.

24.22.5.5.5 The system path loss shall be measured between the two measurement reference planes specified in Figure 24.22.5.5.1. The power loss between the measurement reference planes shall be a positive quantity that is measured and recorded as "measured path loss, 0 dB." Measurements shall be collected over the frequency of operation of the RF PASS under test. The resolution bandwidth of the spectrum analyzer shall be less than or equal to 1 kHz.

24.22.5.5.6 The calibrated path loss, 0 dB shall be calculated as measured path loss, 0 dB gain of calibration antennas, where gain of calibration antennas is the sum of the specified gain of each calibration antenna in decibels.

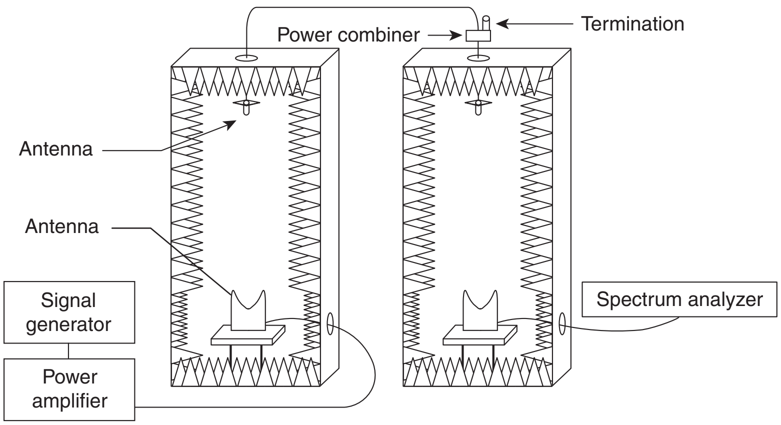


FIGURE 24.22.5.5.1 Configuration for Calibration of Target Path Loss Between Two Anechoic Chambers.

24.22.5.5.7 The external attenuator to achieve the total attenuation from table to table shall be calculated as total attenuation — calibrated path loss, 0 dB, where total attenuation is 100 dB between two anechoic chambers.

24.22.5.6 Procedure for Multi-hop RF Test.

24.22.5.6.1 Alarm Signal Test. The test shall be conducted with the base station acting as the receiver and the RF PASS under test transmitting an alarm signal upon initiation of the alarm signal.

24.22.5.6.1.1 The total attenuation, including cables, connectors, free-space path loss, antenna loss, and external added attenuation between the two anechoic chambers shall correspond to 100 dB. The total attenuation between the reverberation chamber and anechoic chamber shall correspond to 80 dB.

24.22.5.6.1.2 The total attenuation, including cables, connectors, free-space path loss, antenna loss, and external added attenuation, between the base station and the RF PASS under test shall correspond to 260 dB using the calibration procedure specified in 24.22.5.2.

24.22.5.6.1.3 The reverberation chamber paddle shall be turned on and shall rotate at 3 RPM ± 2 RPM.

24.22.5.6.1.4 A wireless link shall be established between the base station and the RF PASS under test before closing the chambers' doors.

24.22.5.6.1.5 The chambers' doors shall be closed for 1 minute before proceeding.

24.22.5.6.1.6 The RF PASS with the largest amount of attenuation between it and the base station shall be the device under test. The duration of time between the initiation of the alarm signal until the reception of the alarm signal shall be recorded. This test shall be repeated three times.

24.22.5.6.1.7 The alarm signal test shall be conducted twice for each of the three trials.

(A) The RF PASS system shall be tested with the RF PASS perpendicular to the surface of the tabletop and the base station antenna parallel to the surface of the tabletop.

(B) The RF PASS system shall be tested with the RF PASS parallel to the surface of the tabletop and the base station antenna parallel to the surface of the tabletop.

24.22.5.6.2 Evacuation Alarm Test. The test shall be conducted with the RF PASS under test acting as a receiver and the base station transmitting an evacuation alarm.

24.22.5.6.2.1 The total attenuation, including cables, connectors, free-space path loss, antenna loss, and external added attenuation between the two anechoic chambers shall correspond to 100 dB. The total attenuation between the reverberation chamber and anechoic chamber shall correspond to 80 dB.

24.22.5.6.2.2 The total attenuation, including cables, connectors, free-space path loss, antenna loss, and external added attenuation, between the base station and the RF PASS under test shall correspond to 260 dB using the calibration procedure specified in 24.22.5.2.

24.22.5.6.2.3 The reverberation chamber paddle shall be turned on and shall rotate at 3 RPM ± 2 RPM.

24.22.5.6.2.4 A wireless link shall be established between the base station and RF PASS under test before closing the chambers' doors.

24.22.5.6.2.5 An alarm shall be sent from the base station without opening the anechoic doors, using any necessary additional software or method. The alarm shall be sent 1.5 minutes after activating the automated click software.

24.22.5.6.2.6 The RF PASS under test shall be kept in motion so that the motion-sensing device shall not trigger the alarm signal. A mechanism to move the RF PASS under test shall be permitted to be used. Any mechanism employed to move the RF PASS under test shall not disturb the field uniformity of the chamber more than 3 dB as specified in 24.18.5.1.

24.22.5.6.2.7 The RF PASS with the highest total attenuation between it and the base station shall be the device under test. The duration of time between the initiation of the evacuation alarm and the reception of the alarm for the RF PASS under test shall be recorded.

24.22.5.6.2.8 The evacuation alarm test shall be conducted twice.

(A) The RF PASS system shall be tested with the RF PASS perpendicular to the surface of the tabletop and the base station antenna parallel to the surface of the tabletop.

(B) The RF PASS system shall be tested with the RF PASS parallel to the surface of the tabletop and the base station antenna parallel to the surface of the tabletop.

24.22.6 Report. The report shall be as specified in 24.18.6.

24.22.7 Interpretation.

24.22.7.1 Pass or fail performance shall be determined for each specimen. A signal that is not received from either test within 30 seconds shall constitute failing performance.

24.22.7.2 One or more specimens failing this test shall constitute failing performance.

Annex A Explanatory Material

Annex A is not a part of the requirements of this NFPA document but is included for informational purposes only. This annex contains explanatory material, numbered to correspond with the applicable text paragraphs.

A.1.1.1 This first consolidation of NFPA 1971, NFPA 1975, NFPA 1981, and NFPA 1982 is an attempt to put all relative ensemble specifications into one place for the benefit of end users. It further serves as the first step to begin a more comprehensive harmonization of terminology, certification, and other requirements for the entire ensemble (including clothing elements, SCBA, and wearable electronics) and to provide opportunities to address full system requirements that has not been possible where there were separate standards. In the first consolidated standard, relevant sections are provided sequential for each respective prior standard to allow for the continuing identification of product types associated with those standards to be referenced. Future consolidation efforts will look to provide more comprehensive attempts to further standardized requirements and test methodology for consistency across the entire protective ensemble.

A.1.2.3 Annex G addresses ensemble attributes related to the integration and interoperability of multiple elements and includes specific test methods for evaluating full ensembles in terms of their protection levels, functionality, comfort, and other factors associated with ensemble integration and interoperability. Test methods are included that can be applied for purposes of research for the assessment of full ensembles by end user organizations.

A.1.3 Beginning with the publication of NFPA 1970, new editions of NFPA 1971, NFPA 1975, NFPA 1981, and NFPA 1982 will not be published as separate, standalone standards. Where an authority having jurisdiction wants to reference the latest edition of one or more of the previous standards, the referencing language should refer to NFPA 1970 or the specific chapters of NFPA 1970, as identified in Section 1.3.

The numbers found in parentheses at the end of each chapter title refer to the former standalone documents and are intended to help users navigate between this standard and the former standalone documents.

A.2.3.5 The use of the 2005 edition of ASTM F1790, *Test Methods for Measuring Cut Resistance of Materials Used in Protective Clothing*, is specifically referenced as changes to the current edition (2021) do not align with desired testing conditions for this standard. The equipment changes and method changes negatively impact the results of desired product characteristics.

A.3.2.1 Approved. The National Fire Protection Association does not approve, inspect, or certify any installations, procedures, equipment, or materials nor does it approve or evaluate testing laboratories. In determining the acceptability of installations or 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 that is concerned with product evaluations and is thus in a position to determine compliance with appropriate standards for the current production of listed items.

A.3.2.2 Authority Having Jurisdiction (AHJ). The phrase "authority having jurisdiction," or its acronym AHJ, is used in NFPA standards in a broad manner because 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.3.2.4 Listed. The means for identifying listed equipment may vary for each organization concerned with product evaluation; some organizations 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.3.3 General Definitions. The terms defined in this section have the meanings stated unless modified by the mandatory requirements of this standard. Where terms are not defined herein, those terms have the ordinarily accepted meanings, or the meaning that the text implies. Terms used in the present tense include the past and future tense. Terms used in the masculine gender include female and neuter genders, terms used in the singular include the plural, and terms used in the plural include the singular.

A.3.3.10 Bitragion Coronal Arc. See Figure A.3.3.10.

A.3.3.11 Bitragion Inion Arc. For test purposes, the bitragion inion arc is identified as Datum Plane 10. See Figure A.3.3.11.

A.3.3.22 CBRN Terrorism Agents. Chemical terrorism agents include solid, liquid, and gaseous chemical warfare agents and toxic industrial chemicals. Chemical warfare agents include, but are not limited to, GB (sarin), GD (soman), HD (sulfur mustard), VX, and specific toxic industrial chemicals. Many toxic industrial chemicals, for example chlorine and ammonia, are identified as chemical terrorism agents because of their availability and the degree of injury they could inflict.

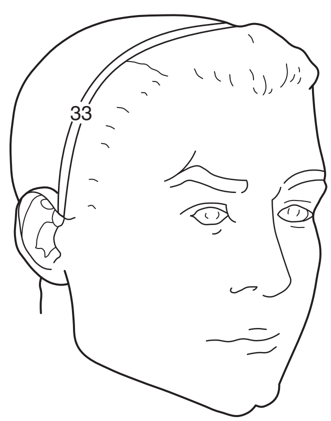


FIGURE A.3.3.10 Bitragion Coronal Arc.

Biological agents are bacteria, viruses, or the toxins derived from biological material. Biological particles can be dispersed as aerosols and liquid-borne pathogens. Airborne biological agents could be dispersed in the form of liquid aerosols or solid aerosols (i.e., a powder of bacterial spores). Liquid-borne pathogens could be potentially encountered during a terrorism incident as a result of deliberate disposal or from body fluids released by victims of other weapons (i.e., explosives, firearms).

CBRN also includes radiological particulates dispersed as aerosols but not for radiological gases or vapors. Airborne particulates have the ability to emit alpha- and beta-particles and ionizing radiation from the decay of unstable isotopes.

A.3.3.34 Combination SCBA/SAR. Combination SCBA/SARs consist of the following:

(1) An SCBA certified as compliant with Chapters 15 through 19 of this standard and having a minimum rated service life of 30 minutes
(2) A connection for the attachment of an air line that provides a continuous supply of breathing air that is independent of the SCBA breathing air supply

The definition does not include SARs that are used in conjunction with escape self-contained breathing apparatus (ESCBA) where the ESCBA provide less than a minimum rated service life of 30 minutes. For the purpose of this standard, combination SCBA/SARs are encompassed by the terms *self-contained breathing apparatus* and *SCBA*.

A.3.3.37 Component. Components include items required for the design and construction of the product and are evaluated and tested as a part of the whole product.

A.3.3.41 Compressed Breathing Air. The quality of the compressed breathing air used in open-circuit SCBA has a direct effect on the performance of the equipment. It is therefore imperative that breathing air consistent with the design criteria established in this standard is used to ensure that the SCBA will continue to meet the performance criteria contained in this standard. It has been established through years of experience that breathing air that meets the requirements of NFPA 1989, which specifies a maximum moisture content of 24 ppm or drier [i.e., a dew point of −54°C (−65°F) or lower] and a maximum particulate level of 5 mg/m^3 air, will meet the needs of both emergency services personnel and the SCBA. *(See also 19.1.3.3.)*

A.3.3.49 Drag Rescue Device (DRD). The DRD is intended solely to assist in pulling or dragging an incapacitated firefighter and is not intended for vertical rescue operations where the victim firefighter would be raised or lowered.

A.3.3.54 Emblems. Users are cautioned that patches or emblems might contribute to burn injury. Emblems or patches used on work apparel are not included in the test requirements of this standard. In particular, users are cautioned about using large emblems or patches on work apparel because these items are not required to be tested under Chapters 10 through 14 of this standard for heat or flame resistance or stored energy. Where non-flame-resistant or non- heat-resistant emblems are attached to the exterior of the work apparel, no more than five (5) separate emblems should be used on a single garment. No individual emblem should cover an area greater than 103 cm^2 (16.0 in.^{2}) and the total area covered by all emblems on a single garment should not exceed 258 cm^2 (40 in.^{2}). Large emblems consisting of discrete letters, numbers, or images should be considered a single emblem.

A.3.3.59 Entry Firefighting. Examples of fires that commonly produce extreme levels of convective, conductive, and radiant heat and could result in incidents incorporating entry firefighting operations include, but are not limited to, bulk flammable liquid fires, bulk flammable gas fires, bulk flammable metals, and aircraft fires. Highly specialized thermal protection is necessary for persons involved in such extraordinarily specialized operations due to the scope of these operations and because direct entry into flames is made. Usually these operations are exterior operations as in outside of structures. Entry firefighting is *not* structural firefighting.

A.3.3.62 Faceshield. The faceshield is not intended as primary eye protection.

A.3.3.66 Flame Resistance. Flame resistance can be an inherent property of the textile material, or it can be imparted by specific treatment.

A.3.3.69 Footwear. See Figure A.3.3.69.

A.3.3.80 Gusset. The gusset generally lacks some layers used in the construction of the footwear upper or might include different layers for the purpose of being flexible. The gusset is not observable from the front of the footwear when the footwear is donned or laced up.

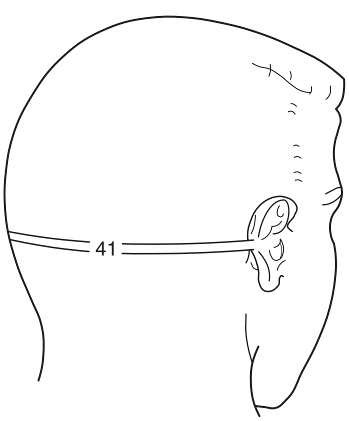


FIGURE A.3.3.11 Bitragion Inion Arc.

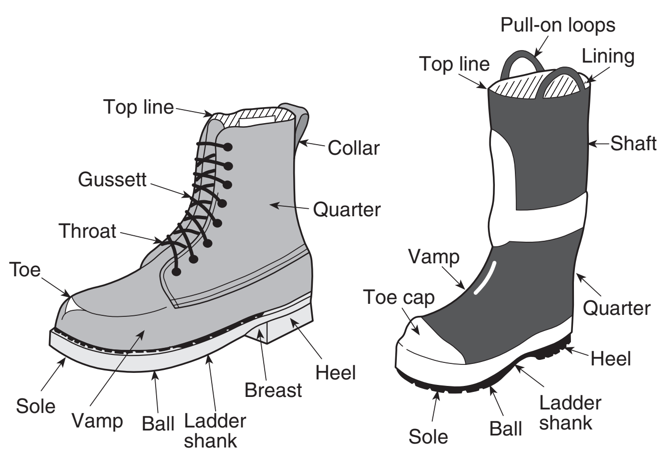


FIGURE A.3.3.69 Identification of Footwear Terms.

A.3.3.83 Hazardous (Classified) Location (HazLoc). A hazardous (classified) location is a location in which an explosive gas atmosphere or explosive dust atmosphere might exist. Electrical equipment used where such atmospheres might exist needs to be protected against the risk of explosion from energy or thermal ignition sources. Within this standard, intrinsic safety (IS) and nonincendive (NI) are protection concepts associated with the rating of equipment for operation in potentially explosive atmospheres. IS and NI ratings consider the nature of the explosive atmosphere encountered — Class I being explosive gas atmospheres and Class II being explosive dust atmospheres — and the frequency or interval of the presence of such explosive atmospheres (i.e., continuously, intermittently, or abnormally). The frequency or interval of the presence of the explosive atmosphere determines the proper Division (i.e., Division 1 or Division 2) or Zone (i.e., Zone 0, Zone 1, or Zone 2) classifications that are applied to a particular IS or NI rating. To determine the appropriate IS or NI rating for electrical devices or circuitry, the AHJ identifies the expected explosive atmospheres likely to be encountered and the expected frequency or interval of the presence of such expected explosive atmospheres.

A.3.3.84 Hazardous Materials. Hazardous materials are any solid, particulate, liquid, gas, aerosol, or mixture thereof that can cause harm to the human body through respiration, ingestion, skin absorption, injection, or contact.

A.3.3.121 NIOSH Certified. An SCBA being "NIOSH certified" is only one part of the certification process to Chapters 15 through 19 of this standard. SCBA that are only NIOSH certified are not compliant with Chapters 15 through 19 and should not be construed as having certification as compliant with NFPA 1970. See Section 15.2 for further details. For the NIOSH certification to remain in effect, the SCBA must be used and maintained in the "as approved" condition.

NIOSH certification is conducted in accordance with the requirements of 42 CFR 84, Subpart H.

A.3.3.125 Particulate Blocking Layer. For the purpose of this standard, the particulate blocking layer is intended to inhibit the passage of smoke particles through the protective clothing element or interface device. The combination of the particulate blocking layer and other layers associated with the element or interface device might also contribute to this function.

A.3.3.126 Particulates. There are at least seven forms of particulate matter, as follows:

(1) *Aerosol.* A dispersion of solid or liquid particles of microscopic size in a gaseous medium such as smoke, fog, or mist.
(2) *Dust.* A term loosely applied to solid particles predominantly larger than colloidal and capable of temporary suspension in air or other gases. Derivation from larger masses through the application of physical force is usually implied.
(3) *Fog.* A term loosely applied to visible aerosols in which the dispersed phase is liquid. Formation by condensation is implied.
(4) *Fume.* Solid particles generated at condensation from the gaseous state, generally after volatilization from melted substances and often accompanied by a chemical reaction such as oxidation. Popular usage sometimes includes any type of contaminant.
(5) *Mist.* A term loosely applied to dispersion of liquid particles, many of which are large enough to be individually visible without visual aid.
(6) *Smog.* A word derived from the words smoke and fog and applied to extensive atmospheric contamination by aerosols arising from a combination of natural and human-made sources.
(7) *Smoke.* Small gasborne particles resulting from incomplete combustion and consisting predominantly of carbon and other combustible materials.

A.3.3.129 Passive Electrical Circuitry. An example of such circuitry is a passive radio-frequency identification (RFID) tag.

A.3.3.133 PFAS. There are various ways PFAS is defined, ranging from specific target analytes with registered chemical abstract service (CAS) numbers to the group of specific chemicals as a 'family' or class of substances.

For this standard, the definition of PFAS is based on the US. House of Representatives (HR 5987, *The PFAS Definition Improvement Act)* November 2021 amendment to Section 8(a)(7) of the *Toxic Substances Control Act* (15 U.S.C. 2607(a)(7)) where the phrase "that contains at least one fully fluorinated carbon atom," was inserted after "perfluoroalkyl or polyfluoroalkyl substance". This and other definitions have been used by different regulatory authorizations and other organizations.

An alternative definition for PFAS is "fluorinated substances that contain at least one fully fluorinated methyl or methylene carbon atom, which are primarily categorized through the presence or absence of a nonfluorinated functional group." This second definition is derived from the 2021 OECD PFAS definition in the Organization for Economic Co-operation and Development (OECD) publication, "Reconciling Terminology of the Universe of Per- and Polyfluoroalkyl Substances: Recommendations and Practical Guidance."

In this standard, the presence of PFAS is determined using an analytical test that detects and quantifies all possible PFAS using currently available state-of-the-art technology for measuring the total fluorine content in materials. A different set of tests is applied for detecting and quantifying specific PFAS chemicals that are found in materials and components subject to restricted substance requirements in this standard.

A.3.3.139 Product Label. The product label is not the certification organization's label, symbol, or identifying mark; however, the certification organization's label, symbol, or identifying mark can be attached to it or be part of the product label.

A.3.3.151 Proximity Firefighting. Examples of fires that commonly produce high levels of radiant heat, as well as convective and conductive heat, and could result in incidents incorporating proximity firefighting operations include, but are not limited to, bulk flammable liquid fires, bulk flammable gas fires, bulk flammable metal fires, and aircraft fires. These operations usually are exterior operations but might be combined with interior operations. Proximity firefighting is not structural firefighting but might be combined with structural firefighting operations. Proximity firefighting also is not entry firefighting. The firefighting activities differ from "entry firefighting" as proximity firefighting does not include direct entry of firefighters into flames. Proximity operations are performed close to the actual fire where the high levels of radiant heat as well as the convective and conductive heat would overcome the thermal protection provided by structural firefighting protective ensembles and the proximity firefighting protective ensembles provide enhanced protection from these thermal exposures. After the fire and heat have been controlled at a proximity firefighting incident, entry into structures or enclosures by firefighters protected by proximity firefighting protective ensembles could be made where the incident requires additional operations for control of the incident.

A.3.3.163 Radiological Particulate Terrorism Agents. Chapters 4 through 9 of this standard only provides partial protection from certain radiation sources. By their nature, these ensembles provide protection from alpha-particles, and the element materials and distance will significantly attenuate beta-particles. These ensembles do not provide any protection from ionizing radiation, such as gamma- and x-rays, other than to keep the actual radiological particulate from direct skin contact.

A.3.3.167 Recognized Component. The term *recognized component* was utilized to clearly distinguish the certification of these products from the certification of finished products. Recognized components can consist of, but are not limited to, fabrics, hardware, sewing thread, glove liners, footwear liners, helmet shells, and so on that are used to construct compliant products. Recognized components are not considered to cover raw materials such as fibers, material finishes, resins, or other materials used to construct the components.

A.3.3.170 Restricted Substance. Restricted substances can be hazardous, toxic, corrosive, ignitable, explosive, chemically reactive, persistent, or bioaccumulative. These substances are restricted because governments or other organizations have established specific limits for their use in various products that either prohibit their use or set maximum limits for their concentration in the respective product. Limits for restricted substances are specifically addressed for forms of PPE given the potential for exposure of individual wearers of the PPE or to individuals handling the PPE, or for potential for contamination of environment in the manufacture of PPE.

A.3.3.171 Restricted Substance Attestation Organization. Specific criteria for restricted substances and their measurement are established in Chapters 4, 7, 8, and 9 as part of this standard.

A.3.3.183.1 Major A Seam. Each TC can identify the various layers in the annex if so desired.

A.3.3.185 Self-Contained Breathing Apparatus (SCBA). For the purposes of Chapters 15 through 19 of this standard, where the term is used without a qualifier, it indicates only open-circuit self-contained breathing apparatus or combination SCBA/SARs. *[See also 3.3.4, Atmosphere-Supplying Respirator; 3.3.34, Combination SCBA/SAR; and 3.3.208, Supplied Air Respirator (SAR).]*

A.3.3.199 Structural Firefighting Protective Ensemble. Structural firefighting protective ensembles include, but are not limited to, garments, helmets, hoods, gloves, and footwear.

A.3.3.208 Supplied Air Respirator (SAR). For the purposes of Chapters 15 through 19 of this standard, combination SCBA/SARs are encompassed by the terms *self-contained breathing apparatus* and *SCBA*.

A.3.3.217 Tongue. The tongue might or might not be made of the same composite as the footwear upper. The tongue might be of a similar material composite as the footwear gusset.

A.3.3.220 Total Fluorine. The measurement of total fluorine is used as a surrogate or proxy estimate technique for the total amount of PFAS in a material or component by determining the amount of fluorine in the sample. Because total fluorine measurements can include findings for both non-PFAS organic chemicals as well as inorganic fluorine-based chemicals, total fluorine measurements are likely to overestimate the levels of PFAS found in any material or component sample.

A.3.3.222 Trim. Retroreflective materials enhance nighttime visibility, and fluorescent materials enhance daytime visibility. "Trim" is also known as "visibility markings" *(see also, 3.3.229, Visibility Markings).*

A.3.3.227 Upper. See Figure A.3.3.69.

A.3.3.229 Visibility Markings. Retroreflective enhancements improve night-time conspicuity, and fluorescent enhancements improve day-time conspicuity.

A.4.1.2.1 NFPA, from time to time, has received complaints that certain items of fire and emergency services protective clothing or protective equipment might be carrying labels falsely identifying them as compliant with an NFPA standard.

NFPA advises those purchasing products certified to this standard to be aware of the following:

For products to comply with NFPA 1970, they must be certified by an independent third-party certification organization. In addition, the item must carry the label, symbol, or other identifying mark of that certification organization.

If the item does not bear the mark of an independent third-party certification organization, is not compliant with NFPA 1970 even if the product label states that the item is compliant.

For further information about certification and product labeling, Chapters 4, 5, 6, 10, 11, 15, 16, 20, or 21 should be referenced. Also, the definitions for *certification/certified*, *labeled*, and *listed* in Chapter 3 should be reviewed.

Third-party certification is an important means of ensuring the quality of fire and emergency services protective clothing and equipment. To be certain that an item is properly certified, labeled, and listed, NFPA recommends that prospective purchasers require appropriate evidence of certification for the specific product and model from the manufacturer before purchasing. Prospective purchasers also should contact the certification organizations and request copies of the certification organization's list of certified products to the appropriate NFPA standard. This listing is a requirement of third-party certification by this standard and is a service performed by the certification organizations.

All NFPA standards on fire and emergency services protective clothing and equipment require that the item be certified by an independent third-party certification organization.

A.4.2.1 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.4.2.5 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.

Without 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.4.2.6 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 agency before any major testing is undertaken.

A.4.2.7.1 For further information and guidance on recall programs, see 29 CFR 7, Subpart C.

A.4.2.9 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.4.3 The testing facility should take suitable precautions to protect testing personnel and to guard against catastrophic failure that could result in a high-pressure gas release, fragmentation, and flying parts and debris. Catastrophic failure can occur, because many tests specified in Chapter 18 involve compressed gas cylinders containing high pressures, and the tests are rigorous in nature.

A.4.3.9.2 A modification of the finish, coating, fiber type, or fiber source is considered a change to the recognized component.

A.4.3.10 An example of a restricted substance attestation organization meeting these requirements is OEKO-TEX Service in their application of OEKO-TEX Standard 100 and the OEKO-TEX Standard 100 Supplement PPE & Materials for PPE.

A.4.3.10.1 Modification of the finish, coating, fiber type, or fiber sources is considered a change to the recognized component.

A.4.5.4 For example, this situation exists where a product is wholly manufactured and assembled by another entity or entities for a separate entity that puts its name and label on the product (frequently called "private labeling") and markets and sells the product as its own product.

A.4.5.5 Subcontractors should be considered to be, but not be limited to, a person or persons, or a company, firm, corporation, partnership, or other organization having an agreement with or under contract with the compliant product manufacturer to supply or assemble the compliant product or portions of the compliant product.

A.4.6 These quality assurance measures are a basic means for a supplier to reasonably manufacture components in a consistent manner. The application of Section 4.6, Recognized Component Supplier Quality Assurance Program, applies to those suppliers that are obtaining recognition of their product. Not all suppliers within the chain of a compliant product manufacturing process are required to comply with these requirements. It is understood that any components purchased by the compliant product manufacturer, which are considered proprietary, would be covered by the ISO 9001, *Quality management systems — Requirements,* registration for that manufacturer.

A.4.7.2 By definition, a hazard might involve a condition that can be imminently dangerous to the end-user. With this thought in mind, the investigation should be started immediately and completed in as timely a manner as is appropriate considering the particulars of the hazard being investigated.

A.4.7.10 An example of a manufacturer that cannot be held responsible would be one that is out of business or bankrupt.

A.4.7.11 The determination of the appropriate corrective action for the certification organization to initiate should take into consideration the severity of the product hazard and its potential consequences to the safety and health of end users. The scope of testing and evaluation should consider, among other things, testing to the requirements of the standard to which the product was listed as compliant, the age of the product, the type of use and conditions to which the compliant product has been exposed, care and maintenance that has been provided, the use of expertise on technical matters outside the certification organization's area of competence, and product hazards caused by circumstances not anticipated by the requirements of the applicable standard. As a guideline for determining which is more appropriate, a safety alert or a product recall, the following product hazard characteristics are provided, which are based on 42 CFR 84, Subpart E, §84.41:

(1) *Critical:* A product hazard that judgment and experience indicate is likely to result in a condition immediately hazardous to life or health (IHLH) for individuals using or depending on the compliant product. If an IHLH condition occurs, the user will sustain, or will be *likely* to sustain, an injury of a severity that could result in loss of life or result in significant bodily injury or loss of bodily function, either immediately or at some point in the future.
(2) *Major A:* A product hazard, other than *Critical* that is likely to result in failure to the degree that the compliant product does not provide any protection or reduces protection *and is not detectable to the user*. The phrase *reduced protection* means the failure of specific protective design(s) or feature(s) that results in degradation of protection in advance of reasonable life expectancy to the point that continued use of the product is *likely* to cause physical harm to the user, or where continued degradation could lead to IHLH conditions.
(3) *Major B:* A product hazard, other than *Critical* or *Major A*, that is likely to result in reduced protection and is detectable to the user. The phrase *reduced protection* means the failure of specific protective design(s) or feature(s) that results in degradation of protection in advance of reasonable life expectancy to the point that continued use of the product is *likely* to cause physical harm to the user, or where continued degradation could lead to IHLH conditions.
(4) *Minor:* A product hazard, other than *Critical*, *Major A*, or *Major B*, that is not likely to materially reduce the usability of the compliant product for its intended purpose or a product hazard that is a departure from the established applicable standard and has little bearing on the effective

use or operation of the compliant product for its intended purpose.

Where the facts are conclusive, based on characteristics of the hazard classified as indicated previously, the certification organization should consider initiating the following corrective actions with the authorized and responsible parties:

(1) *Critical* product hazard characteristics: product recall
(2) *Major A* product hazard characteristics: product recall or safety alert, depending on the nature of the specific product hazard
(3) *Major B* product hazard characteristics: safety alert or no action, depending on the nature of the specific product hazard
(4) *Minor* product hazard characteristic: no action

A.4.7.13 Reports, proposals, and proposed TIAs should be addressed to the technical committee that is responsible for the applicable standard and be sent in care of Standards Administration, NFPA, 1 Batterymarch Park, Quincy, MA 02169-7471.

A.5.1.1 Organizations responsible for specialized functions including, but not limited to, wildland firefighting, proximity firefighting, and other specialized firefighting, emergency medical service, special operations, and hazardous materials response should use appropriate protective clothing and protective equipment specifically designed for those activities.

A.5.1.1.3 The optional liquid and particulate contaminant protection criteria are intended to address protection of firefighters against fireground liquids and smoke particulates that carry chemical and other hazardous contaminants. Individual requirements for protective garments, gloves, and footwear currently specify the use of a moisture barrier or liquid protection requirements; however, the entire ensemble is not evaluated for liquid penetration resistance performance. In particular, interfaces between individual elements are susceptible to inward leakage of liquids that can only be determined when the entire ensemble as configured by the organization is evaluated. Similarly, there are no requirements for particulate penetration resistance of ensemble elements or the overall ensemble with the exception of protective hoods that are also certified for the optional particulate barrier protection. Ensemble elements that incorporate moisture barriers will limit particulate penetration; however, the interfaces between elements will readily permit inward penetration of particulate from smoke and other sources at the fire scene. Standard protective hood interface components have no barrier material and allow the passage of particles through the hood materials to the firefighter's head and neck that are not covered by the SCBA facepiece.

New requirements for optional liquid particulate contaminant protection are only applied to protective garments because of the difficulty of evaluating every conceivable combination of the different ensemble elements in addition to available self-contained breathing apparatus (SCBA) facepieces. This approach can be justified on the basis of fact that protective garments provide the principal integration function for the majority of the ensemble, particularly as applied to interfaces with gloves, footwear, and hood while also addressing the coat to trousers overlap and the closures provided in both coats and trousers. Specific performance testing still involves ensembles; however, the manufacturer of the protective garments selects the other elements of the ensemble to be tested and is required to report which elements are used in this testing.

The optional liquid and particulate contaminant protection criteria are not intended to protect against all hazardous substance exposures, but rather minimize firefighter exposures to routine liquids, including hot, cold, or contaminated water and the bulk of particulates generated at the fire scene. Some liquids and particulate might still pass through the clothing depending on the nature of the exposure, including the exposure time and conditions. Moreover, hazardous vapors or gases could still also penetrate individual ensemble elements or interfaces leading to exposures. Garments that are certified to the optional liquid and particulate contaminant protection criteria are not hazardous materials protective garments and should not be used in place of these specialized ensembles.

Organizations responsible for hazardous materials first response should use protective ensembles and protective clothing specifically designed for those hazardous materials emergencies and should use ensembles that are certified to NFPA 1990 (NFPA 1991, NFPA 1992, and NFPA 1994).

Specific criteria for CBRN protective ensembles previously addressed in the 2007 and 2013 editions of NFPA 1971were moved to NFPA 1994. NFPA 1994 establishes requirements for chemical/biological protection as part of the Class 2 requirements. The 2012 edition of NFPA 1994 specified criteria for single-use CBRN protective ensembles; however, the 2018 edition includes CBRN protection criteria for both single- and multiple-use protective ensembles. The NFPA 1994 requirements referenced are not contained within NFPA 1990.

A.5.1.1.5 Statistics show that firefighters are far more likely to suffer or die from heat-stress-related issues than from thermal exposure. In overhaul operations, the thermal protections required for fire attack are not needed. The thermal barrier adds unnecessarily to heat stress. There might be environmental conditions such as cold environments that might necessitate the use of a garment with thermal insulation. By substituting the use of structural coats and pants with NFPA 1951–compliant coats and trousers (or coveralls) for overhaul, firefighters can operate in a safer environment. All other elements (i.e., helmet, hood, gloves, and footwear) of the structural ensemble, including SCBA with mask donned, should be worn.

A.5.1.1.6 Fire and emergency response organizations are cautioned that accessories are not a part of the certified product but could be attached to the certified product by a means not engineered, manufactured, or authorized by the manufacturer.

Fire and emergency response organizations are cautioned that if the accessory or its means of attachment causes the structural integrity of the certified product to be compromised, the certified product might not comply with the standard for which it was designed, manufactured, and marketed. Additionally, if the accessory or its attachment means are not designed and manufactured from materials suitable for the hazardous environments of emergency incidents, the failure of the accessory or its attachment means could cause injury to the emergency responder.

Because the aftermarket for certified product accessories is so broad, fire and emergency response organizations are advised to contact both the manufacturer of the accessory and the manufacturer of the certified product and verify that the accessory and its means of attachment are suitable for use in the intended emergency response environment. Fire and emergency response organizations should seek and receive written documentation from both the accessory manufacturer and the manufacturer of the certified product to validate the following information:

(1) The accessory for a certified product, and its attachment method, will not degrade the designed protection or performance of the certified product below the requirements of the product standard to which it was designed, manufactured, tested, and certified.
(2) The accessory, when properly attached to the certified product, should not interfere with the operation or function of the certified product, or with the operation or function of any of the certified product's component parts.

Users are also cautioned that the means of attachment of the accessory that fail to attach the accessory safely and securely to the certified product can cause the accessory to be inadvertently dislodged from the certified product and create a risk to the wearer or other personnel in the vicinity.

A.5.1.1.7 Firefighters often wear structural firefighting PPE when mitigating responses that do not involve structural firefighting. Departments should consider providing their members with PPE suitable for nonstructural firefighting incidents such as, but not limited to, technical rescue, vehicle extrication, medical, search and rescue, wildland and urban interface, and nonfire roadway incidents. There might be environmental conditions such as cold environments that might necessitate the use of a garment with thermal insulation.

A.5.1.2 This standard is not designed to be utilized as a purchase specification. It is prepared, as far as practicable, with regard to required performance, avoiding restriction of design wherever possible. Purchasers should specify departmental requirements for items such as color, markings, closures, pockets, and patterns, or other features related to specific elements or ensembles. Tests specified in this standard should not be deemed as defining or establishing performance levels for protection from all structural or proximity firefighting environments.

A.5.1.2.1.1 A list of potential fireground and other related emergency hazards that can be addressed in this standard appears in Table A.5.1.2.1.1 (extracted from NFPA 1851). These hazards include not only hazards arising from the emergency scene but also hazards that might be present from wearer contact with, or use of, protective ensembles and ensemble elements before, during, and after emergency operations.

A.5.1.2.3 The testing requirements in Chapter 9 of this standard are not intended to establish the limitations of the working environment for firefighting but are intended to establish material performance. Users should be advised that when a continual increase of heat is felt through the protective ensemble, the protective ensemble could be nearing its maximum capability and injury could be imminent.

Users should be advised that if unusual conditions prevail, or if there are signs of abuse or mutilation of the protective ensemble or any element or component thereof, or if modifications or replacements are made or accessories are added without authorization of the protective ensemble element manufacturer, the margin of protection might be reduced.

Users should be advised that the protective properties in new structural firefighting protective ensemble elements, as required by this standard, can diminish as the product is worn and ages.

Table A.5.1.2.1.1 List of Potential Fireground and Other Related Emergency Hazards

Physical Hazards	***Chemical Hazards***
Falling objects	Inhalation
Flying debris	Skin absorption or contact
Projectiles or ballistic objects	Chemical ingestion or injection
Abrasive or rough surfaces	Liquefied gas contact
Sharp edges	Chemical flashover
Pointed objects	Chemical explosions
Slippery surfaces	***Electrical Hazards***
Excessive vibration	High voltage
Environmental Hazards	Electrical arc flashover
High heat and humidity	Static charge buildup
Ambient cold	***Radiation Hazards***
Wetness	Ionizing radiation
High wind	Non-ionizing radiation
Insufficient or bright light	***Person-Position Hazards***
Excessive noise	Daytime visibility
Thermal Hazards	Nighttime visibility
High convective heat	Falling
Low radiant heat	Drowning
High radiant heat	***Person-Equipment Hazards***
Flame impingement	Material biocompatibility
Steam	Ease of contamination
Hot liquids	Thermal comfort
Molten metals	Range of motion
Hot solids	Hand function
Hot surfaces	Ankle and back support
Biological Hazards	Communications ease
Bloodborne pathogens	Fit (poor)
Airborne pathogens	Ease of donning and doffing
Biological toxins	
Biological allergens	

[**1851:**Table A.5.1.1]

A.5.1.3.2 Specific design and performance criteria are established in Chapters 5 through 9 of this standard to demonstrate limited protection against liquid and particulate contaminant hazards to reduce the amount of contamination that passes through the garment onto the firefighter's skin and to reduce the contamination that might remain in the garment elements as a result of the exposure. Full-scale tests are used to evaluate the resistance of complete ensembles to penetration of liquids and particulates but are not certified as an ensemble as only the areas underneath the garment are evaluated.

A.5.2.6.10 Once a specific outer shell has been evaluated for its evaporative resistance, that value, "Result C," does not need to be retested in the future. If future composites utilize the same specific outer shell, its previously determined value, "Result C," can be used in the calculation of the composite's evaporative resistance. The same logic applies in the case of the specific moisture barrier and thermal barrier combination as calculated as "Difference D." The following list used with Table A.5.2.6.10 provides an example:

(1) A composite (1) is comprised of an outer shell (OS1) and a moisture barrier/thermal barrier combination (L1). Using the optional test sequence, its evaporative resistance (Sum E1) is calculated.

(2) A second composite (2) comprised of a different outer shell (OS2) and the same moisture barrier/thermal barrier combination (L1) as provided in A.5.2.6.10(1). Rather than repeating steps 5.2.6.1 through 5.2.6.3 to determine A and B, the value of D calculated for L1 is used to calculate Sum E2 along with the evaporative resistance of OS2 in accordance with 5.2.6.8.

(3) A third composite (3) is comprised of OS1 and a different moisture barrier/thermal barrier combination (L2). Rather than repeat the testing of OS1, its previously determined evaporative resistance is used in the calculation of evaporative resistance.

A.5.3.11 The order of testing is from left to right in Table A.9.1(b). Where there is more than one environmental condition for a specific test, the order of environmental conditioning for that test is from top to bottom in Table A.9.1(b).

A.5.3.12 The order of testing is from left to right in Table A.9.1(g). Where there is more than one environmental condition for a specific test, the order of environmental conditioning for that test is from top to bottom in Table A.9.1(g).

A.5.4.1(2)(b) An example of a nonquantitative result would be pass or fail for melting and dripping.

A.5.4.2(2) An example of a nonquantitative result would be pass or fail for melting and dripping.

A.6.1.1 Purchasers might wish to include a requirement in the purchase specifications for an additional label that includes certain information such as the date of manufacture, manufacturer's name, and garment identification number to be located in a protected location on the garment in order to reduce the chance of label degradation and as a backup source of information to aid in garment tracking or during an investigation. Purchasers might also wish to include a requirement in the purchase specifications for inclusion of a blank label or blank space on a label for the end user to "write in" information; however, considerations should also be given to the size of this label and all labels in order to minimize the size and amount of labels utilized in the product.

A.6.1.3 See A.4.1.2.1.

A.6.1.7.1(2) Examples of shell materials are thermoplastic, thermoplastic/leather, fiberglass composite, and fiberglass composite/leather.

A.6.1.7.1(3) For gloves, leather should be identified by the type of hide — for example, cow leather or elk leather. Any significant additional layer should also be identified, such as an additional thermal liner or other layer that is used on the back of the hand in the glove body. Items including, but not limited to, elastic, thread, and liner attachment tapes do not have to be listed on the label.

A.6.1.7.1(4) For example, an additional thermal layer that is used in the significant portion of the footwear should be listed on the label. Similarly, any special form of external reinforcement that covers a significant portion of the footwear should be listed. Zippers, eyelets, toe caps, puncture-resistant plates, and ladder shanks are not required to be listed. Type of leather is not required to be listed. Trade names can be used in place of generic material names, if desired.

A.6.1.7.5 There is currently no standardized or technically practical way to fully determine the exact amount of all PFAS chemicals that might be present in a protective element. However, there are accepted industry practices for measuring the total fluorine in a given material or component that have been used for representing the total PFAS that might be present. The current techniques for measuring total fluorine will report fluorine levels that potentially include fluorine from both organic fluorine chemicals as well as inorganic fluorine chemicals that are not considered PFAS.

It is further recognized that while manufacturers or their suppliers might not intentionally add or believe PFAS has been added to a specific material or component, PFAS might still be present at measurable levels in the tens to hundreds of parts per million based on contaminated raw materials, fabrication processes, or various ways of handling materials. Some regulatory bodies have established limits for PFAS that account for some level of measurable total fluorine or total organic fluorine. A method for total organic fluorine had not been standardized at the time this standard was completed. Nonetheless, the prevailing limit for total fluorine in products has been established as 100 ppm for textile-based products in the following publications: *California Safer Clothes and Textiles Act* (AB 1817), the 2024 edition of OEKO-TEX Standard 100, and the 2024 edition of the AFIRM Restricted Substances List. Consequently, the limit of 100 ppm of total fluorine has become an acceptable practice for distinguishing between products that have "intentionally added" PFAS and those that do not.

Manufacturers choosing to apply this language as part of their label are encouraged to provide supplemental information as part of their user information that helps explain the specific total fluorine measurements that apply to their certified protective elements.

A.6.1.7.6 The purpose of this label is to provide critical information required for inspection and retirement purposes, including the manufacturer's name, identification, or designation; the manufacturer's element identification number, lot number or serial number; and the month and year of manufac-

Table A.5.2.6.10 Example of Procedure in 5.2.3

Composite ID	Outer Shell	Moisture Barrier/ Thermal Barrier Combination	Does the Result C for the given outer shell exist?	Do Results A and B for a given moisture barrier/thermal barrier combination exist?	Calculation of D	Calculation of E
1	OS1	TL1	No, test C1	No, test A1 and B1	D1 = B1 – A1	E1 = C1 + D1
2	OS2	TL1	No, test C2	Yes, A1 and B1	D1	E2 = C2 + D1
3	OS1	TL2	Yes, C1	No, test A2 and B2	D2 = B2 – A2	E3 = C1 + D2

ture. Larger labels might peel and detach from the helmet during use. A smaller label is more likely to remain in place.

A.6.1.8 Nonvisual/machine-readable tags include, but are not limited to, RFID tags, blue tooth, data chips, and so on. These tags are typically scannable and provide specific data when scanned, similar to a bar code. The intent of permitting these supplemental tags is to allow for additional methods of tracking element use, laundering, and so on, while also assuring a level of performance if included within an element.

A.6.3.4 The necessity exists to label the shroud with applicable helmet and cover information. In addition, it is necessary to label the cover (where separate from the shroud) with the applicable helmet and shroud information. Labeling in this manner will ensure all three pieces (helmet, shroud, and cover) are addressed on all individual component labels such that the proper components and models are present and used with one another. Where the shroud and cover are combined, only one label is necessary for both the cover and the shroud.

A.6.4.1 Class designations use Roman numerals, and Division designations use Arabic numerals.

A.6.5.2 Packaging containing the user information can consist of printed materials or instructions to access the information digitally.

A.6.5.4 A statement should be included in the user information advising that, upon the purchaser's request, the manufacturer is to furnish all documentation required by this standard and the test data showing compliance with this standard. A statement also should be included in the user information advising that, upon the purchaser's request, the manufacturer is to furnish a complete specification of all materials and components comprising each certified hood.

A.6.5.6 It is recommended that manufacturers also describe how an individual selecting a specific glove size assesses the relative fit and function of the glove, with suggestions for changing to a different glove size if hand function or protection is impaired.

A.6.5.9(3) The purpose of the information is primarily to document those other elements of the ensemble that were used for qualifying the protective garment(s) to the optional liquid and particulate contaminant protection requirements of this standard. This information does not imply that other individual elements used in testing as indicated by the manufacturer meet any specific requirements for liquid and particulate protection. Additionally, this information does not convey that the specific ensemble tested is certified as an "ensemble" meeting the optional liquid and particulate contaminant protection requirements as this standard does not cover ensemble certification.

A.6.5.11 The test method provided in 9.10.2 represents the best available analytical testing technology at the time this edition was finalized for determining the limited presence of all PFAS in products and might be subject to future updates as testing technology evolves.

A.6.5.12 These results should be viewable on the product listings page of the certification organization's website.

A.7.1 Purchasers of protective clothing should realize that firefighters have to wear many items of protective clothing and equipment. Any interference by one item with the use of another might result in inefficient operations or unsafe situations. Chest girth, sleeve length, and coat length should be required for protective coats; waist girth, inseam length, and crotch rise should be required for protective trousers; and chest girth, sleeve length, waist girth, outseam length from the underarm to the pant cuff, and trunk length from the base of neck to the crotch fold should be required for protective coveralls. Since manufacturers' patterns vary, measurement for sizing should be done by the manufacturer's representative or by a trained person in accordance with the manufacturer's instructions to ensure proper fit.

A.7.1.2 Purchasers might wish to specify additional reinforcement or padding in high-wear or load-bearing areas, such as pockets, cuffs, knees, elbows, and shoulders. Padding could include additional thermal barrier material meeting requirements as specified herein. Reinforcing material could include the outer shell material or leather. Purchasers are cautioned that additional weight caused by excessive reinforcement or padding could lead to fatigue or result in injury. Where garments have an inspection opening installed to facilitate advanced liner inspections as specified in NFPA 1851 the functionality of the opening should be inspected to determine that the opening will permit the examination of the entire liner interior. The inspection opening should be designed to prevent the entering of foreign matter.

A.7.1.3 The fastener system should be specified by the purchaser. Fastener system methods can include, but are not limited to, the following:

(1) Entirely securing the thermal barrier and moisture barrier to a component part of the outer shell with snap fasteners or fastener tape
(2) Zipping the thermal barrier and moisture barrier to the outer shell
(3) Stitching the thermal barrier and moisture barrier into the coat in the neck and into the trouser in the waist area with snap fasteners or hook and pile fasteners securing the remainder
(4) Entirely stitching the thermal barrier and moisture barrier to the outer shell

It is strongly recommended that the thermal barrier and moisture barrier be detachable to facilitate cleaning the garments.

A.7.1.8 Purchasers should specify pockets large enough to hold the items normally carried. Placement should allow for access to the pockets while wearing SCBA. Specifying ballooned pockets can increase capacity but could interfere with maneuverability. Ballooning only the back edges could minimize the maneuverability problem. Divided pockets as well as pockets for specific items such as SCBA facepieces and radios could be desirable.

A.7.1.9.1.2 When evaluating a DRD, consideration should be given to the access point for deployment. The use of oversized tabs or flaps might aid in grasping the DRD with a gloved hand.

A.7.1.9.2 Purchasers should consider specifying wristlets with a thumb hole or bartack creating a thumb hole for the wearer's thumb in order to ensure protection when arms are in the raised position.

A.7.1.11 Coat length is not addressed in this document as it must be determined by the individual donning both coat and trouser and proceeding through the directions contained in NFPA 1550 to ensure adequate overlap between the coat and trouser. Overlap is a significant safety issue and can be best addressed by careful overlap evaluation and ensuring only those coat/trouser combinations are worn that are recommended by the manufacturer of those ensemble items.

A.7.1.12 Methods for attaching harnesses and belts to garments include, but are not limited to, sewing of any harness or belt components to garment materials, the use of loop through which harnesses or belts are inserted, or the use of fastener tape for attaching these items.

A.7.2.2 The high-visibility materials required on firefighter PPE effectively enhance visual conspicuity during the variety of fireground operations. The continuous use of high-visibility garments is one component of a strategy to mitigate risks from struck-by hazards, which are known to cause serious firefighter injuries and fatalities on an annual basis. Please note that additional high-visibility requirements for firefighters on or near roadways are regulated by the US Federal Highway Administration's *Manual on Uniform Traffic Control Devices (MUTCD)*, 2009 edition, §6D.03, pp. 564-565. It is the responsibility of the authority having jurisdiction to specify appropriate high-visibility apparel from the available garment options, and, based on a risk assessment, to establish policies for high-visibility apparel use in accordance with prevailing regulations (the *MUTCD*) and in compliance with applicable standards (e.g., NFPA 1971, ANSI/ISEA 107, *American National Standard for High Visibility Safety Apparel and Accessories*, and ANSI/ISEA 207, *American National Standard for High Visibility Public Safety Vests*). Users of protective clothing should be aware that reflective trims have varying durability under field-use conditions. Trim can be damaged by heat but still appear to be in good condition when it might have lost retroreflective properties. Trim can become soiled and lose fluorescing and retroreflective qualities. Trim can lose retroreflective qualities in rain or in firefighting water exposures.

Trim should be checked periodically by using a flashlight to determine retroreflective performance. The trim should be bright. Samples of new trim can be obtained from the manufacturer for comparison, if necessary.

A.7.2.3 Use of vertical trim on the front of a protective coat has been shown to be capable of detrimentally affecting the performance of SCBA in high heat exposure conditions, such as flashover heat/flame conditions.

A basic minimum trim pattern has been established to eliminate CIL requirements and the requirements for minimum square inches for trim. It was decided to use minimum 325 in.^{2} fluorescence on a size 40 coat and for all other coats to have trim established proportionately using a trim pattern instead of actual square-inch requirements.

It is recommended that the circumferential bands on the coat not be aligned. An irregular pattern of bands improves the conspicuousness of the user.

A.7.2.4 It is recommended that the trim on trousers be positioned at least 75 mm (3 in.) above the leg hem.

A.7.4.8 Examples of items that might be installed or attached include, but are not limited to, the following:

(1) Front holders for helmet identification shields
(2) Supplemental faceshields
(3) Other eye/face protection where goggles are provided with the helmet as the required faceshield/goggle component identified in 7.5.2

A.7.5.2 Many helmet designs expose the faceshield/goggle component(s) to abrasion, heat, flame, and particulate contamination. Purchasers might wish to specify a means of protecting the component(s). This could include, but not be limited to, faceshield/goggle components that retract inside the helmet, and coverings for the component(s) that are inherently resistant to the firefighting environment. Fire departments should consider the health risks associated with contaminated goggles coming in direct contact with the wearer's face. Goggles do not have to be attached to the helmet.

A.7.7.3.5 The procedures for the measurement of wrist crease are shown in Figure A.7.7.3.5(a) through Figure A.7.7.3.5(d).

A.7.7.3.5(4) The measurements given in 7.7.3.5(4)(a) through 7.7.3.5(4)(d) are palm lengths and were determined using historical anthropometric data that related digit length to glove length for various sized gloves.

A.7.7.4 Manufacturers can provide upon request a size chart for each model or style of glove based on hand breadth and index finger length as measured on a Brannock-style measuring device.

A.7.7.5 The proposed sizing system requires D2 index finger lengths for each size. The data in Table A.7.7.5 from "Hand Anthropometry of U.S. Army Personnel" (Greiner 1991) is provided as guidance for the other fingers.

After selecting a size from 7.7.5, the ratios in Table A.7.7.5 can be used for guidance for the other finger lengths. Refer to the original study (Greiner 1991) for a complete discussion on the variance for each of these measurements.

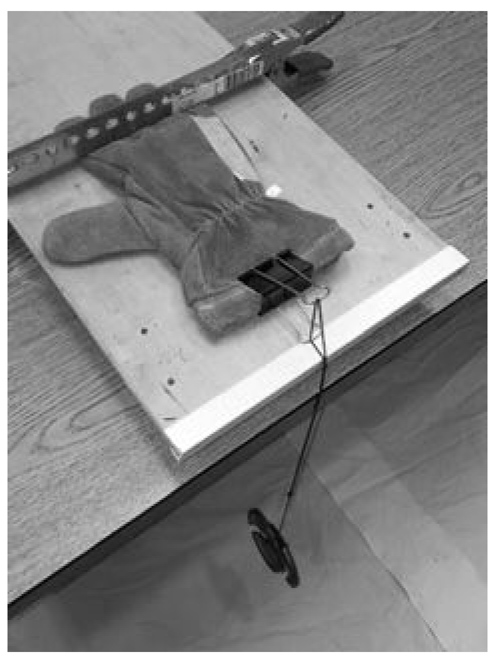


FIGURE A.7.7.3.5(a) Glove on Measurement Board with Attached Weight.

The values contained in Figure 7.7.4.1 are bare-hand dimensions, not glove pattern dimensions. Guidelines for applying these dimensions to flat glove patterns vary, depending on such factors as the type of pattern being used, the number of layers in the glove, and the type of fit desired for the glove.

A.7.7.5.1.1 A unique sizing system can include a series of measurements or other means by which an end user can assess their glove size prior to trying on a glove. Specific dimensions

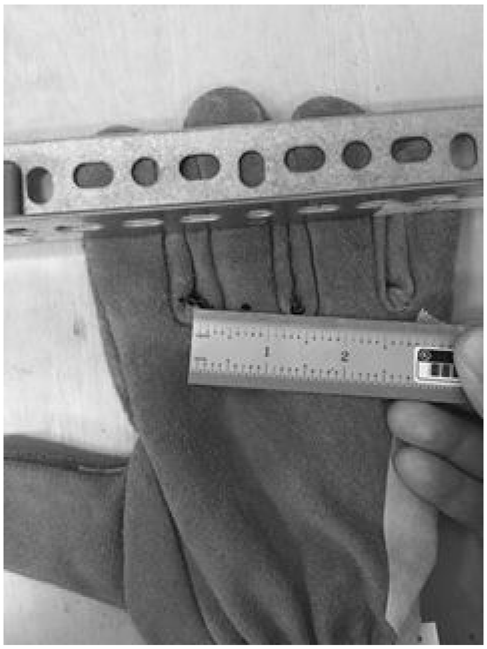


FIGURE A.7.7.3.5(b) Determining the Location for the Bottom of Digit Three.

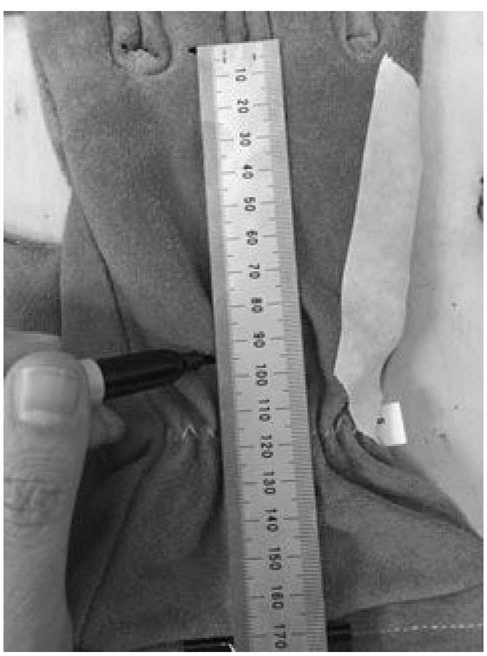


FIGURE A.7.7.3.5(c) Marking the End Point of the Added Dimension.

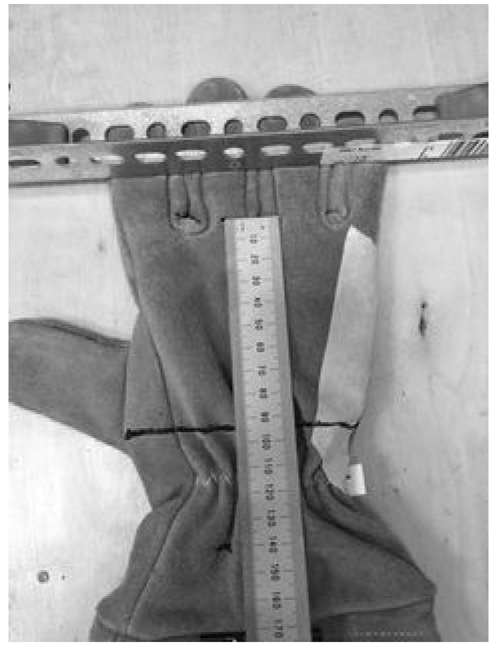


FIGURE A.7.7.3.5(d) Line Drawn Marking the Wrist Crease.

Table A.7.7.5 Finger Sizing System

		Means		Means	
	Finger	**Females (mm)**	**Females: Ratio Compared to D2**	**Males (mm)**	**Males: Ratio Compared to D2**
D1	Thumb	63.50	0.91	69.70	0.93
D2	Index	69.60	1.00	75.30	1.00
D3	Middle	77.20	1.11	83.80	1.11
D4	Ring	72.20	1.04	79.20	1.05
D5	Little	58.30	0.84	64.70	0.86

Source: Greiner, T. M., "Hand Anthropometry of US Army Personnel," US Army Natick Soldier Research Development and Engineering Center, 1991.

that can be considered include, but are not limited to, hand length, index finger length, length of other fingers or thumb, hand circumference, hand breath, digit length (by individual finger), and digit circumference (by individual finger). One proposed system is based on recent research undertaken by the Division of Safety Research for NIOSH and is reported in "Firefighter Hand Anthropometry and Structural Globe Sizing: A New Perspective." This sizing system uses a large number of hand and finger dimensions to define a seven-size system, including small, small-medium, small-medium wide, central medium, medium-large, medium-large wide, and large, designed to accommodate firefighters with dimensions from the 2.5th to 97.5th percentile. Figure A.7.7.5.1.1 shows how this system is related to the default sizing system. Table A.7.7.5.1.1(a) and Table A.7.7.5.1.1(b) show how the hand dimension measurements are applied to the NIOSH-recommended firefighter glove system and how the measurements are made, respectively.

Table A.7.7.5.1.1(a) Specific Hand Dimensions On Which NIOSH-Recommended Glove Sizing System is Based

	New	Small (*n* = 94)		S-M (*n* = 87)		S-M Wide (*n* = 91)		Central (*n* = 393)		M-L Wide (*n* = 78)		M-L (*n* = 71)		Large (*n* = 105)	
Hand Dimension	**Old**	**XS (*n* = 3)**		**S (*n* = 16)**		**M (*n* = 84)**		**L (*n* = 188)**		**XL (*n* = 100)**		**XXL (*n* = 38)**		**XXXL (*n* = 5)**	
		M	***SD***	***M***	***SD***	***M***	***SD***	***M***	***SD***	***M***	***SD***	***M***	***SD***	***M***	***SD***
Hand length	New	180	4.8	190	4.5	191	4.5	196	5.8	203	3.9	204	5.0	211	5.2
	Old	171	5.1	184	9.2	193	7.7	197	8.6	201	8.7	205	8.6	206	7.3
Hand breadth	New	89	4.1	91	3.0	99	3.3	97	3.4	101	3.1	95	3.3	102	3.1
	Old	84	0.6	90	4.8	95	4.3	97	4.2	99	4.3	99	4.2	101	1.6
Palm length	New	104	4.4	109	3.9	111	3.4	113	4.5	118	3.7	117	4.7	120	4.2
	Old	97	3.1	105	6.1	111	5.1	113	5.3	115	5.7	117	4.9	118	4.1
Palm breadth	New	87	4.4	89	2.9	97	3.2	95	3.4	100	3.0	94	3.3	101	2.9
	Old	81	3.0	87	4.2	94	4.3	96	4.2	98	4.3	98	4.3	101	2.1
Palm breadth (fingers closed)	New	82	4.2	84	3.1	93	3.6	91	3.8	97	3.4	89	3.7	98	3.3
	Old	77	3.3	83	4.2	89	4.6	91	4.8	93	4.9	94	4.9	98	2.4
Thumb length	New	63	2.5	68	2.8	67	2.6	70	3.1	72	3.1	74	3.0	76	3.2
	Old	60	0.6	65	5.0	69	4.0	71	3.7	72	3.5	74	3.8	70	4.4
Thumb breadth	New	22	1.6	22	1.3	25	1.4	24	1.2	26	1.2	23	1.3	25	1.5
	Old	20	0.6	22	1.0	24	1.5	24	1.7	25	1.5	25	1.5	25	1.2
Index length	New	69	2.3	73	2.5	72	2.3	75	2.8	78	2.1	78	2.4	82	2.6
	Old	69	2.5	71	3.3	74	4.0	76	3.9	77	3.9	79	4.4	79	5.8
Index breadth	New	21	1.2	21	1.4	24	1.1	23	1.0	25	1.1	21	1.3	24	1.4
	Old	19	0.6	21	1.0	22	1.5	23	1.6	23	1.7	23	1.5	24	1.1
Middle length	New	76	2.5	81	2.6	80	2.6	83	2.8	85	2.1	87	2.5	91	2.3
	Old	75	2.1	78	3.9	82	3.9	84	4.5	86	4.1	87	4.8	87	4.9
Middle breadth	New	21	1.3	20	1.2	24	1.3	22	1.1	24	1.1	21	1.6	23	1.4
	Old	19	0.6	21	1.2	22	1.5	22	1.7	23	1.8	23	1.7	24	0.7
Ring length	New	72	2.4	76	2.4	76	2.7	79	2.9	81	2.2	83	2.8	86	2.5
	Old	71	2.0	75	4.4	78	3.8	80	4.5	82	4.1	82	5.1	83	6.3
Ring breadth	New	20	1.3	20	1.2	23	1.2	22	1.1	24	1.1	20	1.6	23	1.4
	Old	18	0.6	20	1.4	21	1.6	22	1.6	22	1.8	22	1.5	23	1.1
Pinky length	New	58	2.4	62	2.6	61	2.6	65	2.8	66	2.8	68	3.0	71	3.3
	Old	55	2.6	61	3.8	64	4.0	65	4.1	67	4.4	68	4.6	66	5.0
Pinky breadth	New	18	1.3	18	1.1	20	1.2	20	1.0	21	1.1	19	1.5	21	1.3
	Old	16	1.0	18	1.2	19	1.6	20	1.5	20	1.4	20	1.2	21	0.9

A.7.7.5.1.3 An example for such details would be the method by which an individual's hands are measured and the specific size that is recommended for the specific measurements used in the manufacturer's glove system.

A.7.7.6 Leather is specifically excluded because of uncertainties in the applicability of the test methods for measuring various restricted substances. Principal textile-based fabric materials include fourchettes but do not include reinforcement layers or other portions of the glove that do not cover the majority of the hand. Other components such as thread, elastic, and labels are also excluded.

A.7.10.10 Leather is specifically excluded because of uncertainties in the applicability of the test methods for measuring various restricted substances. Principal textile-based fabric material layers exclude laces, labels, zippers, removable insoles, and reinforcement layers.

A.7.13.5 When designing hoods for proper fit, the headforms specified in ISO 16900-5, *Respiratory protective devices — Methods of test and test equipment — Part 5: Breathing machine, metabolic simulator, RPD headforms and torso, tools, and verification tools* can provide a range of head sizes that should be considered when trying to properly fit a hood to a range of users.

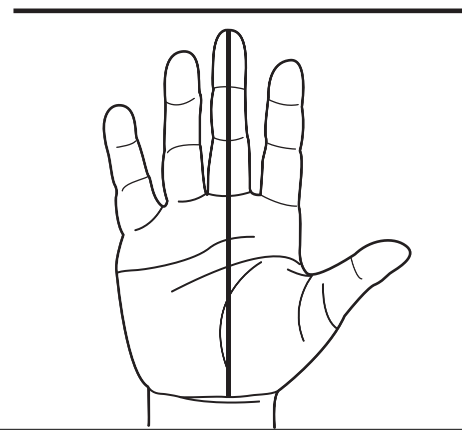
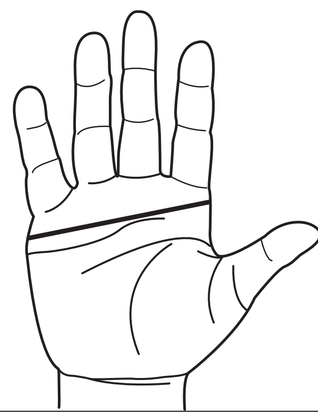
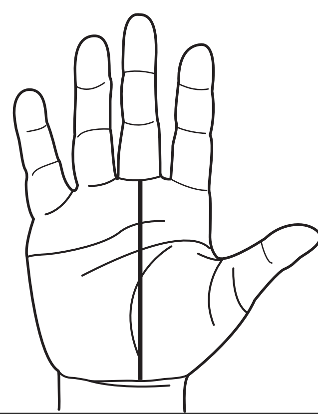
A.7.13.5.3 The sizing specified is based on the hoods meeting the 5th to 95th percentile dimensions found in the NIOSH Firefighter Anthropometric Database. This information can be found online at www.cdc.gov/niosh.

A.7.13.6.3 Invalidation of the NIOSH certification might occur as the result of modifications to the respirator by the attachment of additional parts or interface components, or through modification of the respirator configuration in order for the respirator to be donned with the ensemble. This requirement is not intended to affect common industry practices for the integration of respirators with protective ensembles such as through the use of a soft, flexible gasket material on the hood of a protective ensemble that provides a circumferential seal around the respirator facepiece.

A.7.16.2 See A.7.1.9.2.

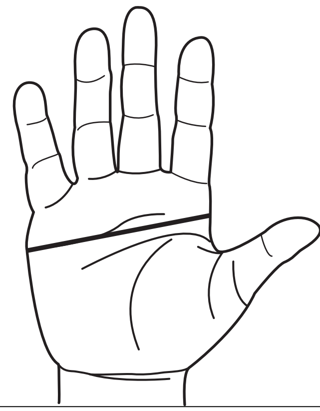
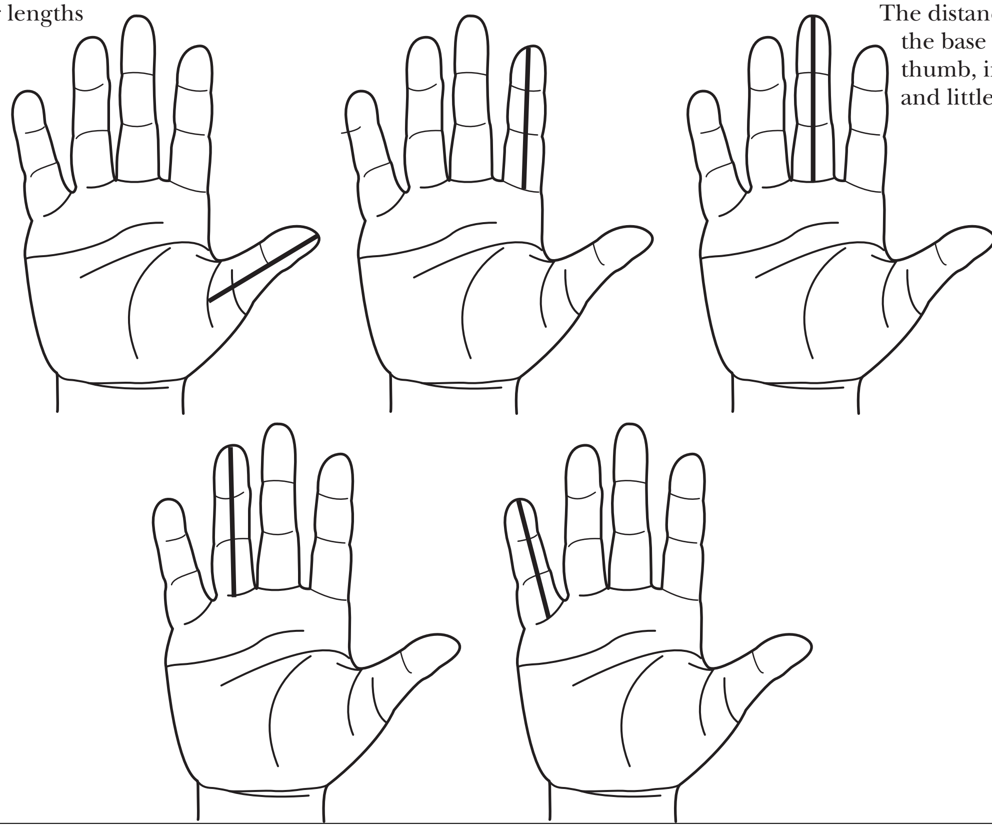
A.7.19.4.1.1 Design features, including the placement of reinforcement materials, trim, and pockets, are not considered unique for the requirement in 7.19.4.1.1. Differences in terms of garment outer shells, moisture barriers, thermal barriers, reinforcement materials, trim, and other construction materials are also not considered unique for this requirement.

Table A.7.7.5.1.1(b) Description of Specific Hand Dimensions Used in NIOSH-Recommended Glove Sizing System

Dimension	Figure	Definition
Hand length		The distance from the base of the hand at the wrist crease to the tip of the middle finger, measured along the long axis of the hand.
Hand breadth		The length from the point of the left side of the joint connecting the little finger to the palm to the point of the right side of the joint connecting the index finger to the palm (metacarpal-phalangeal joints).
Palm length		The distance from the base of the hand at the wrist crease to the furrow at the base of the middle finger.

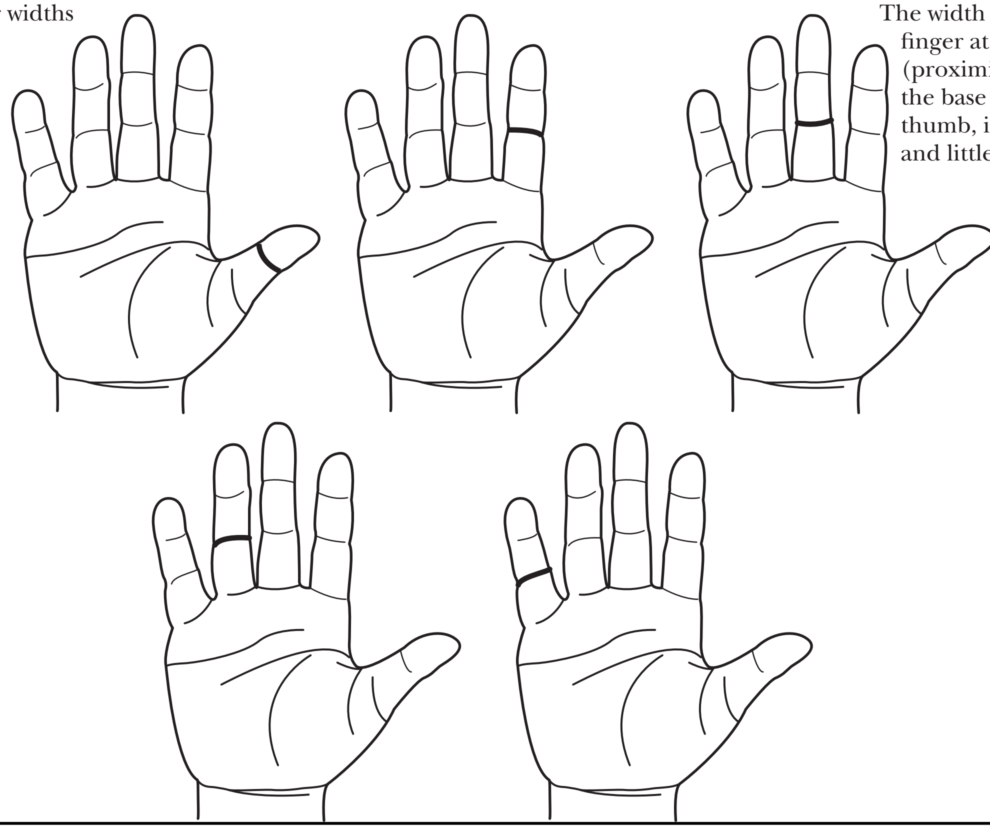
(continues)

Table A.7.7.5.1.1(b) ***Continued***

Dimension	Figure	Definition
Palm breadth		The length from the point of the left of the distal transverse crease to the point of the right of the proximal transverse crease.
Thumb and finger lengths		The distance from the tip to the base of the finger for thumb, index, middle, ring, and little fingers.

(continues)

Table A.7.7.5.1.1(b) ***Continued***

Dimension	Figure	Definition
Thumb and finger widths		The width of the specific finger at the first (proximity) knuckle from the base of the finger for thumb, index, middle, ring, and little fingers.

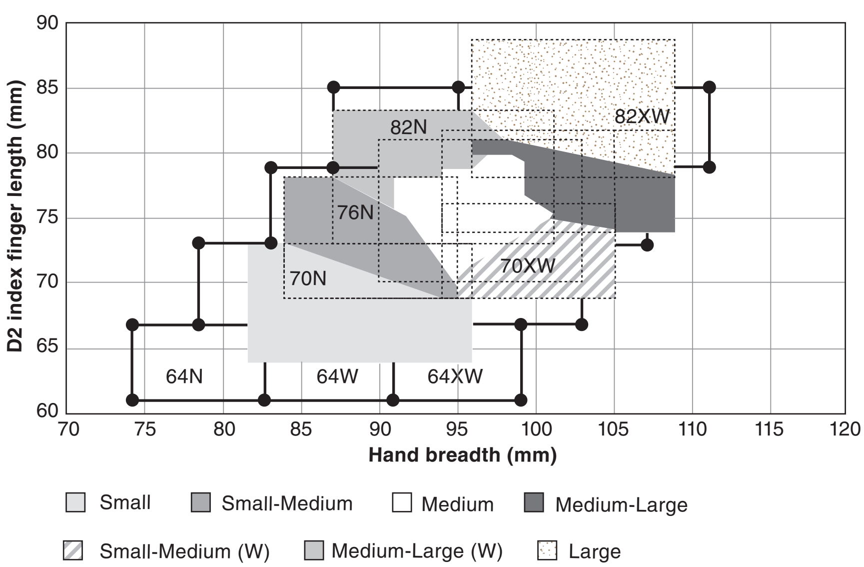


FIGURE A.7.7.5.1.1 Comparison of NIOSH-Based Glove System Recommendations (Shaded) with Default Sizing System.

A.7.19.4.4 Undergarments are permitted to be used as a means for further attenuating direct particulate or liquid contact with the firefighter's skin as a means for reducing their exposure to fireground contamination. Examples of undergarments providing this function could include lightweight knitted garments that cover the potentially exposed areas of the firefighter's skin, particularly in interface areas, using materials that are capable of either retarding or adsorbing liquids or particulates that bypass the principal garment. When worn, these garments can be with the protective garment and can be easily removed for later cleaning and reuse after appropriate cleaning.

A.7.20.1.1 Passive electrical circuity that complies with 7.20.1.1 does not present a risk of ignition in an explosive atmosphere, or a risk of fire and electric shock.

A.7.20.2.1 This suitability is demonstrated by being certified as one of the following in accordance with UL 121201, *Nonincendive Electrical Equipment for Use in Class I and II, Division 2 and Class III, Divisions 1 and 2 Hazardous (Classified) Locations*:

(1) Nonincendive equipment, stand-alone type
(2) Nonincendive equipment, electrically interconnected type
(3) Nonincendive system

A.7.20.3.1 This suitability is demonstrated by being certified as one of the following in accordance with UL 913, *Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, and III, Division 1 Hazardous (Classified) Locations*:

(1) Intrinsically safe apparatus, stand-alone type
(2) Intrinsically safe system

A.8.1.1 Thermal protective performance (TPP) is a measure of the thermal insulation provided by the garment composite: outer shell, moisture barrier, and thermal barrier. The test uses an exposure heat flux representative of the thermal energy present in a flashover.

A 6 in. square specimen of the composite is placed in a holder that suspends the specimen horizontally over the heat source. The heat source consists of two Meker burners and a radiant panel that are adjusted to provide a 50/50 balance of convective and radiant energy at a heat flux of 2 calories/cm^2/sec.

The outer shell of the sample composite is positioned to face the heat source. A weighted sensor containing a copper calorimeter is placed on top of the specimen, on the facecloth of the thermal barrier. A water-cooled shutter between the specimen and heat source is withdrawn to begin the exposure. The copper calorimeter, which is connected to a computer, measures the heat transfer through the specimen. The time required for enough thermal energy to transfer through the sample composite to cause a second degree burn is measured. This time is then multiplied by the exposure heat flux (2 calories) to provide a TPP rating (e.g., 20 seconds × 2 calories = a TPP rating of 40). Higher TPP ratings indicate better performance.

TPP test results have some inherent variability. In recognition of this variability, each TPP test consists of three specimens. The TPP rating is based on the average TPP results of the three specimens. If an individual test result for one specimen varies from the average of the three specimens by more than 8 percent, the results from that test set are discarded.

It should be noted that this is a harsh exposure and does not represent conditions in which firefighters are intended to work. It measures the ability of the composite to provide a few seconds to escape from such an exposure. It should also be understood that although the heat flux used in this test is severe, this is a laboratory test and firefighters can encounter conditions even more severe.

A.8.1.15 Firefighters can encounter many common liquids during the normal performance of their duties, such as doing firefighting operations. The performance requirements of 8.1.15 should not be interpreted to mean that the protective garments are suitable or are permitted to be used for protection to the wearer during any hazardous materials operation. It is the intent of this standard to provide protection from intrusion throughout the protective garment body by certain liquids, including some common chemicals.

A.8.1.27 The method for the light degradation test, while similar to the test method described in Section 8.62 of the 2018 edition of NFPA 1971, includes a significant modification to how the test method was previously performed where in the new test for this edition, the moisture barrier is sandwiched between a layer of a specified outer shell and thermal barrier, and the UV light exposure occurs directly on the outer shell side of the three-layer composite. This results in the attenuation of the UV light energy impingement to the moisture barrier as would be expected in actual garment configuration and use.

A.8.2.2 Total heat loss (THL) is a performance requirement for evaporative heat transfer. It measures how well the garment composite (i.e., outer shell, moisture barrier, and thermal barrier) allows heat and moisture vapor to transfer away from the wearer, thus helping to reduce heat stress.

The test consists of two parts. Part 1, "dry heat," is the insulation factor. Part 2, "wet heat," is the heat lost as moisture vapor passes through the composite. The test takes both of these parts into consideration, thus the term "total heat loss."

The test plate (sweating hot plate) represents sweating skin and the way in which sweating skin evaporates heat. The plate is heated to 35°C (95°F) (approximately skin temperature), and the test chamber temp is controlled at 25°C (77°F). The composite is placed on the plate as it is worn, with the face cloth of the thermal barrier on the plate and the outer shell on the top or outermost layer. Moisture is delivered to the plate to simulate sweating. The test measures the amount of electricity (W/m^2) required to maintain the plate at a constant temperature. If more heat is escaping through the composite, more electricity is required to maintain the plate at a constant temperature. Higher THL ratings indicate better performance.

THL test results have some inherent variability. In recognition of this variability, each THL test consists of three specimens. The THL rating is based on the average THL results of the three specimens. If an individual test result for one specimen varies from the average of the three specimens by more than 10 percent plus or minus, the results from that test set are discarded.

All THL testing is performed on pristine (i.e., unwashed) samples only. The testing is performed in this way for the following reasons:

(1) THL testing is a "benchmark" test that allows the comparison of material composite performance where prior

research by Stull et al. established the criteria based on a correlation with physiological impact of new clothing system on the wearer.

(2) Washing of composite samples has found to affect some fabric systems in ways that affect ease of conducting the THL test and subsequent results but do not necessary represent how garment total heat loss will change for full clothing

(3) If end user organizations are interested in understanding the impact of laundering on garment THL, a better evaluation would be whole garment testing as recommended in Annex H. In that testing, full garments are placed on a manikin and the whole garment total heat loss is measured; however, the impact of laundering should be assessed by comparing whole washed garments with unwashed garments to have an appropriate understanding for how garment THL is affected by laundering.

The technical committee used Stull et al. to justify the implementation of the THL testing and for basing the current requirement. This study found that a difference of 60 to 70 W/m^2 was needed to establish significant differences for the physiological impact between ensemble composites; however, it is important to point out that the study involved a large span of THL values where at the lowest end of THL, composites were considered nonbreathable and the highest THL was based on a nonbarrier middle layer.

A.8.2.2.1 Evaporative resistance is a performance requirement for evaporative heat transfer in a hot condition. It measures how well the garment's base composite (i.e., outer shell, moisture barrier, and thermal barrier) allows moisture vapor to evaporate from the testing surface thereby allowing evaporative cooling to take place.

This test ignores the insulation component of heat loss and only measures the evaporative resistance in a hot/humid environment (35°C, 40 percent RH). Insulation is not considered because in stressful conditions (i.e., where the air temperature is equal to or greater than skin temperature) heat cannot be lost by conduction but can be gained from the outside environment. The measurement of evaporative resistance is also necessary outside of the THL testing conditions (25°C, 65 percent RH) as research by Gao et al. has shown that membranes perform similarly in this mild condition but the performance changes significantly as the testing environmental temperature increases.

It should be noted that the differences in evaporative resistance that would result in any difference in physiological performance are dependent on how hard a person would be working and the environment in which they are working.

A.8.4.4(8) This requirement applies to any component that is attached to the helmet by the helmet manufacturer before shipment.

A.8.7.9 Firefighters can encounter biohazards during the normal performance of their duties, including rescue of victims from fires, extrication of victims from vehicles or other entrapment situations, provision of first responder or emergency medical care, or other rescue situations. It is the intent of this standard to provide protection from intrusion throughout the glove body by certain liquids, including some common chemicals and from blood-borne pathogens.

A.8.7.11 Firefighters can encounter many common liquids during the normal performance of their duties, such as during structural firefighting operations. The performance requirement of 8.7.11 should not be interpreted to mean that gloves for structural firefighting are suitable or are permitted to be used for protection to the wearer during any hazardous materials operations. It is the intent of this standard to provide protection from intrusion throughout the glove body by certain common liquids and from blood-borne or other liquid-borne pathogens.

Water is also included as a liquid. The inclusion of water in the liquid penetration requirement satisfies essential safety criteria for structural firefighter gloves. The glove requirements are largely based on the work of G. C. Coletta, I. J. Arons, L. Ashley, and A. Drennan in NIOSH 77-134-A, *The Development of Criteria for Firefighters' Gloves,* and Arthur D. Little in NIOSH 77-134-B, *Glove Requirements.* This NIOSH report is the landmark study in this field and the merits of its testimony should not be underestimated. It subsequently has been validated by the work of NASA, Project FIRES, the International Association of Fire Fighters, and reports by the fire service. The study identified a set of qualitative and quantitative criteria for firefighter gloves. Those criteria form the basis from which recommendations were made for both new glove standards and a prototype glove system that met those standards. The NIOSH survey of hand and wrist injury statistics and firefighter's task-oriented needs provided the most in-depth identification of structural firefighter glove requirements to date. That study identified the following critical performance needs:

(1) Resistance to cut
(2) Resistance to puncture
(3) Resistance to heat penetration (radiant and conductive)
(4) Resistance to wet heat penetration (scald-type injury)
(5) Resistance to cold
    (a) Dry
    (b) Wet
(6) Resistance to electricity
(7) Dexterity
(8) Resistance to liquids
    (a) Penetration
    (b) Retention
    (c) Material degradation
(9) Comfort
    (a) Cold and heat
    (b) Absorbency
    (c) Weight
    (d) Stiffness
    (e) Fit
(10) Resistance to flame
(11) Durability
(12) Drying
(13) Visibility

Thus, NIOSH developed a comprehensive list of all the design and performance parameters required by fire service gloves. This list addressed documented hazards encountered by structural firefighters and it served as the foundation for the development of the first and all subsequent editions of the former glove standard, NFPA 1973, as well as this standard. The following outlines how closely the NIOSH committee has followed the NIOSH guide for design criteria, performance criteria, and test methods for firefighter gloves.

Critical performance needs as addressed in Chapters 4 through 9 of this standard are as follows:

(1) Resistance to cut: 8.7.13
(2) Resistance to puncture: 8.7.14
(3) Resistance to heat penetration: 8.7.5, conductive heat resistance; and 8.7.1, thermal protective performance
(4) Resistance to wet heat penetration: 8.7.5, conductive heat resistance; 8.7.1, thermal protective performance; and 8.7.11, liquid penetration resistance (as recommended by the NIOSH study)
(5) Resistance to cold: 8.7.11, liquid penetration resistance (as recommended by the NIOSH study)
(6) Resistance to electricity: These criteria were not addressed, as the committee decided that it could convey that the glove was suitable for live electrical use
(7) Dexterity: 8.7.15
(8) Resistance to liquids: 8.7.11 (as recommended by the NIOSH study)
(9) Comfort: 8.7.15, dexterity; and 7.7.4.1, sizing
(10) Resistance to flame: 8.7.6
(11) Durability: No performance requirements, but durability is addressed in Section 6.5, User Information Requirements for Both Ensembles, as part of manufacturer's instructions
(12) Drying: No performance requirements, but drying is addressed in Section 6.5, User Information Requirements for Both Ensembles, as part of manufacturer's instructions
(13) Visibility: No requirements, but visibility is addressed in other protective clothing standards

This NIOSH comprehensive listing of all the design and performance parameters required by fire service gloves shows that the water portion of the liquid penetration resistance performance requirement is an integral component for satisfying the following three protective criteria:

(1) Wet heat resistance
(2) Liquid resistance
(3) Cold resistance

The NIOSH study relied on the water penetration requirement to ensure a minimum level of protection in otherwise untested areas and the committee agrees with the NIOSH study. In defense of this requirement, the NIOSH committee has provided the following expanded justifications for each of these three criteria.

Wet Heat Resistance. The wet heat resistance concept encompasses at least the following five types of combined thermal/wet exposures:

(1) Radiant energy on a wet glove
(2) Conductive heat transfer to a wet glove
(3) Wetting of an already heated glove
(4) Steam jet exposure, such as from a broken steam line
(5) Saturated water–vapor atmosphere, such as from scalding water/steam from the hose nozzle during firefighting operations

The NIOSH committee addressed the first two types of exposure in 8.7.1 and 8.7.5 (TPP and conductive heat testing) with wet gloves. The last three types of exposures are addressed in 8.7.11 (the water portion of the liquid penetration resistance requirement).

No tests other than those for water penetration have been included in the standard to simulate the last three kinds of exposures. This is because the NFPA committee has relied on the documentation of NIOSH and D. L. Simms and P. L. Hinkley, *Materials Suitable for Clothing Aircraft Fire Crash Rescue Workers*, Part 10, "The Effect of Water on Clothing" (an early study on the interactive effect of heat and water on thermal transfer in protective clothing), to show that the water penetration requirement satisfies those needs.

The NIOSH study states the following: "Firefighters' gloves should protect against scald-type injury by meeting the criteria for both resistance to heat penetration and to liquid penetration."

The Simms study states the following: "A sudden rise in temperature sufficient to produce a scald did not occur at all if a moistureproof layer was included in the clothing."

The Simms study concludes that, in the absence of continuous wetting throughout the exposure period, the assemblies with moisture barriers provided more protection and were "recommended." In assemblies without moisture barriers, the wetting of the hot/dry materials caused a sudden rise of temperature and severe scalds, and these assemblies should be "avoided."

The committee believes that the liquid penetration resistance test for water is the best available technique for evaluating a glove's ability to resist these three wet heat assaults until more sophisticated techniques are developed. To the committee's knowledge, no other appropriate procedures for testing these criteria are currently available. The previous literature citations document the liquid penetration resistance test for water as being appropriate and field experience confirms it to be adequate for protection of the firefighter.

Liquid Resistance. As noted by NIOSH, the liquid resistance concept encompasses three kinds of hazards: liquid penetration, liquid retention, and material degradation. Gloves not meeting the liquid penetration resistance requirement for water produce burn injuries quickly when assaulted by hot or boiling water. The liquid penetration resistance test for water directly evaluates whether water can penetrate through the glove materials. Furthermore, according to NIOSH, if liquid penetration resistance is not required, a firefighter more readily encounters a wet glove/wet hand situation. This combination reduces working efficiency by degrading a firefighter's manipulative and gripping abilities. These requirements have been addressed in 8.7.15 and 8.9.2 (dexterity and grip). However, the dexterity and grip testing that is specified necessitates the use of a testing subject and is done only at room temperature and not in conditions of extreme heat or cold. Including a liquid penetration resistance requirement for the glove limits the negative impact that these conditions can have on dexterity and grip.

Liquid retention (i.e., a glove's tendency to soak up liquids) can be hazardous, since it influences both comfort and function. The committee relied on both 8.7.11 (liquid penetration resistance) and 8.7.15 (dexterity) to satisfy this criterion.

Cold Resistance. In addressing the resistance to cold, the NIOSH study states the following: "Firefighter's gloves used in winter conditions should be constructed with enough insulation to keep the skin above 18°C (65°F) during nonsedentary exposures to ambient temperature of 34°C (30°F). Gloves should meet the criteria for resistance to liquid penetration as an integral part of these criteria."

Because firefighting gloves have to be insulative to high heat exposures, they normally are effectively insulative to cold exposures as well. As a result, no separate cold insulation requirements are included in the standard. Gloves also have to be similarly insulative under cold/wet exposures. In lieu of an insulative test, the cold/wet condition has been addressed by 8.7.11 (liquid penetration resistance). All the data and experience available to the committee shows that drier insulation is more insulative than wetter insulation under cold exposures.

The committee believes that resistance to cold is a safety issue since, if it is not adequately provided for in the glove, it can lead to cold burn (frostbite) injuries. A lack of resistance to cold also can degrade grip and manipulative performance. Almost every area of the country can experience freezing conditions, although in some southern locales it is not a frequent event. Firefighters, however, can experience cold exposures from sources other than weather, such as cold storage occupancies. The committee believes it is not necessary to differentiate performance for different areas of the country for any personal protective equipment.

A number of technical papers have been published over the past 50 years that established the following facts:

(1) The insulative value of clothing can be quantitatively measured in clo units.
(2) Moisture in clothing insulation reduces the clo value of protective clothing.
(3) Compression of clothing reduces the clo value of clothing.
(4) Manual dexterity is reduced as the ambient temperature decreases from 18°C to 29°C (65°F to 20°F).
(5) Moisture in clothing accelerates the loss of heat from the hand.
(6) Manual dexterity begins to degrade as hand skin temperature decreases below 18°C (65°F).

Points (1) through (6) show the deleterious effect of water in gloves on manual dexterity and protection, especially in cold exposures.

In summary, the liquid penetration resistance requirement and test for water is the most appropriate test available to measure water penetration resistance in a glove. It is the only currently available method for providing resistance to several kinds of wet heat exposures. Furthermore, it also addresses the necessity for a glove to resist cold/wet exposures, to be dexterous during cold/wet exposures, and to be resistant to excessive absorption of and deterioration by water. Without the liquid penetration resistance requirement for water, a firefighter would have no protection from hot/cold water, which can produce scald and frostbite injuries, respectively. Without the liquid penetration resistance requirement for water, the standard would fail to address the resistance to wetting of an already heated glove, steam jets, saturated water–vapor atmospheres, and insulation against cold/wet exposures.

A.8.7.15 The glove hand function test referenced in the body of the standard can be supplemented by the following:

(1) Exploration of dexterity tests for all sizes or, since it is typically a greater challenge, exploration of dexterity testing on the extra-small sizes
(2) Exploration of glove interface with other firefighting vocational tools used by the purchaser
(3) Wear-testing the gloves being considered with particular attention to use on toggles, switches, and knobs

A.8.7.18 It is the intent of this standard to provide protection from intrusion throughout the glove body by certain common liquids and from blood-borne pathogens. The performance and testing requirements for glove composite materials for liquid penetration are found in 8.7.11 and Section 9.4.3, Liquid Penetration Resistance Test, respectively, and the performance and testing requirements for glove composite materials for biopenetration are found in 8.7.9 and Section 9.4.5, Viral Penetration Resistance Test, respectively. The whole glove performance and testing requirements of 8.7.18 and Section 9.5.2, Whole Glove Liquid Integrity Test 1, use water as a convenient and repeatable medium for evaluating whole glove integrity, since the provisions of Sections 9.4.3 and 9.4.5 only allow for testing of glove composites and not the entire glove. A precedent exists in NFPA 1992 where water is used to test the integrity of the entire protective suit.

A.8.7.19 The glove donning performance requirement is intended to evaluate the overall design of the glove for repeated use. Many factors can affect the performance, including proper sizing, glove interior design, wrist opening configuration, lining material selection, liner pullout, and integrity of the assembly. The time limits of this test are not necessarily indicative of field use. In particular, purchasers might wish to comparatively test wet (as well as dry) don/doff characteristics before making a final purchase decision.

A.8.10.2.1 Examples of footwear components include, but are not limited to, a narrow reflective piping down a seam of the footwear upper, the aglet at the end of a lace, or lace keeper.

A.8.10.10 Fire department personnel should be warned that the electrical hazard-resistant protective properties in new, unworn structural firefighter boots as required by this standard will diminish or be eliminated as the boot and the soles/heels wear or if they are punctured or cut.

A.8.21 The specific limits or criteria for restricted substances are derived from the combination of the 2024 editions of the OEKO-TEX Standard 100, the Supplement PPE & Materials OEKO-TEX Standard 100, and the AFIRM Restricted Substances List.

The certification organization should use its best judgment in determining the relevant categories of restricted substances to be evaluated based on the information provided by the manufacturer or supplier for the respective material(s) and component(s).

A.9.1 Table A.9.1(a) through Table A.9.1(j) are provided as a quick reference for conditioning and testing of elements and cannot be relied on as requirements.

Table A.9.1(a) Testing of Structural Firefighting Garments

Test	Section Number	Test Material or Component											Conditioning			
		Whole Garment	Composite	Outer Shell	Moisture Barrier	Thermal Barrier	Labels	Other Materials	Hook and Loop	Thread	Seams	Hardware	Trim	Washing/ Drying[a]	Room Temp[b]	Convective Heat[c]
Flame resistance	9.2.1			X	X	X		X					X	X	X	
Heat/thermal resistance	9.2.4			X	X	X	X	X			X[d]	X	X	X	X	
TPP	9.2.16		X												X	
Thread melting	9.2.5									X					X	
Tear resistance	9.3.1			X	X	X								X	X	
Burst strength	9.3.3										X[e]			X	X	
Seam-breaking strength	9.3.4										X			X		
Cleaning shrinkage resistance	9.9.1			X	X	X	X							X	X	
Water absorption resistance	9.4.1			X										X	X	
Water penetration resistance	9.4.2				X									X	X	X
Liquid penetration resistance	9.4.3				X						X[d]			X	X	X
Corrosion resistance	9.4.6											X[f]			X	
Total heat loss	9.7.1		X												X	
Label durability and legibility	9.8.12						X							X	X	X
Trim retroreflectivity and fluorescence	9.8.1												X		X	X
Whole garment and ensemble liquid penetration	9.5.1	X													X	
Breaking strength	9.3.2			X										X	X	
CCHR	9.2.10		X											X	X	
DRD material strength	9.3.20													X	X	
DRD function	9.8.11	X									X				X	
Particle inward leakage	9.5.3	X[g]														
Transmitted and stored thermal energy	9.2.15												X		X	
Fastener tape strength	9.3.19								X						X	
Evaporative resistance	9.7.2		X												X	
Water resistance: impact penetration					X						X[d]					
Water resistance: hydrostatic pressure					X						X[d]					
Contamination removal efficiency removal				X	X	X		X[h]								

(continues)

Table A.9.1(a) ***Continued***

		Test Material or Component										Conditioning				
Test	**Section Number**	**Whole Garment**	**Composite**	**Outer Shell**	**Moisture Barrier**	**Thermal Barrier**	**Labels**	**Other Materials**	**Hook and Loop**	**Thread**	**Seams**	**Hardware**	**Trim**	**Washing/ Drying[a]**	**Room Temp[b]**	**Convective Heat[c]**
Flame resistance following fuel exposure and cleaning				X										X	X	
Acceptable levels of restricted substances				X	X	X		X[h]							X	
Liquid repellency and penetration resistance				X										X	X	

[a]See 9.1.2.
[b]See 9.1.3.
[c]See 9.1.5.
[d]Moisture barrier seams only.
[e]Knit seams only.
[f]Metal hardware only.
[g]Optional test.
[h]For wristlets only.

Table A.9.1(b) Conditioning and Testing of Structural Firefighting Helmets

Test	Section Number	Specimen Numbers					
		Room Temperature[a]	Wet[b]	Low Temperature[c]	Radiant[d]	Convective Heat[e]	Washing/ Drying[f]
Helmet, faceshield, and goggle flame resistance test 2	9.2.2	1					
Heat resistance	9.2.4	2					
Retention	9.3.9	1					
Suspension retention	9.3.10	1					
Shell retention	9.3.8	13					
Electrical resistance	9.6.1	4					
Faceshield, goggle luminous transmittance	9.8.2	6					
Faceshield, goggle impact resistance	9.3.11	3	4	9		13	
Top impact	9.3.5	3	4	9	7	11	
Label legibility	9.8.13	2	4	9	7		
Impact acceleration	9.3.6	5	6	10	8		
Penetration	9.3.7	3	4	9	14	12	
Faceshield, goggle lens scratch resistance	9.3.12	8					
Hardware corrosion	9.4.6	3					
Trim retroreflectivity and fluorescence	9.8.1	X					
Thread heat resistance	9.2.5	X					
Ear cover, chin strap, goggle fabrics flame resistance	9.2.1	X					X
Ear cover, chin strap heat resistance	9.2.4	X					X
Ear cover TPP	9.2.16	X					
Helmet soft goods ease of removal and installation	9.9.2	X					
Contamination removal efficiency *(see 8.4.17)*	9.9.3	X					X
Restricted substances	8.21	X					

[a]See 9.1.3.
[b]See 9.1.7.
[c]See 9.1.4.
[d]See 9.1.6.
[e]See 9.1.5.
[f]See 9.1.2.

Table A.9.1(c) Testing of Structural Firefighting Gloves

Test	Section Number	Test Material or Component							Test Conditioning				
		Whole Glove	Glove Composite	Glove Lining	Glove Gauntlet	Glove Wristlet	Thread	Hardware	Room Temp[a]	Washing/ Drying[b]	Convective Heat[c]	Wet[d]	Flex[e]
Restricted substances	8.21		X	X	X	X			X				
TPP	9.2.16		X		X	X			X	X			
Heat and thermal shrinkage resistance	9.2.4	X		X					X	X			X
Conductive heat resistance test 1	9.2.7		X						X	X		X	
Flame resistance test 3	9.2.17	X							X	X			
Thread melting	9.2.5						X		X				
Viral penetration resistance	9.4.5		X						X	X	X		
Liquid penetration resistance	9.4.3		X						X	X	X		
Cut resistance	9.3.15		X		X	X			X	X			
Puncture resistance test 1	9.3.14		X						X			X	
Glove hand function	9.8.4	X							X				
Burst strength	9.3.3					X			X				
Seam breaking strength	9.3.4				X	X				X			
Whole glove liquid integrity test 1	9.5.2	X							X	X	X		
Glove donning	9.8.3	X								X			
Liner retention	9.3.16	X							X	X			
Label durability and legibility test 1	9.8.12	X							X	X	X		
Grip	9.8.5	X							X				X
Torque	9.8.6	X							X				
Tool	9.8.7	X							X				
Transmitted and stored thermal energy	9.2.15		X									X	
Corrosion resistance	9.4.6							X	X				

[a]See 9.1.3.
[b]See 9.1.2 or 9.1.12.
[c]See 9.1.5.
[d]See 9.1.8, 9.1.9, or 9.1.10.
[e]See 9.1.11.

Table A.9.1(d) Testing of Structural Firefighting Footwear

		Test Material or Component										Test Conditioning		
Test	Section/ Paragraph Number	Whole Footwear	Footwear Composite	Footwear Textiles	Footwear Component	Footwear Sole	Footwear Toe Section	Footwear Moisture Barrier	Footwear Moisture Barrier Seam	Thread	Labels	Room Temp[a]	Convective Heat[b]	Wet[c]
Toe impact/ compression	7.10.9 (ASTM F2413)						X					X		
Puncture resistance device flex	7.10.9 (ASTM F2413)				X							X		
Restricted substances	8.21			X				X				X		
Conductive heat resistance test 2	8.10.1/9.2.8	X										X		
Flame resistance test 4	8.10.2/9.2.3	X										X		
Thread melting	8.10.3/9.2.5									X		X		
Liquid penetration resistance	8.10.4/9.4.3			X	X			X	X			X	X	
Viral penetration resistance	8.10.5/9.4.5							X	X			X	X	
Puncture resistance	8.10.6/9.3.14	X	X									X		
Cut resistance	8.10.7/9.3.15	X	X									X		
Slip resistance	8.10.8/9.8.9	X										X		
Abrasion resistance	8.10.9/9.3.17	X				X						X		
Electrical insulation test 2	8.10.10/9.6.2	X										X		
Ladder shank bend	8.10.11/9.8.8				X							X		
Eyelet and stud post attachment	8.10.12/9.3.18	X										X		
Corrosion resistance	8.10.13/9.4.6				X							X		
Label durability and legibility	8.10.14/9.8.12	X									X	X		
Heat and thermal shrinkage resistance	8.10.15/9.2.4	X										X		
Radiant heat resistance test 1	8.11.2/9.2.11	X	X									X		X
Conductive heat resistance test 1	8.11.3/9.2.7	X	X									X		

[a]See 9.1.3.
[b]See 9.1.5.
[c]See 9.1.9.

Table A.9.1(e) Testing of Structural Firefighting Hood Interfaces

		Test Material or Component					Test Conditioning	
Test	Section Number	Whole Hood	Hood Material or Composite	Hood Seam	Hood Thread	Hood Label	Washing/ Drying[a]	Room Temperature[b]
Flame resistance	9.2.1		X			X	X	X
Heat/thermal resistance	9.2.4	X				X	X	X
TPP	9.2.16		X					X
Thread melting	9.2.5				X			X
Burst strength	9.3.3		X					X
Seam strength	9.3.4			X			X	X
Cleaning shrinkage	9.9.1	X					X	X
THL	9.7.1		X					
Label durability and legibility	9.8.12					X	X	X
Hood opening size retention	9.8.10	X						X
Transmitted and stored thermal energy	9.2.15		X					X
Particulate blocking resistance	9.4.4		X	X			X	X
Restricted substances	8.21		X				X	X
Contaminate removal efficiency	9.9.3		X					

[a]See 8.1.2.
[b]See 8.1.3.

Table A.9.1(f) Testing of Proximity Firefighting Garments

		Test Material or Composite												Conditioning		
Test	Section Number	Garments	Composite	Outer Shell	Moisture Barrier	Thermal Barrier	Winter Liner	Labels	Other Materials	Thread	Seams	Hardware	Trim	Washing/Drying[a]	Room Temp[b]	Convective Heat[c]
Flame resistance	9.2.1			X	X	X	X		X				X	X	X	
Heat/thermal resistance	9.2.4			X	X	X	X	X	X			X	X		X	
TPP	9.2.16		X												X	
Thread melting	9.2.5									X					X	
Tear resistance	9.3.1			X	X	X	X							X	X	
Seam strength	9.3.4										X			X		
Cleaning shrinkage resistance	9.9.1			X	X	X	X							X		
Water absorption resistance	9.4.1			X										X		
Water penetration resistance	9.4.2				X									X	X	X
Liquid penetration resistance	9.4.3				X						X			X	X	X
Viral penetration resistance	9.4.5				X						X			X	X	X
Corrosion resistance	9.4.6											X			X	
Total heat loss	9.7.1		X												X	
Label durability	9.8.12							X								
Overall liquid penetration	9.5.1	X													X	
Breaking strength	9.3.2			X												
CCHR	9.2.10		X											X	X	
DRD function	9.8.11															
DRD material strength	9.3.20															
Radiant heat resistance test 2	9.2.12			X											X	
Wet flex	9.4.7			X											X	
Adhesion after wet flex	9.4.8			X											X	
Flex at low temperature	9.4.9			X											X	
Resistance to high temperature blocking	9.2.6			X											X	
Restricted substances	8.21			X	X	X									X	

[a]See 8.1.2.
[b]See 8.1.3.
[c]See 8.1.5.

Table A.9.1(g) Conditioning and Testing of Proximity Firefighting Helmets

Test	Section Number	Specimen Numbers					
		Room Temperature[a]	Wet[b]	Low Temperature[c]	Radiant[d]	Convective Heat[e]	Washing/ Drying[f]
Helmet, faceshield flame resistance	9.2.2	1					
Heat resistance	9.2.4	2					
Retention	9.3.9	1					
Suspension retention	9.3.10	1					
Shell retention	9.3.8	13					
Faceshield luminous transmittance	9.8.2	6					
Faceshield impact resistance	9.3.11	3	4	9		13	
Faceshield radiant reflective	9.2.14	15					
Faceshield lens scratch resistance	9.3.12	8					
Faceshield adhesion of reflective coating	9.3.13	1					
Top impact	9.3.5	3	4	9	7	11	
Label legibility	9.8.13	2	4	9	7		
Impact acceleration	9.3.6	5	6	10	8		
Penetration	9.3.7	3	4	9	14	12	
Radiant heat transmittance	9.2.13	15					
Hardware corrosion	9.4.6	3					
Thread heat resistance	9.2.5	X					
Shroud, cover, chin strap flame resistance	9.2.1	X					X
Shroud, cover, chin strap heat resistance	9.2.4	X					X
Shroud TPP	9.2.16	X					
Shroud, cover radiant reflective	9.2.14	X					
Shroud, cover wet flex	9.4.7	X					
Shroud, cover adhesion after wet flex	9.4.8	X					
Shroud, cover flex at low temperature	9.4.9	X					
Shroud, cover high temperature blocking	9.2.6	X					
Shroud, cover tear resistance		X					X
Contamination removal efficiency *(see 8.4.1.7)*	9.9.3	X					X
Restricted substances	8.21	X					

[a]See 9.1.3.
[b]See 9.1.7.
[c]See 9.1.4.
[d]See 9.1.6.
[e]See 9.1.5.
[f]See 9.1.2.

Table A.9.1(h) Testing of Proximity Firefighting Gloves

Test	Test Material or Component									Test Conditioning					
	Section Number	Whole Glove	Glove Composite	Glove Lining	Glove Outer Shell Material	Glove Gauntlet	Glove Wristlet	Thread	Hardware	Room Temp[a]	Washing/ Drying[b]	Convective Heat[c]	Wet[d]	Flex[e]	Abrade[f]
Restricted substances	8.21		X	X		X	X			X					
TPP	9.2.16		X			X	X			X	X				
Heat and thermal shrinkage resistance	9.2.4	X		X						X	X			X	
Conductive heat resistance test 1	9.2.7		X							X	X		X		
Flame resistance test 3	9.2.17	X								X	X				
Thread melting	9.2.5							X		X		X			
Viral penetration resistance	9.4.5		X							X	X	X			
Liquid penetration resistance	9.4.3		X							X	X				
Cut resistance	9.3.15		X			X	X			X	X				
Puncture resistance test 1	9.3.14		X							X			X		
Glove hand function	9.8.4	X								X					
Burst strength	9.3.3						X			X					
Seam breaking strength	9.3.4					X	X				X				
Whole glove liquid integrity test 1	9.5.2	X								X	X	X			
Glove donning	9.8.3	X									X				
Liner retention	9.3.16	X								X	X				
Label durability and legibility test 1	9.8.12	X								X	X	X			
Grip	9.8.5	X								X			X		
Torque	9.8.6	X								X					
Tool	9.8.7	X								X					
Transmitted and stored thermal energy	9.2.15		X										X		
Radiant heat resistance test 2	9.2.14				X					X					X
Wet flex	9.4.7				X					X					
Adhesion after wet flex	9.4.8				X					X					
Flex at low temperature	9.4.9				X					X					

(continues)

Table A.9.1(h) *Continued*

	Test Material or Component									Test Conditioning					
Test	Section Number	Whole Glove	Glove Composite	Glove Lining	Glove Outer Shell Material	Glove Gauntlet	Glove Wristlet	Thread	Hardware	Room Temp[a]	Washing/ Drying[b]	Convective Heat[c]	Wet[d]	Flex[e]	Abrade[f]
Resistance to high temperature blocking	9.2.6				X					X					

[a]See 9.1.3.
[b]See 9.1.2 or 9.1.12.
[c]See 9.1.5.
[d]See 9.1.8, 9.1.9, or 9.1.10.
[e]See 9.1.11.
[f]See 9.2.14.3.4.

A.9.1.6.8 A radiant heat test for helmets is specified. Under controlled conditions, a radiant heat load of 1 W/cm^2 is applied until a temperature of 260°C (500°F) is reached on a transducer. This temperature alone does not simulate actual field conditions but is a test devised to put extreme heat loads on helmets in an accurate and reproducible manner by testing laboratories. However, the radiant heat load of 1 W/cm^2 was selected as an average value based on studies of fire conditions that relate to field use.

A.9.1.9 A test apparatus that can provide this method of wetting consists of a chamber in which a specialized nozzle directs flow downward onto a horizontally positioned specimen that is placed on a balance. An apparatus meeting the requirement in this section consists of a plexiglass chamber with piping that supports a full cone brass misting nozzle that is positioned at a distance of 560 mm (22 in.) above a specimen on top of a balance protected in a plastic bag that uses a plexiglass 150 mm × 150 mm (6 in. × 6 in.) square as the balance pan in lieu of the original balance pan. Pressure to the nozzle is provided by a 560 W (¾ horsepower) clear water pump with a capacity of 2.46 m^3/hr (gal/hr), a maximum pressure of 296 kPa (43 psi), and a 25 mm (1 in.) NPT outlet. A gate valve is positioned to control flow of water from a 20 L (5 gal) bucket reservoir into the pipe with a 200 mesh water filter installed prior to the nozzle. The system is also equipped with an overflow value and venturi valve to eliminate dripping from the nozzle during starting and ending of the water flow. The entire assembly is mounted to a movable cart. Specific instructions for the operation of this system are as follows:

(1) Fill the 20 L (5 gal) bucket at least one-half full of tap water *[see Figure A.9.1.9(a)]*. The bucket cannot be removed from the cart, but this can be achieved by pouring water from inside the chamber through a funnel or pumping water in from the side into the top of the bucket.
(2) Always maintain several centimeters (a few inches) of water in the bucket. If the bucket is empty, the pump will lose its prime. To reprime the pump, remove the brass screw on the prime valve located on the top/back of the pump *[see Figure A.9.1.9(b)]*. Pour water into the pump until it is full, and replace the screw.
(3) Plug the pump (black cord) into the outlet box/switch that is located underneath the front left side of the unit, as shown in Figure A.9.1.9(c).
(4) Plug the outlet box/switch (red cord) into a standard 220 volt outlet. This cord is located on the right side of the cart pictured in Figure A.9.1.9(d).
(5) Open the main flow valve fully. For the open position, the handle should be "in line" with the pipe as shown in Figure A.9.1.9(e).
(6) Attach the bottom end of the overflow tube onto the bucket as shown in Figure A.9.1.9(f) to continuously drain the water from the test apparatus back into the system.
(7) Turn the blue handle to fully open the overflow valve, as shown in Figure A.9.1.9(g).
(8) Remove the blue rubber cap from the nozzle *[see Figure A.9.1.9(h)]* that is used to prevent excess water from prematurely getting on the sample.
(9) Remove the plastic and metal sections on top of the balance shown in Figure A.9.1.9(i) as these items are not needed.
(10) Place the scale in a clear plastic bag and seal. as shown in Figure A.9.1.9(j). Note: The scale set on is a plexiglass elevated platform that is shown in Figure A.9.1.9(k) to allow drainage.
(11) Center the scale in the spray chamber and place a 150 mm × 150 mm (6 in. × 6 in.) plexiglass square on top of the scale in the chamber *[see Figure A.9.1.9(l)]*.
(12) Place the sample on the plexiglass balance pan. Turn on the scale, tare to 0.0 g, place the sample on the plexiglass scale tray, and tare again to 0.0 g as shown in Figure A.9.1.9(m).
(13) Multiply the weight of the sample times the percent of the weight gain that needs to be achieved. This will give the ending weight value to stop the timer.
(14) Close the chamber door for even air flow.
(15) Turn on the pump switch and timer until desired weight is met (calculated above).
(16) Turn off the pump switch and timer. Note: Periodically the water filter should be cleaned. The water filter is located inside the black elbow on the top of the main flow pipe *[see Figure A.9.1.9(n)]*. Unscrew the top cap, remove the filter, rinse under water, and replace.

Photographs showing the front and back views of the complete test apparatus are provided in Figure A.9.1.9(o) and Figure A.9.1.9(p).

Table A.9.1(i) Testing of Proximity Firefighting Footwear

		Test Material or Component										Test Conditioning		
Test	Section/ Paragraph Number	Whole Footwear	Footwear Composite	Footwear Textiles	Footwear Component	Footwear Sole	Footwear Toe Section	Footwear Moisture Barrier	Footwear Moisture Barrier Seam	Thread	Labels	Room Temp[a]	Convective Heat[b]	Wet[c]
Toe impact/ compression	7.10.9 (ASTM F2413)						X					X		
Puncture resistance device flex	7.10.9 (ASTM F2413)				X							X		
Restricted substances	8.21			X				X				X		
Conductive heat resistance test 2	8.10.1/9.2.8	X										X		
Flame resistance test 4	8.10.2/9.2.3	X										X		
Thread melting	8.10.3/9.2.5									X		X		
Liquid penetration resistance	8.10.4/9.4.3							X	X			X	X	
Viral penetration resistance	8.10.5/9.4.5							X	X			X	X	
Puncture resistance	8.10.6/9.3.14	X	X									X		
Cut resistance	8.10.7/9.3.15	X	X									X		
Slip resistance	8.10.8/9.8.9	X										X		
Abrasion resistance	8.10.9/9.3.17	X				X						X		
Electrical insulation test 2	8.10.10/9.6.2	X										X		
Ladder shank bend	8.10.11/9.8.8				X							X		
Eyelet and stud post attachment	8.10.12/9.3.18	X										X		
Corrosion resistance	8.10.13/9.4.6				X							X		
Label durability and legibility	8.10.14/9.8.12	X									X	X		
Heat and thermal shrinkage resistance	8/10.15/9.2.4	X										X		
Conductive heat resistance test 3	8.12.2/9.2.9	X	X									X		
Radiant heat resistance test 2	8.12.3/9.2.12	X	X									X		X

[a]See 9.1.3.
[b]See 9.1.5.
[c]See 9.1.9.

Table A.9.1(j) Testing of Proximity Firefighting Hood Interfaces

			Test Material or Component				Test Conditioning	
Test	**Section Number**	**Whole Hood**	**Hood Material or Composite**	**Hood Seam**	**Hood Thread**	**Hood Label**	**Washing/ Drying[a]**	**Room Temperature[b]**
Flame resistance	9.2.1		X			X	X	X
Heat/thermal resistance	9.2.4	X				X	X	X
TPP	9.2.16		X					X
Thread melting	9.2.5				X			X
Burst strength	9.3.3		X					X
Seam strength	9.3.4			X			X	X
Cleaning shrinkage	9.9.1	X					X	X
Label durability and legibility	9.8.12					X	X	X
Hood opening size retention	9.8.10	X						X
Restricted substances	8.21		X					X
Contaminate removal efficiency	9.9.3		X				X	X

[a]See 8.1.2.
[b]See 8.1.3.

FIGURE A.9.1.9(a) Fill Bucket for Test Apparatus.

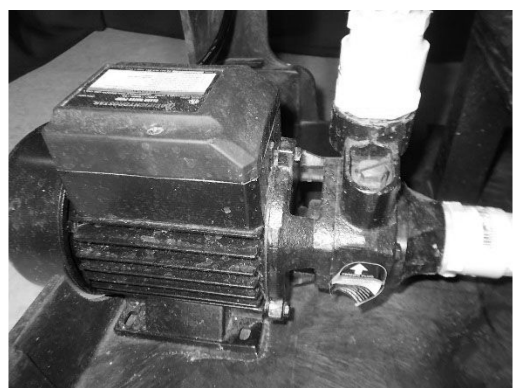


FIGURE A.9.1.9(b) Test Apparatus Pump Showing Brass Screw on Prime Valve.

FIGURE A.9.1.9(c) Location of Outlet for Pump Electrical Connection.

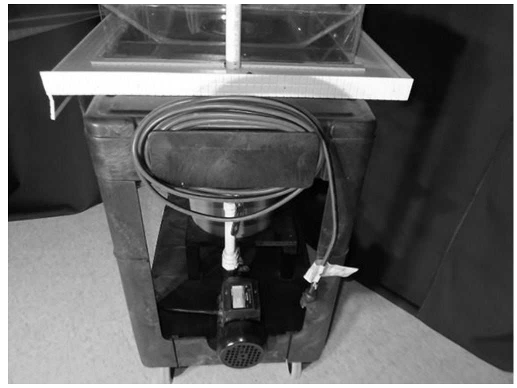


FIGURE A.9.1.9(d) Location of Power Cord for Test Apparatus.

A.9.1.13.2 The HPI is intended to represent the "average" wearing position of the helmet by the end user but might not represent each firefighter's preference for how they wear their helmets. Manufacturers are required to document how they arrived at the HPI used to evaluate each unique helmet model or style.

A.9.1.17 When a glove is two-dimensional rather than three-dimensional (the glove in Figure 9.1.17 is three-dimensional), then the same methodology should be applied to the two-dimensional glove. For example, if there are requirements for the sides of the fingers, then the area of the glove that would cover the sides of the fingers should be considered for these requirements even though the glove does not have fourchettes.

When wearing a correctly sized glove and laying the gloved hand completely flat on an even, flat surface, the portion of the glove that comes in contact with the even, flat surface should be considered the palm test areas of the glove. The layers immediately above the palm areas should be considered the areas next to the palm areas.

The finger sides should include the interior side areas of the small, ring, middle, and index fingers for a glove, that are hidden from sight, as observed both from the glove palm and glove back sides, when an individual wearing a correctly sized glove has his or her fingers completely closed.

The back area is intended to include all parts of the glove that are not defined as the palm area or the side areas. The layers immediately beneath the back areas should be considered the side areas next to the back areas.

A.9.1.18.4 The mandrel spacing should be measured according to Figure A.9.1.18.4(a) and Figure A.9.1.18.4(b).

A.9.1.22 Figure A.9.1.22(a) to Figure A.9.1.22(h) provide photographs for the application of the procedures for using the marking fixture to mark and measure footwear, moisture barrier or other interior layer, and liquid test level heights.

A.9.2.4.8.6 Where there is more than one moisture barrier layer, it is intended that only the layers between the hand and the nearest moisture barrier layer be tested. Also for this test the concern about separation is within a layer rather than between layers. Thermal protection is diminished with separation such as hole formation or consumed materials.

FIGURE A.9.1.9(e) Location of Test Apparatus Main Flow Valve (in Open Position).

FIGURE A.9.1.9(f) Overflow Tube Clamped onto Test Apparatus Bucket.

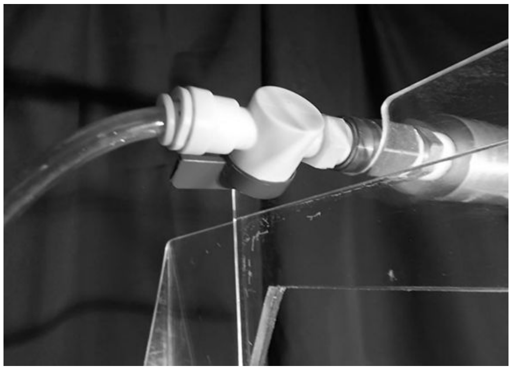


FIGURE A.9.1.9(g) Test Apparatus Overflow Valve in Open Position.

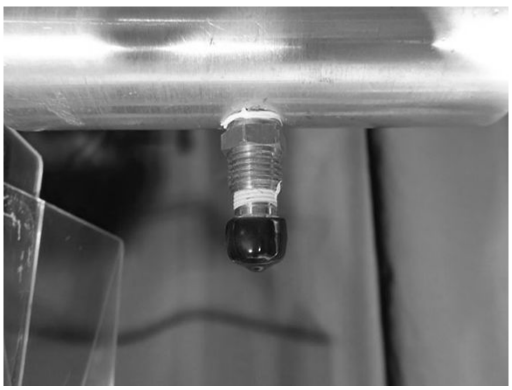


FIGURE A.9.1.9(h) Rubber Cap on Test Apparatus Spray Nozzle.

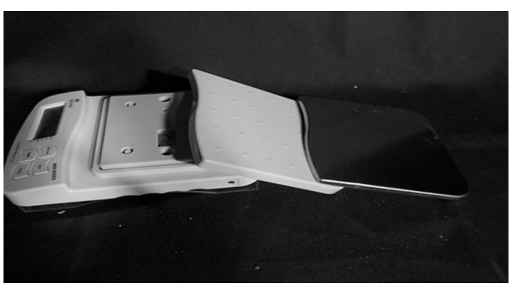


FIGURE A.9.1.9(i) Tray and Pan Cover for Removal from Balance.

A.9.2.4.13.4(2) A cotton muslin fabric has been found to be a suitable material for the construction of the lightweight bag to hold the beads.

A.9.2.4.13.4(5) The intent of this permissive language is to make it easier to fully clamp glove configurations that have wristlets that can overstretch during their suspension in the oven. This modification of the sample is only allowed if the wristlet is homogeneous in its material design and construction and must retain at least 25 mm (1 in.) from the seam that connects the wristlet to the glove body. This requirement does not apply to gloves that might have separate gauntlets that consist of materials that are different from the glove body.

FIGURE A.9.1.9(j) Coverage of Scale by Plastic Bag.

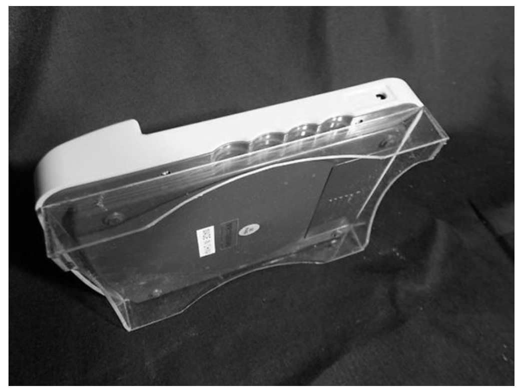


FIGURE A.9.1.9(k) Plexiglass Standard Supporting Scale.

FIGURE A.9.1.9(l) Scale Encapsulated in Plastic Bag and Centered in Spray Chamber.

A.9.2.4.14.4 A rack placed in the oven on which the footwear sample can be positioned is preferred over suspending the footwear with hooks or by other means. A photograph of the technique used for supporting the boot in the oven is recommended as means for reporting this technique.

A.9.2.4.14.9.1 Examples of footwear components include, but are not limited to, a narrow reflective piping down a seam of the footwear upper, the aglet at the end of a lace, or lace keeper.

FIGURE A.9.1.9(m) Sample on Scale Tared to 0.0 g.

FIGURE A.9.1.9(n) Location of Test Apparatus Water Filter.

FIGURE A.9.1.9(o) Front View of Wet Conditioning Test Apparatus.

FIGURE A.9.1.9(p) Back View of Wet Conditioning Test Apparatus.

A.9.2.4.14.15 Examples of possible statements that could be included in a report with failing results include leakage near the top line (suggesting wicking) or a pin hole on the left lower middle area vamp (indicating a possible defect or damage in the adjacent area). The use of photographs is suggested to indicate areas of failure.

A.9.2.4.16.4 The inclusion of the graduations provides a means for quantifying the level of noncompliance for instances where the hood sample does not freely slide down the top portion of the cone of the hood measuring device.

A.9.2.4.16.13 This average should be based on a total of 12 values of percent shrinkage with 4 values per specimen.

A.9.2.4.16.14 This average should be based on a total of 9 values of percent shrinkage with 3 values per specimen.

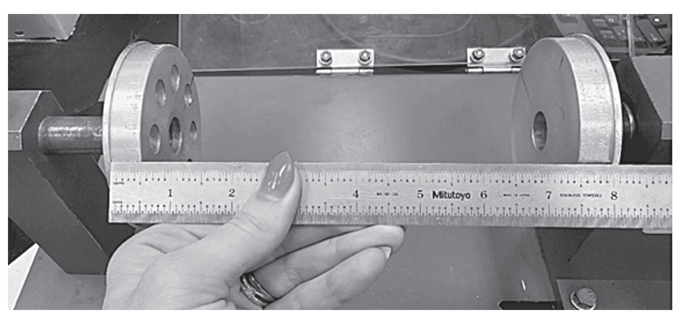


FIGURE A.9.1.18.4(a) Mandrel Starting Position.

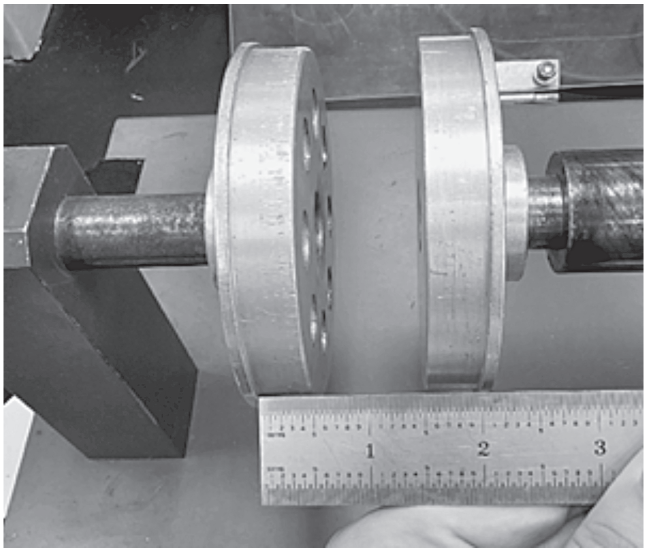


FIGURE A.9.1.18.4(b) Mandrel Closed Position.

A.9.2.5.4 The specified procedure in ASTM D7138, *Standard Test Method to Determine Melting Temperature of Synthetic Fibers*, involves the use of differential scanning calorimetry to determine the precise melting temperature of the specimen. This procedure is in contrast to the previous method employed in NFPA 1971 (2013 edition and earlier) where a visual determination of whether thread melted at 260°C (500°F) was made.

A.9.2.16 The TPP test method described in Section 9.2.16, Thermal Protective Performance (TPP) Test, is intended for the measurement of structural firefighting protective ensemble elements and proximity firefighting protective ensemble elements including garment composites, hoods, shrouds, ear covers, and gloves.

A.9.2.16.1.1 The specimen mounting configuration in this test that positions the specimen in contact with the sensor is not

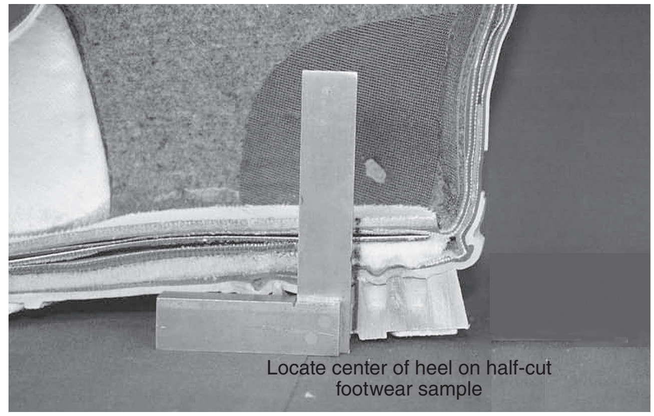


FIGURE A.9.1.22(b) Technique to Locate Center of Heel for Determining Footwear Height.

recommended for station/work uniforms, wildland firefighting protective clothing, or industrial protective clothing.

A.9.2.16.5 These quartz lamps may be offered with a clear or frosted finish on the quartz tube. While similar, the two lamp types are known to produce different test results. To reduce variability, this standard specifies the use of only frosted type lamps. Some manufacturers might designate the frosted lamps as "transparent" or "translucent."

A.9.3.5.4.9 *Equipment Guidelines.* The instrumentation should be allowed to warm up until it stabilizes. No simple means exists to calibrate the impact system required by this standard. Nevertheless, calibration is necessary. The equipment should be checked for repeatability before and after each series of tests by impacting a standardized elastomeric shock pad. A minimum of three such impacts are recorded before and after testing. If the post-test average readings of the three impacts differs from the pretest average by more than 5 percent, the entire test series is discarded.

The impact tester should have a guide rail at least 3 m (9.8 ft) in height and capable of producing impact velocities

FIGURE A.9.1.22(a) Full Footwear Sample Shown with Vertical Cross-Section of Footwear Sample.

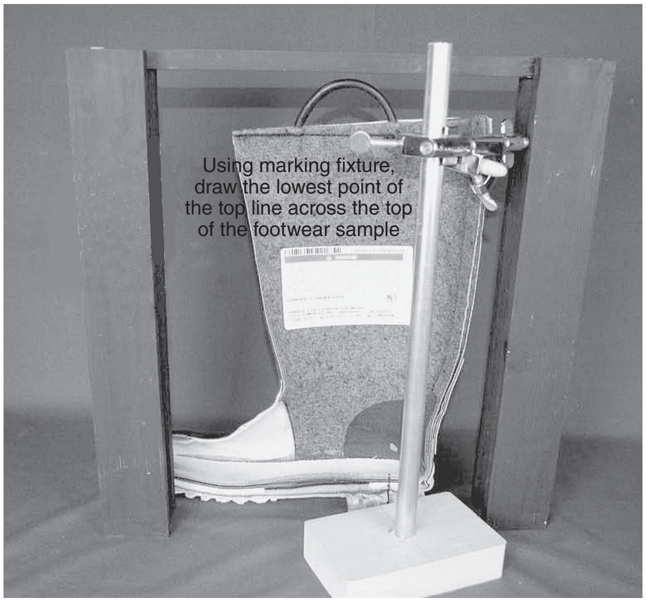


FIGURE A.9.1.22(c) Use of Marking Fixture to Draw Top Line Across Top of Footwear Sample.

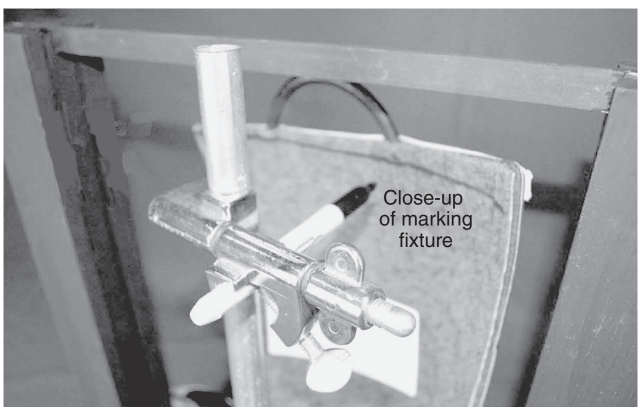


FIGURE A.9.1.22(d) Close-Up of Marking Fixture.

required by this standard. Test anvils, headforms, transducers, and so forth, mounted to the base should be attached so that no energy is absorbed through deflections and the base should be at least 25 mm (1.0 in.) thick steel. Guide mechanisms that slide on the rail should have recirculating ball bearings to minimize friction. The impactor guide mechanism should contain an automatic brake to prevent second impacts (bounding). A velocity detector is required to assure proper drop heights. The position of said detector should be adjustable so that the speed of impact is measured no more than 20 mm (0.79 in.) from the point of impact. A detector flat attached to the guide mechanism that passes through or by the detector should not be greater than 26 mm (1.02 in.) in height. The detector should be capable of resolving velocities of 0.01 millisecond increments. Magnetic detector systems can also be used if equivalency is established. An electronic timer is used to determine the speed at which the flag traverses the detector. The load cell should conform to the following characteristics:

(1) Size: 75 mm (3.0 in.) diameter min

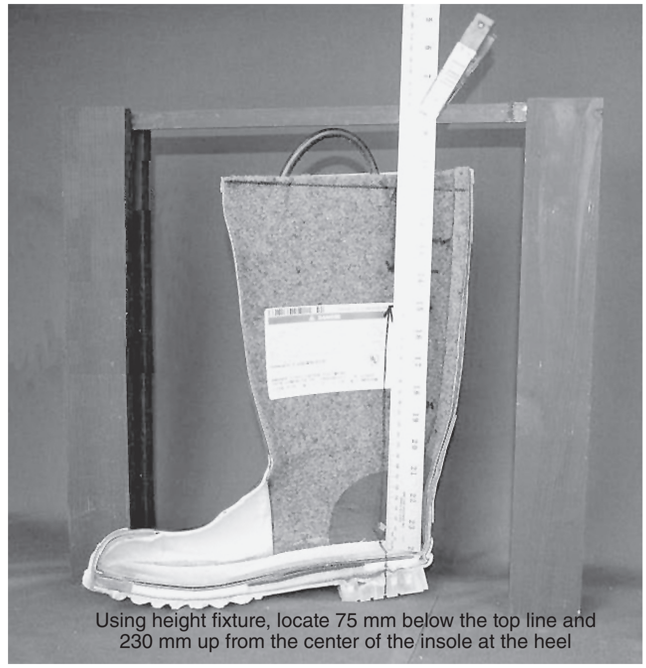


FIGURE A.9.1.22(e) Use of Height Fixture and Ruler to Locate Prospective Liquid Level Test Height.

(2) Measuring range: 0–5000 N (0–1124 lbf) min
(3) Resolution: 45 N (10.1 lbf) max
(4) Accuracy, linearity: ±2.5% full-scale max
(5) Rigidity: 4.5×10^9 N/m (2.6×10^7 lbf/in.) min
(6) Transverse sensitivity: 3.0% max

The load cell/headform mounting system should not have a resonant frequency less than 5 kHz, and the frequency response of the system should be in compliance with SAE Recommended Practice J211b, *Channel Class 1000*.

It is recommended that the load cell output be recorded with a storage oscilloscope, transient recorder, or similar device designed to store maximum readings. However, maximum for readings can be obtained using a peak-indicating meter designed to store only a maximum reading. The frequency response of peak-indicating meters should at least meet the requirements of SAE Recommended Practice J211b, *Channel Class 1000*. Resolution should be 45 N (10.1 lbf) max with rise time capability less than 0.01 milliseconds.

Calibration. Strain gauge-type load cells can generally be calibrated statically by applying a known dead weight to the top of the load cell and checking the output signal. This works well with an oscilloscope or voltmeter. However, transient vibrations tend to create a problem when using peak-indicating meters, and thus the load must be applied and/or removed with extreme care. Furthermore, static calibration does not take into account the dynamic response of the measuring system. Dynamic calibration is recommended but requires a calibrated reference accelerometer and a calibrating medium (shock pad). The reference accelerometer should have the following characteristics:

(1) Measuring range: 0–400 Gs min
(2) Resolution: 1.0 G max
(3) Accuracy, linearity: 1.0% full-scale max

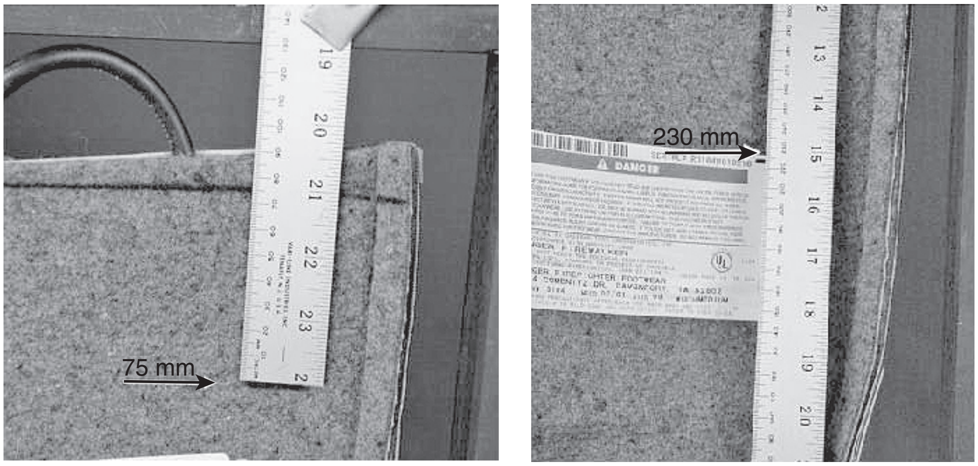


FIGURE A.9.1.22(f) Close-Ups of Heights Marked on Interior of Footwear Sample.

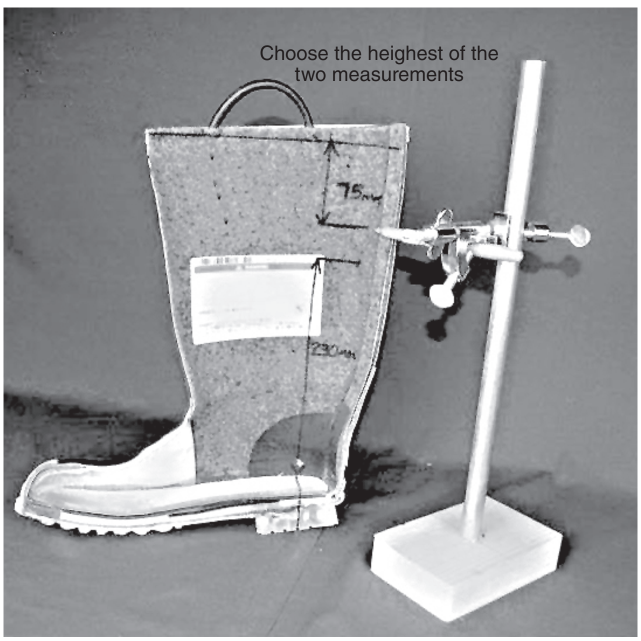


FIGURE A.9.1.22(g) Comparison of Height on Interior of Footwear Sample to Set Liquid Test Height.

(4) Transverse sensitivity 3.0% max
(5) Resonant frequency: 20 kHz min
(6) Frequency response: ±0.5 db @ 0.1 hz–2.0 kHz
(7) Repeatability/stability: 1.0% full-scale max

The calibrating medium should have the following characteristics:

(1) Material: Elastomer (high resilience and low hysteresis)
(2) Durometer: 50–60 Shore A
(3) Thickness: 25 mm (1.0 in.) min
(4) Size: 100 m (4.0 in.) diameter min

The accelerometer is mounted on top of the 3.6 kg (8.0 lb) impactor along its vertical axis (±2.5 degrees of true vertical) according to the manufacturer's instructions. A dual channel storage oscilloscope is recommended for making simultaneous

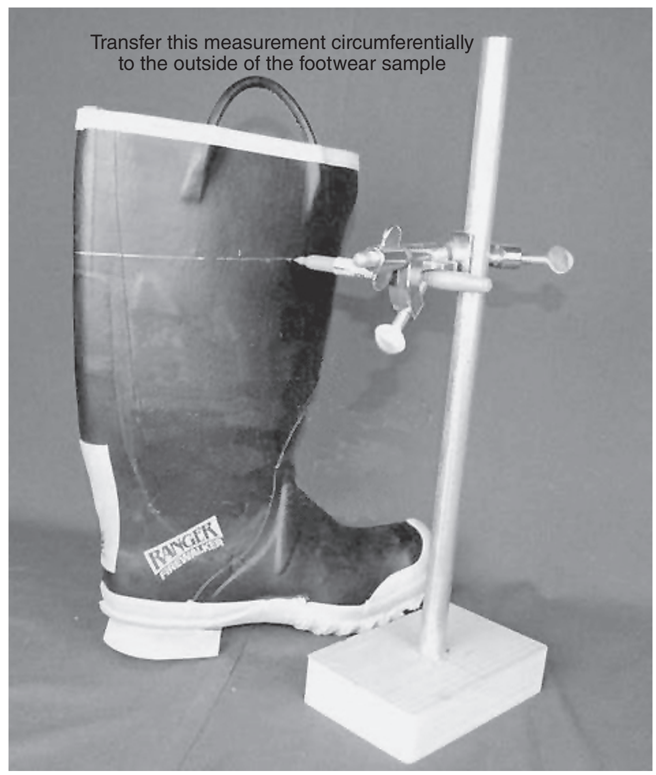


FIGURE A.9.1.22(h) Marking of Liquid Test Line on Exterior of Footwear Sample.

records of both accelerometer and load cell outputs. Both accelerometer and oscilloscope should be in recent calibration.

Force Measuring System Calibration Procedure. Remove headform from load cell and mount the calibrating medium to the top of the load cell. All electronic systems should be turned on and allow to stabilize. The impactor, with accelerometer attached, should be dropped onto the calibrating medium from a height that yields a maximum acceleration reading of 100 Gs ± 10 Gs. Outputs of both accelerometer and load cell should be recorded. The two maximum values should read within 2.5 percent of each other according to $F = ma$ (Force = mass × acceleration). This degree of accuracy must be repeatable throughout at least five impacts.

Velocity Measuring System Calibration Procedure. If a simulated detector flat (ball) cannot be dropped in "free fall" from a known height through or by the detector, the velocity measuring system should be returned to the manufacturer at least every 12 months for recalibration. Otherwise, a ball of known diameter can be dropped from a known height to trigger the velocity detector. The ball must be large enough to properly trigger the detector and have enough mass to negate the effects of aerodynamic friction. The ball should be dropped from at least 1 m (3.3 ft). The actual velocity is then calculated from the following equation:

[A.9.3.5.4.9]

$$V = \sqrt{2gh}$$

where:
g = gravitational constant
h = drop height

This value is then compared to the measured velocity. Both values should agree within 1.0 percent.

System Repeatability Procedure. With the calibrating medium (shock pad) described above mounted to the top of the load cell, three consecutive drops of the impactor onto the medium should be made. The velocity of impact should be maintained at 4.0 m/sec ± 0.03 m/sec (13.1 ft/sec ± 0.1 ft/sec). The repeatability value should be the average of the three maximum transmitted force readings. However, the total range for the three values should not exceed 5.0 percent of the average value.

A.9.3.6.4.8 The instrumentation should be allowed to warm up until it stabilizes. No simple means exists to calibrate the impact system required by this standard. Nevertheless, calibration is necessary.

The equipment should be checked for repeatability before and after each series of tests by impacting a standardized elastomeric shock pad as specified in A.9.3.5.4.9. A minimum of three such impacts should be recorded before and after testing. If the post-test average readings of the three impacts differs from the pretest average by more than 5 percent, the entire test series is discarded.

The impact tester should have a guide rail at least 2.0 m (6.6 ft) in height to produce impact velocities required for this standard.

The flat anvil should be made to be interchangeable on the base and be attached so that no energy is absorbed through deflections and the base should be at least 25 mm (1 in.) thick steel. Guide mechanisms that slide on the rail should have recirculating ball bearings to minimize friction. A velocity detector is required to assure proper drop heights. The position of said detector should be adjustable so that the speed of impact is measured no more than 20 mm (0.79 in.) from the point of impact. A detector flag attached to the guide mechanism that passes through or by the detector should not be greater than 25 mm (1 in.) in height. The detector should be capable of having a resolution no greater than 0.01 milliseconds. The photo beam, visible, infrared, and so forth, should have emitter/receiver slots no greater than 0.05 mm (0.002 in.) running normal to the path of travel of the flag. Magnetic detector systems can also be used if equivalency is established. An electronic timer is used to determine the speed at which the flag traverses the detector. A mounting ball should be attached to the guide mechanism, in such a way as to prevent rotation. Test headforms are mounted on said ball with a clamping ring such that the headforms can be swiveled about the ball. An accelerometer should be mounted inside the ball, having its axis (or the vertical axes, in the case of a triaxial accelerometer) within 2.5 degrees of vertical alignment.

The accelerometer should conform to the following characteristics:

(1) Shape: Cubic, with flat sides
(2) Size: 25 mm (1.0 in.) max dimensions
(3) Measuring range: 0–500 Gs min
(4) Resolution: 1.0 G max
(5) Accuracy, linearity: 1.0% full-scale max
(6) Transverse sensitivity: 5.0% max
(7) Resonant frequency: 20 kHz min
(8) Frequency response: ±5 db @ 0.1 Hz-2 kHz
(9) Repeatability/stability: 1.0% full-scale max

The frequency response of the system should be in compliance with SAE Recommended Practice J211b, *Channel Class 1000.* Each channel resolution should be 1.0 G max with rise time capability less than 0.01 milli-seconds.

Calibration. While there are several acceptable methods of accelerometer calibration, one method can be performed using the fixture specified in A.9.3.5.4.9 for dynamic calibration. In this case, however, the calibrated reference accelerometer and the test accelerometer should be fixed in "piggyback" fashion, one on top of the other. The cubic shaped test accelerometer lends itself well to this procedure. The axis should be in vertical alignment with the axis of the reference accelerometer and the vertical axis of the impactor. Practice has demonstrated that thin, "double stick" tape can be used to fixture the accelerometers one on top of the other. This assumes that the flat surface of the accelerometers in contact with the tape is at least 50 mm^2 (2.0 in.^{2}) and that the cables are properly tied down and held in place.

Acceleration Measuring Procedure for Test Accelerometer. Remove the test accelerometer from the mounting ball. Mount this unit on the impactor, then mount the calibrated reference accelerometer on top of the test accelerometer. Mount the calibrating medium as specified in A.9.3.5.4.9. All electronic systems should be turned on and allowed to stabilize. The impactor with accelerometers attached should be dropped onto the calibrating medium from a height that yields a maximum acceleration, as indicated by the reference accelerometer of 200 G ± 20 G. The vertical axis outputs of both accelerometers should be recorded. The two maximum values should read within 2 percent of each other. This degree of accuracy should be repeatable through at least five impacts.

(Alternate) Acceleration Measuring System Dynamic Calibration Procedure. Mount the calibrating medium on top of the load cell and install the load cell in place of the test anvil. All electronic systems should be turned on and allowed to stabilize. Position the headform inverted with the basic plane horizontal. The headform with accelerometer installed should be dropped onto the calibrating medium from a height which yields a maximum acceleration reading of 300 ± 20 Gs. Outputs of both

accelerometer and load cell should be recorded. The two maximum values should read within 2.5 percent of each other according to $F = ma$ (Force = mass × acceleration). This degree of accuracy shall be repeatable through at least five impacts.

Velocity Measuring System Calibration Procedure. For checking the calibration of velocity detectors, see A.9.3.5.4.9.

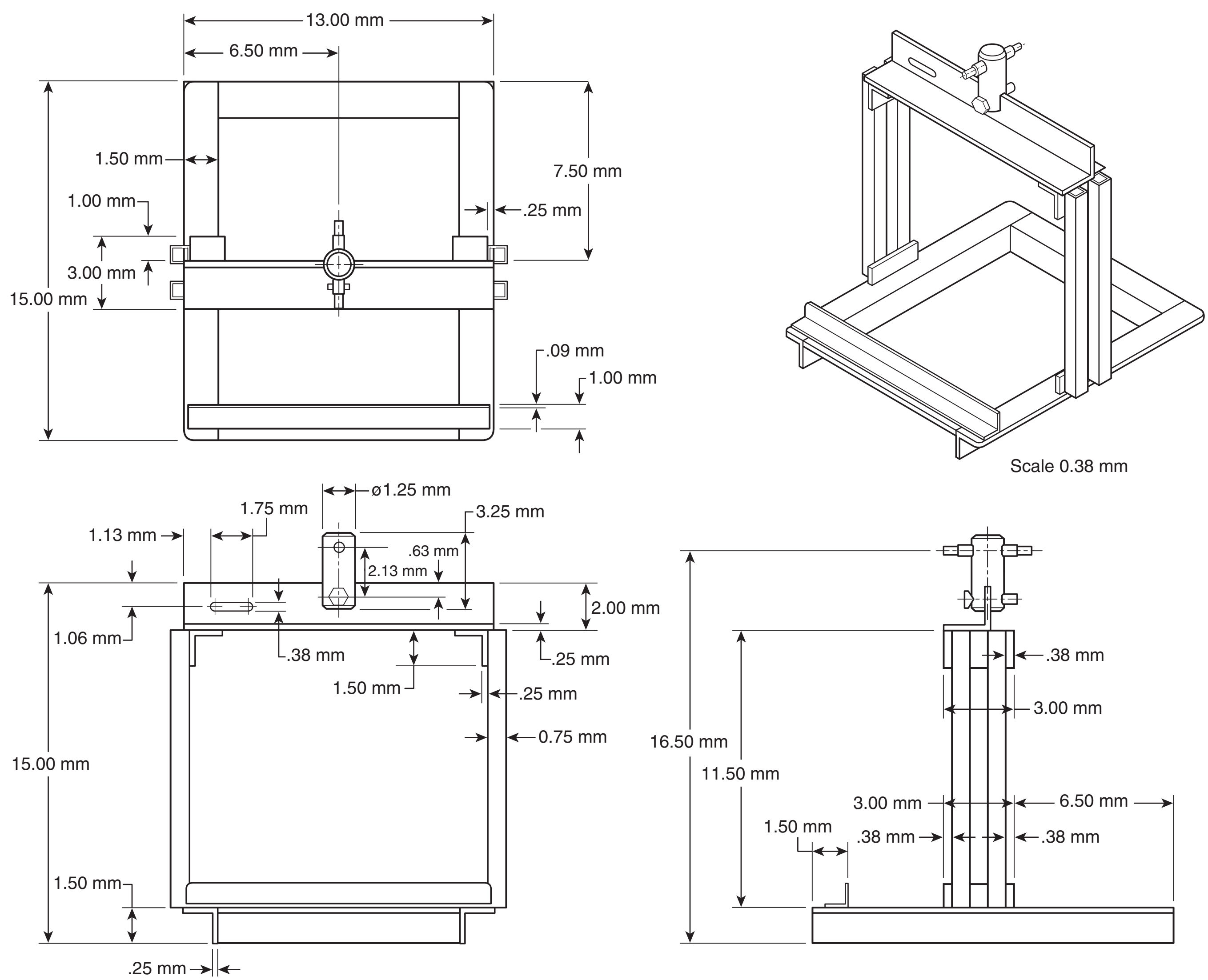
System Repeatability Procedure. Mount the calibrating medium (shock pad) described in A.9.3.5.4.9 onto the test base in place of the test anvil(s). Position the headform inverted, with the basic plane horizontal. With the accelerometer connected to the recording/computing instrumentation, three consecutive drops of the headform onto the medium should be made. The velocity of the impact should be maintained at 3.0 m/sec ± 0.03 m/sec (9.8 ft/sec ± 0.1 ft/sec). For each drop a maximum G value should be recorded. The repeatability value should be the average of the three measurements. However, the total range for all three values should not exceed 5.0 percent of the average value.

A.9.3.6.5.9 The test anvil should not be moved from its alignment as specified in 9.3.6.4.4, except in those circumstances where contact of the brim will first occur for the helmet brim. Every effort should be made to maintain the alignment specified in 9.3.6.4.4, since significant deviations of this alignment will result in erroneous accelerations measurements.

A.9.3.8.4.1 Figure A.9.3.8.4.1(a), Figure A.9.3.8.4.1(b), and Figure A.9.3.8.4.1(c) represent one complete test, not multiple examples of one test. Other appropriate test fixtures might be used.

A.9.3.9.4.2 Figure A.9.3.9.4.2 represents an example of an appropriate retention test fixture. Other appropriate test fixtures might be used.

A.9.3.9.5.4 The retention system test is measuring vertical movement. When applying the load, the helmet could shift from its original horizontal plane position. If this occurs, the helmet should be secured in such a manner that the horizontal



For U.S. units, 1 mm = 0.0394 in.

FIGURE A.9.3.8.4.1(a) Shell Retention Test Fixture.

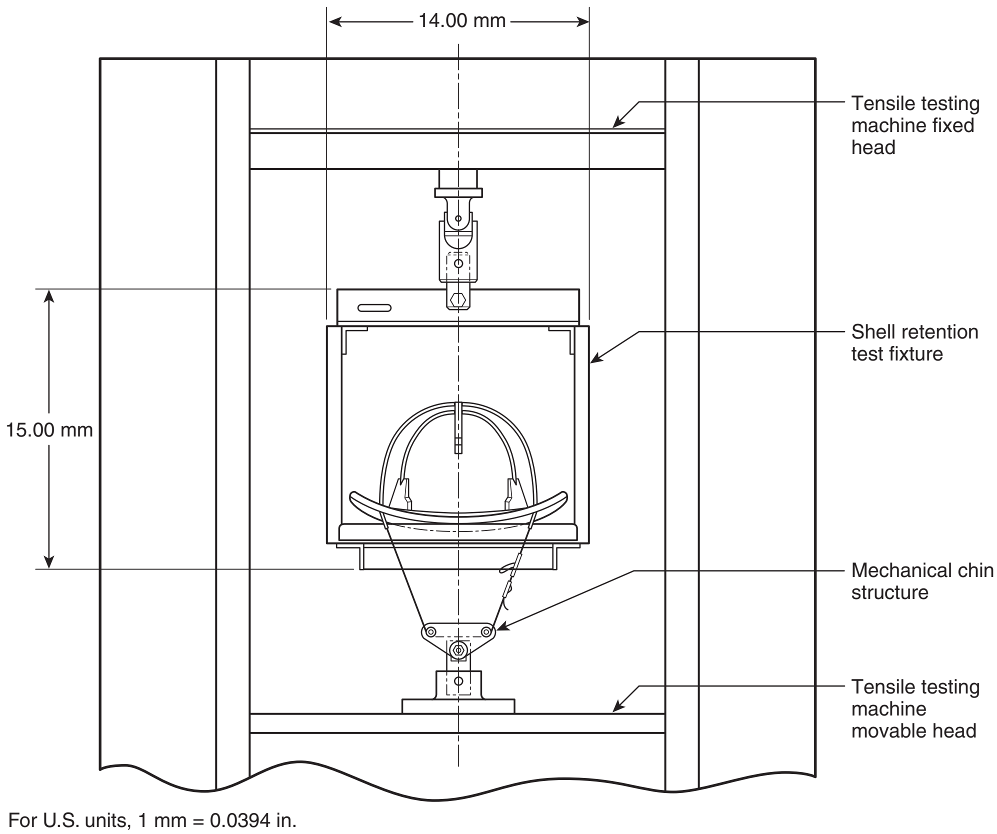


FIGURE A.9.3.8.4.1(b) Shell Retention Test Setup 1.

plane position is maintained, but the vertical movement is not influenced.

A.9.3.11.4.1.3 This prevents missile tumble, helps to protect the operator if the tube extends to within a short distance of the device being tested, and allows the exact space necessary for insertion of the missile at the top. Partial shielding of the headform might be advisable to protect the operator's feet.

A.9.3.11.5.1.1 The steel balls move at dangerous speeds, and other forms of safety devices, such as interlocks and palm switches, might be desirable in a particular setup.

A.9.4.2.4.3 A restraining cloth is not permitted because the purpose of the test is for the evaluation of the coating or lamination quality for the coating, film, or laminate. Future versions of this test might entail modification of the test procedures and criteria for ascertaining continued moisture barrier integrity of the coating, film, or laminate following different conditioning steps.

A.9.4.3.4.2 The list of common fireground chemicals is intended to provide a number of substances to which firefighters might be exposed during ordinary fireground and other emergency operations. It is not intended to be an all-inclusive list of hazardous liquids to which firefighters might be exposed while wearing protective clothing.

The list of chemicals is used in the evaluation of the liquid penetration resistance of moisture barriers provided in structural and proximity firefighting protective ensemble elements with the objective that moisture barrier materials and seams should not allow the penetration of these liquids through the element onto the firefighter's skin. This penetration might occur as the result of the liquid causing degradation of the moisture barrier material or seam. In some cases, such as in glove and footwear elements, it might not be possible to inspect the moisture barrier.

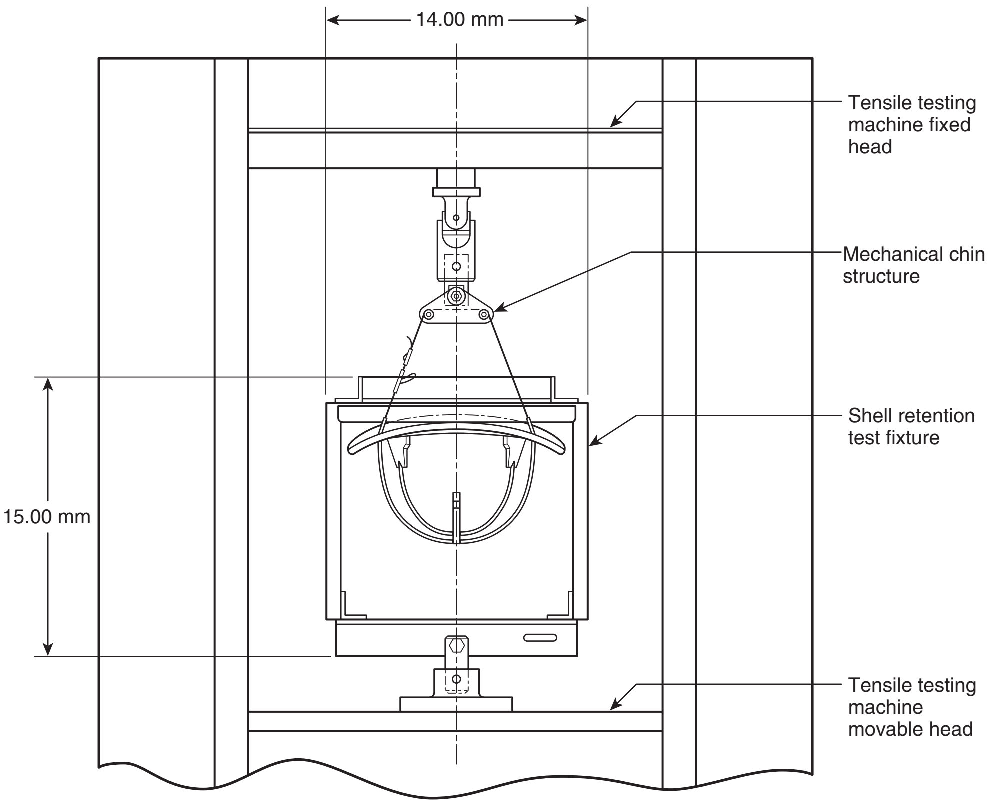
A.9.4.4.2.3 A reference sample is tested to confirm the equipment is functioning in the appropriate range prior to the commencement of a series of testing or when the test equipment is modified or repaired.

A.9.4.4.5.2 The slurry of suspended latex spheres with a particle size range of 0.1 µ to 1.0 µ in water can be made by diluting the uniform latex spheres at a ratio of 1000 to 1 in 1 L of 0.05 µ deionized filtered water. The nominal particle sizes employed must fall within the midpoint or lower of the particle size channel range. For example, if the particle size range is 0.1 µ to 0.15 µ, the nominal particle size should not be greater than 0.125 µ.

The following references cite that fireground particles are within the specified range:

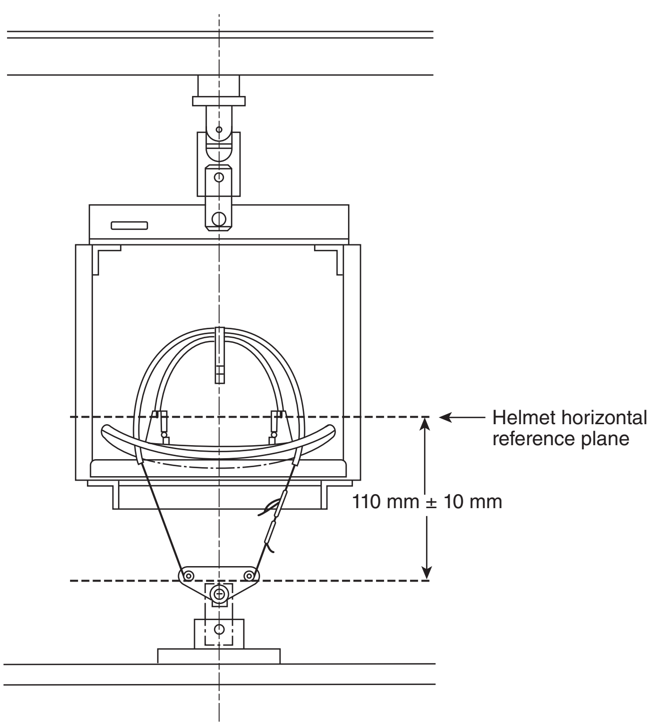
(1) Fabian, T., et al., *Firefighter Exposure to Smoke Particulates*, DHS AFG Grant #EMW-2007-FP-02093, Project Number: 08CA31673, 2010.

(2) Kleeman, M., et al., "Size and Composition Distribution of Fine Particulate Matter Emitted from Wood Burning, Meat Charbroiling, and Cigarettes," *Environmental Science & Technology,* Vol. 33, pp. 3516–3523, 1999.



For U.S. units, 1 mm = 0.0394 in.

FIGURE A.9.3.8.4.1(c) Shell Retention Test Setup 2.



For US units, 1 mm = 0.0394 in.

FIGURE A.9.3.9.4.2 Retention Test Fixture.

(3) Koseki, H., "Large Scale Pool Fires, Results of Recent Experiments," *Fire Safety Science*, Vol. 6, pp. 115–132, 2000.

(4) Nowlen, S., "A Review of Research at Sandia National Laboratories Associated with the Problem of Smoke Corrosivity," *Fire Safety Journal*, Vol. 15 pp. 403–413, 1989.

(5) Rau, J., "Composition and Size Distribution of Residential Wood Smoke Particles," *Aerosol Science and Technology*, Vol. 10, pp. 181–192, 1989.

A.9.4.10 See A.8.1.27.

A.9.5.2.4.1 The water markable glove should be thin, snug fitting, and show liquid contact easily, and the fabric should not have any surface treatment.

A.9.5.3.4.8 The super-high-intensity lamp, model SB-100P with flood bulb from Spectroline®, or equivalent, has been found suitable for use to meet the black light specifications.

A.9.5.3.5.3 Areas of the indicator garment are masked to provide an additional means of evaluating leakage. The removal of the masked areas following testing allows for uncontaminated areas for comparison purposes. Using inappropriate materials for masking can affect the indicator garment by tearing, leaving residue, skewing black light visual analysis, and so forth.

A.9.5.3.5.12 The super-high-intensity lamp model SB-100P with flood bulb from Spectroline®, or equivalent, has been found suitable for use to meet the black light specifications.

A.9.7.1 Copies of an IAFF report can be obtained from the International Association of Fire Fighters Department of Health and Safety, 1750 New York Avenue, NW, Suite 300, Washington, DC 20006-5395.

Copies of an NFPRF report can be obtained from the National Fire Protection Research Foundation, 1 Batterymarch Park, Quincy, MA 02169–7471.

A.9.7.1.5 These modifications should be used instead of Note 6 in ASTM F1868, Part C.

A.9.7.2.1.2 Because evaporative resistances are additive—which is not true for heat loss—it is possible to reduce the total amount of testing required by testing the outer shells and liners (e.g., moisture barriers and thermal barriers) separately and adding the two components (i.e., shells and liners) together to determine the evaporative resistance of the composite.

A.9.8.2.5 The Gardner pivotal sphere haze meter is described in ASTM D1003, *Standard Test Method for Haze and Luminous Transmittance of Transparent Plastics.*

A.9.8.11.4.3.3 The blackout film is intended to simulate the use of the DRD in fireground scenarios. The adhesive vinyl being specified is a lightly obscured vinyl that provides vision up to 1 m (3 ft), silhouettes up to 3.2 m (10 ft), and 70.4 percent blackout when applied to the facepiece.

A.9.9.1.9.9 This average should be based on a total of 12 values of percent shrinkage with 4 values per specimen.

A.9.9.1.9.10 This average should be based on a total of 9 values of percent shrinkage with 3 values per specimen.

A.9.10.1.1 Identified test methods for restricted substances are based on information in both the 2024 editions of the OEKO-TEX Standard 100 and the AFIRM Restricted Substances List.

A.9.10.2.5 An equivalent combustion ion chromatography procedure is described in "Combined use of total fluorine and oxidative fingerprinting for quantitative determination of side-chain fluorinated polymers in textiles," (Liagkouridis, I., et al.).

A.9.11 This test method is provided as the basis for demonstrating a minimum level of bloodborne pathogen protection for garments. It includes two evaluation techniques that involve the measurement of hydrostatic pressure according to AATCC TM127, *Test Method for Water Resistance: Hydrostatic Pressure*, and AATCC TM42, *Test Method for Water Resistance: Impact Penetration Test.* Both evaluation techniques are specific for the Level 3 requirements in AAMI PB70, *Liquid barrier performance and classification of protective apparel and drapes intended for use.*

A.10.1.1.2 Work apparel certified to Chapters 10 through 14 of this standard meets the minimum thermal stability requirements as defined in 13.1.2. Garments such as fitness clothing might not meet the minimum thermal stability requirements of Chapters 10 through 14 and should not be worn while on duty. Such garments can contribute to burn injury. These types of performance fitness clothing should also not be worn as undergarments beneath work apparel. In extreme conditions, undergarments such as socks, briefs, boxer shorts, boxer briefs, and bras made of thermally unstable materials could expose the wearer to additional burn injury. Organizations should evaluate the potential risk that these undergarments might present.

A.10.1.1.4 For departments that would like to understand how much cooling is being provided by wicking performance of their work apparel, ASTM F3628, *Standard for Measuring the Cooling Energy Provided by Wicking Liquid Moisture and Evaporating it from Clothing Materials Using a Sweating Hot Plate*, provides a means to quantify the cooling provided by the wicking and evaporation of sweat from a fabric. The results of this test, known as the cooling efficiency, might be helpful in evaluating this measure of comfort and aiding in the process of specifying work apparel.

A.10.1.1.5 Work apparel that are certified as compliant only with Chapters 10 through 14 of this standard are not primary protective garments and cannot be relied on to provide protection from specific hazards, such as those encountered during structural or wildland firefighting. Other standards are written for garments that provide primary protection for specific hazards to which firefighters can be exposed while participating in emergency operations or training. However, compliant work apparel could also be certified to another standard for primary protective garments and thus be both a primary protective garment for the specific hazard that the other standard addresses and a work apparel that is compliant with Chapters 10 through 14. Station/work uniforms that receive such dual certification (to Chapters 10 through 14 and to a primary protective garment standard) would always exceed the minimum requirements of Chapters 10 through 14. Examples of primary protective garment standards include, but are not limited to, NFPA 1951, NFPA 1977, NFPA 1990, and NFPA 1999.

A.10.1.1.6 The authority having jurisdiction should conduct a risk assessment and determine the level of visibility required for work apparel based on the anticipated use of such garments during these incidents. Where the AHJ anticipates visibility hazards, such as darkness, obscuration (smoke, fog, dust), and proximity to traffic, moving machinery, or heavy equipment operation, the AHJ should be aware of various types of visibility markings. In the case of personnel operating in proximity to traffic, moving machinery, or heavy equipment in operation, the AHJ needs to understand that special high-visibility markings are required by 23 CFR 655. This regulation requires that the *Manual on Uniform Traffic Control Devices* (MUTCD) be followed on all roads open to public travel. In Section 6D.03, the MUTCD specifies that all workers, including emergency responders, within the right-of-way who are exposed either to traffic or to work vehicles and construction equipment within the temporary traffic control (TTC) zone shall wear high-visibility safety apparel that meets the Performance Class 2 or 3 requirements of ANSI/ISEA 107, *American National Standard for High-Visibility Safety Apparel and Accessories.* Section 6D.03 includes an option specifying that in lieu of ANSI/ISEA 107 apparel, emergency and incident responders and law enforcement personnel within the TTC zone can wear high-visibility safety apparel that meets the performance requirements of ANSI/ISEA 207, *American National Standard for High-Visibility Public Safety Vests.* An additional option within Section 6D.03 specifies that firefighters and other emergency responders working within the right-of-way and engaged in emergency operations that directly expose them to flame, fire, heat, or hazardous materials can wear retroreflective turn-out gear that is specified and regulated by other organizations, such as NFPA.

Users are encouraged to conduct a wear trial and develop user findings and recommendations when dealing with work clothing elements that make claims to provide moisture management. Moisture management clothing can also be described as wicking, active transport, or similar descriptive terms that imply comfort to the wearer by moving sweat away from the body. The AHJ should be aware that it can be difficult to objectively quantify findings or such claims. User perception of comfort should be considered over such claims of moisture management.

A.10.1.1.9 Emergency response organizations are cautioned that accessories are not a part of the certified product but could be attached to the certified product by a means not engineered, manufactured, or authorized by the manufacturer. Emergency response organizations are cautioned that if the accessory or its means of attachment causes the structural integrity of the certified product to be compromised, the certified product might not comply with the standard for which it was designed, manufactured, and marketed. Additionally, if the accessory or its attachment means are not designed and manufactured from materials suitable for the hazardous environments of emergency incidents, the failure of the accessory or its attachment means could cause injury to the emergency responder.

Because the aftermarket for certified product accessories is so broad, fire and emergency response organizations are advised to contact both the manufacturer of the accessory and the manufacturer of the certified product and verify that the accessory and its means of attachment are suitable for use in the intended emergency response environment. Emergency response organizations should seek and receive written documentation from both the accessory manufacturer and the manufacturer of the certified product to validate the following information:

(1) The accessory for a certified product, and its attachment method, will not degrade the designed protection or performance of the certified product below the requirements of the product standard to which it was designed, manufactured, tested, and certified.
(2) The accessory, when properly attached to the certified product, shall not interfere with the operation or function of the certified product, or with the operation or function of any of the certified product's component parts.

Users are also cautioned that the means of attachment of the accessory that fail to attach the accessory safely and securely to the certified product can cause the accessory to be inadvertently dislodged from the certified product and create a risk to the wearer or other personnel in the vicinity.

A.10.1.2.2 Certain performance attributes of station work uniforms cannot be adequately assessed under controlled laboratory conditions. An example of such attributes are claims of moisture management. Many manufacturers claim moisture management properties of base-layer garments, but there is currently no standardized means of adequately assessing the impact on firefighter safety. The impact on firefighter safety can vary in different scenarios, depending on the primary protective clothing worn over the station work uniform.

In the 2014 edition of NFPA 1975, optional requirements for odor-resistant work apparel were included. This category was intended to address the antimicrobial properties of work apparel and used an industry-accepted test method for antimicrobial activity of apparel materials. This optional category was removed because the term *odor resistance* was not directly related to firefighter or emergency responder safety, and additional material testing would be needed for making a true antimicrobial claim consistent with the US government regulations required to support specific claims of antimicrobial performance and efficacy.

A.10.1.2.3 The purchaser should provide the vendor with a detailed specification for the specific performance and design criteria. In addition to the performance requirements specified in Chapter 13 and to ensure that work apparel are ordered and manufactured in a consistent manner, purchasers should consider the development of a detailed purchase specification that should include the following:

(1) Compliance of the garments with Chapters 10 through 14 of this standard.
(2) Reference item numbers for each item required by the purchase specification.
(3) Additional material/component requirements.
(4) Individual sizing. Work apparel that restricts movement or conflicts with the function of primary protective garments increases the risk of injury. ASTM F1731, *Standard Practice for Body Measurements and Sizing of Fire and Rescue Services Uniforms and Other Thermal Hazard Protective Clothing*, can be useful for sizing work apparel.
(5) Color.
(6) Number of units.
(7) Special service requirements.
(8) Pockets or emblems (number, type, and detailed description of placement).
(9) Special wrapping and packaging requirements.
(10) Shipment terms and conditions.
(11) Manufacturer's warranty.

Where the purchaser specifies additional requirements that exceed those of Chapters 10 through 14 of this standard, the purchaser should consider requiring the vendor to provide test data that demonstrate garment compliance with the additional requirements of the purchasing agreement. Test methods and test procedures should be discussed and agreed on by the purchaser and vendor as part of the specifications acceptance process.

To facilitate effective and consistent communications between the purchaser and the vendor, specific contact persons should be designated to address such issues as contract requirements, order status, delivery schedules, and problem resolution.

The purchaser should develop a coordinated system to maintain records on purchase order details and specifications, testing results for any requested performance criteria that exceeds the requirements of Chapters 10 through 14 of this standard, vendor performance, delivery schedules, and invoice inventory. The purchase specifications and the system should provide the procedures needed to address compliance or noncompliance with the purchasing contract.

A.10.1.3.6 Emergency services organizations (fire, hazardous materials, law enforcement, medical, skilled trades, technical rescue, USAR) should determine what requirements for use of work apparel apply in their jurisdiction. Regulations of national, state/provincial, regional/county/district, and local government occupational safety and health agencies, and policies of insurance or underwriters organizations should be studied for their application to operations conducted by the emergency services organization.

A.11.1.9.1 Class designations use Roman numerals, and Division designations use Arabic numerals.

A.11.1.9.2 Class designations use Roman numerals, and Division designations use Arabic numerals.

A.11.2.2 Packaging containing the user information can consist of printed materials or instructions to access the information digitally.

A.11.2.6(3) To avoid possible damage to the garment and possible reduction and loss of inherent or treated flame resistance characteristics of the garment, the manufacturer should be contacted prior to disinfecting or cleaning the garment by a method not prescribed on the product. Work apparel should not be cleaned in home washing machines. See 11.1.7 and 11.2.6 for information regarding how to identify the manufacturer and the garment.

For information on the prevention and transmission of communicable diseases and carcinogens caused by contaminated garments, see NFPA 1581 and OSHA regulation 29 CFR 1910.1030, or consult the Centers for Disease Control, the local board of public health, the American Medical Association, the US Fire Administration, the Environmental Protection Agency, or the International Association of Fire Fighters.

A.12.1.5 Aftermarket products applied after the construction of the garment, such as insect-repellent, antimicrobial, water-repellent, and other finishes, could impact the performance and protective properties and reduce them below the requirements of this standard. Treatments could also void the manufacturer's warranty. The organization should thoroughly evaluate any potential claim by a manufacturer for an aftermarket application and consult the manufacturer of the garment as well.

A.12.3 The explosion protection requirements for fire service electrical devices, such as SCBA and PASS devices (and thermal imagers and RF devices) are derived from intrinsic safety and nonincendive requirements of *NFPA 70*. With an option for the inclusion of electrical circuitry now added for structural and proximity firefighting protective ensembles and ensemble elements and for work apparel, similar explosion protection requirements have been added. See A.17.1.8 and A.22.5 for additional details.

A.12.3.1.1 Passive electrical circuity that complies with 12.3.1.2 does not present a risk of ignition in an explosive atmosphere, or a risk of fire and electric shock.

A.12.3.2.1 This suitability is demonstrated by being certified as one of the following in accordance with UL 121201, *Nonincendive Electrical Equipment for Use in Class I and II, Division 2 and Class III, Divisions 1 and 2 Hazardous (Classified) Locations*:

(1) Nonincendive equipment, stand-alone type
(2) Nonincendive equipment, electrically interconnected type
(3) Nonincendive system

A.12.3.3.1 This suitability is demonstrated by being certified as one of the following in accordance with UL 913, *Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, and III, Division 1 Hazardous (Classified) Locations*:

(1) Intrinsically safe apparatus, stand-alone type
(2) Intrinsically safe system

A.13.2 Two separate test requirements are provided for manufacturers who wish to claim use of flame-resistant textile fabrics in their manufacture of work apparel. When the requirements found in Section 13.2 are met, additional label language is used to indicate that the garments are flame resistant.

A.13.3 For the purpose of this standard, *water resistance* is defined as "a finish or inherent property [of a fabric] that limits the absorption of water." Water resistance may also encompass other properties including water repellency and water penetration resistance. These additional test properties can be applied if other types of water resistance are required or desired for the specific work apparel item under consideration.

A.13.4 It is important that users understand that insect repellency is a finish or treatment and that performance or bite protection is likely to decline over time and after laundering.

A.14.4.1.2 Examples of major seams include but are not limited to seat seams, side seams, and inseams of pants; seat seams, side seams, inseams, yoke seams, sleeve set, and shoulder seams of coveralls; and yoke seams, side seams, sleeve set, side seams, and shoulder seams of shirts. Major seams do not include seams that do not expose the wearer's skin or undergarments when ruptured, for example, pocketing or emblem seams.

A.15.1.1.1 The use of SCBA by firefighters is always assumed to be in atmospheres immediately dangerous to life or health (IDLH). There is no way to predetermine hazardous conditions, concentrations of toxic materials, or percentages of oxygen in air in a fire environment, during overhaul (salvage) operations, or under other emergency conditions involving spills or releases of hazardous materials. Thus, SCBA are required at all times during any firefighting, hazardous materials, or overhaul operations. General use criteria are contained in NFPA 1550.

A.15.1.1.4 Both NIOSH 42 CFR 84, "Respiratory Protective Devices, Tests for Permissibility," and Chapters 15 through 19 of this standard require any accessory attached to an SCBA to be certified under both of these documents.

Emergency response organizations are cautioned that accessories are not part of the certified product but could be attached to a certified product by means not engineered, manufactured, or authorized by the certified product manufacturer.

Emergency response organizations are cautioned that if an accessory or its means of attachment causes the performance of the certified product to be compromised, the certified product might not be compliant with the standard with which it was originally certified as compliant. Additionally, if an accessory or the accessory's means of attachment are not designed and manufactured from suitable materials for the hazardous environments of emergency incidents, the failure of the accessory, or means of attachment, could cause injury to the emergency responder.

Where users desire an accessory that is not part of the certification of the SCBA, the user must contact the SCBA manufacturer to seek approval for the accessory.

Attachment of any accessory that is not approved and part of the certification of the SCBA will void the certification.

A.15.1.2.2 Although SCBA that meet this standard have been tested to more stringent requirements than required for NIOSH certification, there is no inherent guarantee against SCBA failure or firefighter injury. Even the best-designed SCBA cannot compensate for either abuse or the lack of a respirator training and maintenance program. The severity of these tests should not encourage or condone abuse of SCBA in the field.

The environmental tests utilized in this standard alone might not simulate actual field conditions, but they are devised to put extreme loads on SCBA in an accurate and reproducible manner by test laboratories. However, the selection of the environmental tests was based on summary values derived from studies of conditions that relate to field use.

A.15.1.2.3 To help guide the purchase of SCBA, refer to NFPA 1852.

A.15.1.3.1.1 Prior to the issuance of the 2019 edition of NFPA 1981, NIOSH/NPPTL policy did not permit the use of an emergency breathing support system (UEBSS; also known as "buddy breathing"), but investigations by the Task Group on UEBSS assigned by the Respiratory Protection Equipment (RPE) Technical Committee to investigate this issue found that the fire service successfully uses and trains on these types of devices. The Technical Committee approached NIOSH/NPPTL about this topic, and NIOSH/NPPTL opened Docket #147 to obtain input and comments from all interested parties. Based upon the input that NIOSH/NPPTL received, and on the fact that there is now UEBSS technology that can prevent two users from being contaminated during UEBSS use in an IDLH environment, NIOSH/NPPTL has changed their policy of prohibiting the use of UEBSS and will now certify UEBSS for the function for which it has been designed. The RPE Technical Committee created performance requirements for UEBSS to ensure continued compliance with Chapters 15 through 19 of this standard when the UEBSS is used.

It is important to note that the duration of the SCBA air supply is dependent upon the volume of air in the cylinder and its rate of consumption, and that the use of an UEBSS will reduce the duration of the air supply from the cylinder. In addition, the authority having jurisdiction should develop standard operating procedures and training requirements to ensure that the UEBSS is properly used.

A.15.2.2.2 SCBA that are certified by NIOSH include a rated service time based on laboratory tests required by NIOSH. The SCBA is tested using a specified breathing machine with a breathing rate of 40 L/min. NIOSH uses this 40 L/min rate because it represents a moderate work rate that an average user can sustain for a period of time. To attain a rated service time of 30 minutes during this 40 L/min test, the typical SCBA cylinder must contain 1200 L or more of compressed breathable air. A 45 ft^3 cylinder has a capacity of 1273.5 L, based on 28.3 L/ft^3. Because actual work performed by a firefighter often results in a ventilation rate that exceeds 40 L/min, firefighters frequently will not attain the rated service time of 30 minutes. During extreme exertion, for example, actual service time can be reduced by 50 percent or more.

To ensure proper utilization of equipment in actual situations, after training and instruction, it is recommended that users gain confidence by actually using the SCBA in a series of tasks representing or approximating the physical demands likely to be encountered.

In addition to the degree of user exertion, other factors that can affect the service time of the SCBA include the following:

(1) The physical condition of the user *(see also ANSI Z88.6, Respiratory Protection — Respirator Use — Physical Qualifications for Personnel)*
(2) Emotional conditions such as fear or excitement, which can increase the user's breathing rate
(3) The degree of training or experience the user has had with such equipment
(4) Whether the cylinder is fully charged at the beginning of use
(5) The facepiece fit
(6) Use in a pressurized tunnel or caisson [At 2 atmospheres of pressure (gauge pressure of 29.4 psi), the duration will be one-half the duration obtained at 1 atmosphere of pressure (gauge pressure of 14.7 psi); at 3 atmospheres of pressure (gauge pressure of 44.1 psi), the duration will be one-third the duration obtained at 1 atmosphere of pressure.]
(7) The condition of the SCBA
(8) The SCBA effective dead air space, which is a volume proportional to the CO_2 concentration in the inhaled breathing gas

During normal breathing without a facepiece, carbon dioxide, which is produced by the body's metabolism, is released to the environment with each breath. The facepiece of an SCBA reduces this environment to a small space around the face. On exhalation, a portion of the carbon dioxide–rich exhaled breath is trapped in this space. On inhalation, fresh air from the SCBA cylinder mixes with this carbon dioxide–rich air and then enters the lungs. The concentration of carbon dioxide is dependent on facepiece configuration, flow characteristics, and ventilation rate.

The full effect of increased dead air space has not been demonstrated. However, the scientific work done in this area shows that an increase of CO_2 in the inhalation air leads to increased ventilation and, consequently, shorter service time for a given air supply. Means to reduce CO_2 in the inhalation air by using, for example, a well-fitting nose cup have been demonstrated to give longer service time. Contact each manufacturer for specific data.

A.15.2.9.2 The text of the 2019 edition of NFPA 1981 incorrectly indicates a 2018 edition date.

A.16.2.7 Users should be aware that NFPA 1550 requires that all SCBA be airflow tested at least annually in accordance with the manufacturer's instructions. This interval of testing might not be adequate when SCBA are used more frequently. It is recommended that airflow testing be based on the number of SCBA uses rather than based solely on time intervals.

A.16.2.7.1(6) Examples of specific substances for which a warning is provided include bleach or other hypochlorite solutions, when applied to SCBA textile components, or certain solvents when applied to surfaces of the SCBA.

A.16.2.7.1(7) Examples of tools include the types of brushes that are deemed suitable for hand cleaning of SCBA.

A.16.2.7.1(8) Cleaning parameters include the temperature of water used for washing and rinsing in addition to the length of time that the SCBA is subject to cleaning or drying.

A.16.2.7.1(10) Where possible, the SCBA manufacturer should alert the organization or end user to specific contaminants that might warrant specialized cleaning such as hazardous materials, asbestos, opioid drugs, and CBRN agents.

A.17.1.2.2 NFPA 1500 specifies that SCBA cylinders used for structural firefighting have a minimum gas capacity of 59.99 ft^3 (1699 L) of air. This requirement for SCBA used during structural firefighting limits SCBA cylinders to those rated by NIOSH for service times of 45 minutes or greater, with the exception of the NIOSH 30-minute rated 3000 psi cylinder. The NIOSH time rating is based on a breathing rate of 40 L/min.

A.17.1.8 For decades, the explosion protection requirements for SCBA and PASS devices have traditionally been derived from intrinsic safety (IS) requirements of the *National Electrical Code (NEC), NFPA 70,* which provides requirements for fixed electrical power installations in hazardous (classified) locations such as refineries and grain elevators. The use-case for fire service SCBA and PASS devices is different in many ways from fixed electrical installations. In addition, recently some changes were made in how testing organizations test certain fire service devices for explosion protection (e.g., portable radios). These changes provided an opportunity to revisit what exact level of explosion protection is really required for portable devices in the fire service. The committee has spent a significant amount of time looking at the various issues, reviewing the past history of incidents, and talking to industry experts. This standard with regard to explosion protection reflects that extensive analysis and the resulting decision. The following information is an explanation of some of the many issues and tradeoffs that were considered during this process.

First, the term "*certified on delivery*" warrants explanation. The firefighter faces many varied operating conditions and therefore needs equipment that can span those multiple conditions. Designing for hazardous locations, as classified by the *NEC*, is done with standards that often assume permanent mounting of electrical fixtures within a defined area. None of those areas approaches the environment found within any structure fire. As such, there is no established set of failure mechanisms, practices for design, or means of testing and validation that would make a product certified for use in an *NEC* classified area retain its "*guarantee of safety*" in a structural fire. In other words, a product designed and certified for even the most hazardous conditions can lose their "*guarantee of safety*" after its first exposure to adverse environments commonly found on the fire ground. In a sense then, the pursuit of traditional *NEC* intrinsic safety certifications might not have provided the level of assurance that the fire service in fact thought it did. Because the purpose and scope of this document is first and foremost rooted in defining a product suitable for use on an active fire ground, it cannot be ignored that one of its requirements can be invalidated by the resulting product's intended use case.

Next, there is the reality that to date, in the United States, there has been no known instance of fire service SCBA or PASS devices ever having caused an explosion. However, there remain multiple first-responder missions in environments that do resemble *NEC* classified hazardous locations. These include incident scenes without a current active fire, such as fuel spills, reported or actual gas leaks, and so on. These environments resemble classified hazardous locations in that there is likely a presence of an ignitable atmosphere; however, they differ in the following ways from what was envisioned in the *NEC* for explosion protection certifications as follows:

(1) In these areas, there is likely to be multiple pieces of commercial or industrial equipment not designed to any explosion protection standard and, by their very nature, could be capable or even likely of igniting an atmosphere in normal or intended operation. In contrast, products designed for use in *NEC* classified environments are designed so as to prevent the chance of combustion under normal operating conditions (i.e., Division 2 classified areas), or for situations where there are multiple faults (i.e., Division 1 classified areas).
(2) Devices used by the firefighter spend much of their product life in relatively benign environments, interrupted by brief excursions into extremely hostile environments where combustion is often already taking place. Due to the transient nature of this exposure, there is only a small window of time where the benefit of a product being designed for use in an explosive atmosphere is of value. By contrast, products designed for use in *NEC* classified Division 1 hazardous locations utilizing intrinsic safety (IS) as the type of explosion protection, are intended for continuous use in those environments.
(3) Portable electrical devices used by first responders have multiple items that can either be disconnected or replaced, such as RSMs, batteries, and interfaces to self-contained breathing apparatus (SCBA) masks. For example, intrinsic safety (IS) rated portable radios come with instructions not to change the battery in a hazardous environment. However, it is very possible that the RSM connection could accidentally become disconnected in the hazardous atmosphere. By contrast, fixed electrical installations in hazardous areas are physically interconnected by secured conduit and cable systems to the enclosures. This minimizes the likelihood of any sparks being created within the area that contains the hazardous material, and also contains any explosions that might occur.

It is recognized that it might be desirable to obtain the level of confidence and safety resulting from the inherent explosion protection design techniques required to gain certification for use in *NEC* classified Division 1 hazardous locations. However, currently no solution exists that would enable a product to retain its "*guarantee of safety*" during or after exposure to the extreme environment of an active fire. It is this intent which is captured by the term "*certified on delivery*." There is an expectation that both the users and the AHJ will monitor explosion protection equipment for continued fitness for use, including regular visual inspection for obvious compromise, examination and replacement of aging or damaged batteries, and periodic maintenance as prescribed by the manufacturer.

Therefore, at this time, this minimum standard requires Division 2 nonincendive (NI) certification for SCBA and PASS devices. This does not stop vendors and the fire service from pursuing Division 1 intrinsic safety (IS) certified SCBA and PASS devices if they so desire.

A.17.1.8.2.1 This suitability is demonstrated by being certified as one of the following in accordance with UL 121201, *Nonincendive Electrical Equipment for Use in Class I and II, Division 2 and Class III, Divisions 1 and 2 Hazardous (Classified) Locations*:

(1) Nonincendive equipment, stand-alone type

(2) Nonincendive equipment, electrically interconnected type
(3) Nonincendive system

A.17.1.8.3.1 This suitability is demonstrated by being certified as one of the following in accordance with UL 913, *Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, and III, Division 1 Hazardous (Classified) Locations*:

(1) Intrinsically safe apparatus, stand-alone type
(2) Intrinsically safe system

A.17.1.12 Health and safety benefits are the primary reason for pneumatic data logging. Technologies are currently available that make pneumatic data logging for all SCBA a reasonable and necessary minimum feature.

Pneumatic data logging records various data points related to the performance and mechanics of SCBA. Both users of SCBA and agencies can derive large benefit from the recorded pneumatic data logging events. These range from training agencies for the evaluation of air management to resource management agencies that have to substantiate changes in SCBA such as breathing air volume.

After-event review agencies will derive substantial benefit when reviewing post-SCBA incidents. These agencies will be much better equipped with knowledge of likely air events before and after any review. Since pneumatic data logging can be used to assist in evaluating a respiratory protection program, both mechanical and user performance can be better understood and improved.

A.17.3.1 The intent of this section is that the requirements will be met in at least one HUD covering the display of pressure. Any other informational display HUDs in the mask can be used for other monitoring purposes.

A.17.4 Use of the RIC UAC is intended for emergency situations. Recharging breathing air cylinders during routine operations and training should follow applicable safe filling practices outlined in, but not limited to, NFPA 1550, NFPA 1852, and manufacturing instructions.

A.18.1 The current NIOSH certification test method, 42 CFR 84, uses a ventilation rate of 40 L/min, while Chapters 15 through 19 of this standard require an airflow test based on a ventilation rate of 100 L/min. A ventilation rate of 100 standard L/min encompasses the 98th percentile of all firefighters studied. The ability of the SCBA to supply the 100 L/min of breathing gas is measured in this airflow performance test by monitoring the pressure within the facepiece.

Specific response times for both the pressure transducer and recorder are specified in this standard. It is important to note that if other types of recording devices, measuring equipment, and testing methods are used, pressure fluctuations might appear in the facepiece as short (millisecond) negative pressure spikes. The significance of these spikes to the actual protection afforded the user by the SCBA is not fully understood at this time. Additional studies are needed to determine the significance, if any, of these spikes. Because the negative spikes might affect the actual protection offered by the SCBA, it is recommended that a facepiece fitting program be established.

Quantitative fitting tests are recognized to be the best method for determining the facepiece-to-face seal and should be performed by the fire service wherever SCBA are used. For departments that wish to perform quantitative fit testing, a suggested procedure for conducting such tests can be found in ANSI Z88.2, *Practices for Respiratory Protection*; ANSI Z88.10, *Respirator Fit Test Methods*; and 29 CFR 1910.134, "Respiratory Protection."

A.18.9 This standard contains an abrasion test that is used to evaluate the outside surface of the facepiece lens. This standard does not address the abrasion resistance of the interior surface of the facepiece lens. Current facepiece lens interior surfaces can be uncoated, coated with an antifog agent, coated with an abrasion-resistant agent that does not comply with the performance required in Section 18.9, or coated with an abrasion-resistant coating that does comply with the performance required in Section 18.9. Information regarding coatings on the lens interior surface should be obtained from the SCBA manufacturer.

A.18.10 Because the communications test requires human subjects, there were variations in the data used to determine the appropriate pass or fail criteria. Therefore, a statistical approach to analyze the data was required to determine whether an individual SCBA meets the pass or fail criteria of Section 18.10. A null hypothesis test utilizing the Student *t*-distribution is the appropriate method to do this.

The Student *t*-distribution of 2.13 results from the following conditions: degrees of freedom = 4; confidence level = 95 percent. Refer to any current statistical text for further information.

A.18.23 The NFPA 1981 Task Group on Strength of Connection (connection between the facepiece and the second stage regulator) was established to provide additional guidance and recommendations to the Technical Committee to help prevent unintentional release of the second stage regulator in NFPA-compliant SCBA.

A new design requirement has been included in this edition of the standard where double actions are required to release the second stage regulator from the facepiece to reduce or eliminate any chance of second stage regulator release caused by external forces.

This design philosophy gives manufacturers the scope to design solutions with limited design restrictions and allows users to choose a design solution that best suits their operational requirements while still having improved safety of the connection. There is always a compromise between ease of operation and ease of removal.

The double action could still be a single button, but requiring a double action (e.g., slide-and-push or rotate-and-push). A double button can be used; however, pushing one of the buttons must not release the second stage regulator. Again, the double button must not be able to be pressed by a single action by external forces. A release button press and a second action to overcome an internal clip, spring detent, or rotational lock are acceptable. A slide movement from a retaining mechanism/latch is acceptable as long as the slide is not in the same direction as the button release action, as this would be a single action.

It is very important for SCBA users to understand that muscle memory/repetitive skill training is not performed solely by reading training materials. Repetitive skill training with a specific SCBA helps to ensure that a learned response with that specific SCBA will occur and can become second nature to the firefighter. While this hands-on training is very important in regular SCBA training, it is critically important whenever firefighters receive a new SCBA model from the same or a different manufacturer. The fire department must ensure sufficient repetitive skill/muscle memory training for all users before firefighters use their new SCBAs in an IDLH atmosphere. While didactic training is very important, there is no substitute for hands-on training with the specific SCBA they will be using.

This new design requirement does not remove any training responsibilities by the authority having jurisdiction or the users to ensure that the second stage regulator is secured properly to the facepiece.

A.19.1.3.3 The quality of the compressed breathing air used in open-circuit SCBA has a direct effect on the performance of the equipment. It is therefore imperative that breathing air consistent with the design criteria established in this standard is used to ensure that the SCBA will continue to meet the performance criteria contained in this standard. It has been established through years of experience that breathing air that meets the requirements of NFPA 1989 which specifies a maximum moisture content of 24 ppm or drier [i.e., a dew point of −54°C (−65°F) or lower] and a maximum particulate level of 5 mg/m^3 air, will meet the needs of both emergency services personnel and the SCBA.

A.19.1.5.1 The following is the calibration procedure for a breathing machine:

(1) *Equipment setup.* With the breathing machine stopped, connect a spirometer (Collins Medical model 06031 or equivalent) to the mouth of the headform such that an airtight connection is made. Indication of an airtight connection should be interpreted as an imperceptible change in indicated spirometer volume over a 30 second period.
(2) *Volume measurement at 100 L/min rate.*
   (a) Select the "Breathe at 100 L/min Rate" on the breathing machine control panel.
   (b) Measure the tidal volume of the breathing machine bellows by reading the spirometer.
   (c) Verify volume measured (V_m) to be 3.4 L, ±0.1 L.
   (d) Select "stop" on the breathing machine control panel.
(3) *Volume measurement at 40 L/min rate.*
   (a) Select "Breathe at 40 L/min Rate" on the breathing machine control panel.
   (b) Measure the tidal volume of the breathing machine bellows by reading the spirometer.
   (c) Verify volume measured (V_m) to be 1.67 L, ±0.1 L.
   (d) Select "stop" on the breathing machine control panel.
(4) *Adjustments.*
   (a) If the volume measured (V_m) is between 3.3 L and 3.5 L for the 100 L/min breathing rate and between 1.57 L and 1.77 L for the 40 L/min breathing rate, then the breathing machine is ready for the NFPA airflow performance testing to be conducted.
   (b) If the volume measured (V_m) is not between 3.3 L and 3.5 L for the 100 L/min breathing rate and not between 1.57 and 1.77 L for the 40 L/min breathing rate, then the breathing machine must be adjusted appropriately and the V_m remeasured before the NFPA airflow performance testing is conducted.

A.19.3.4.5 See Annex D for surrogate cylinder preparation.

A.19.8.4.5 A means for doing this is by use of a properly calibrated smoke meter and standard light source.

A.19.8.4.7 Silica flour could present a health hazard. When using silica flour, ensure that the chamber is functioning properly and not leaking.

A.19.10.4.12.2 Any changes made to the pink noise speaker configuration require recalibration of the pink noise spectrum per 19.10.4.13.

A.19.14.5.1 It is not the intention of this paragraph to require manufacturers to supply a separate modified SCBA for each EOSTI to be tested. In practice, it could be simpler to provide one SCBA with instructions to the testing laboratory on how to block each sensing device. The laboratory would block out all EOSTI except one and perform the test. After completion of one test, the laboratory would block the unblocked EOSTI and remove the block from another, repeating until each indicator has been tested.

A.19.25.4.12.2 Any changes made to the pink noise speaker configuration require recalibration of the pink noise spectrum per 19.10.4.13.

A.19.28.5.4.2 The gas flow will be approximately 30 L/min (63 SCFH).

A.20.1.1.1 NFPA 1550 requires that each person involved in rescue, firefighting, or other hazardous duties be provided with and use a PASS.

PASS should be worn on protective clothing or protective equipment, or as an integrated part of another item of protective clothing or protective equipment and used whenever the member is involved in fire suppression or similar activities, regardless of whether SCBA is worn. This might require the PASS to be moved from one protective clothing item to another or the department to purchase additional PASS for use where structural protective clothing is not worn, as in, for example, wildland firefighting, technical rescue, and high-angle rescue.

PASS are designed to assist in locating firefighters or other emergency services personnel who become incapacitated or are in need of assistance.

RF PASS contain an optional RF transceiver that enables the PASS to automatically transmit alarm signals and receive evacuation alarms via RF signals. The RF PASS responds to an evacuation alarm with an audible and visual signal. A complete RF PASS system includes a base station that monitors for an alarm signal from the portable RF PASS unit and emits an audible and visual signal when this alarm is received. The base station is also capable of sending an evacuation alarm to the RF PASS.

NFPA 1561 and Section 10.4 of NFPA 1550 require every fire department to establish a system of firefighter accountability that provides for the tracking and inventory of all members during emergency operations.

A.20.1.1.2 Appropriate testing criteria have been developed to include RF PASS in this standard as an option.

Purchasers and manufacturers of PASS should understand that Chapters 19 through 23 of this standard address the minimum requirements for PASS. New technologies and capabilities are available for PASS for the tracking and accountability of emergency services personnel, and emergency services organizations might want to consider specifying such additional features and capabilities that are not included within the minimum standard.

PASS enhancements (accessories) could include the following:

(1) Electronic personnel accountability
(2) Person-to-person local distress notification
(3) Person locator systems
(4) Additional systems information (data logging features such as cylinder pressure, temperature, breathing rates, elapsed time, etc.)

Where purchasers are interested in RF PASS capabilities, they should consider the benefits and limitations of the additional capabilities before making a purchase. Emergency services organizations vary greatly in size, response types, and capabilities. Fire departments on the West Coast, for example, are more likely to encounter multiple-alarm wildland fires than New York City, Boston, or Chicago, which are more likely to experience multiple-alarm tenement or row house building fires than wildfires. Flood-prone regions are less likely to have underground garages, sub-basements, or subway systems. All these examples provide different challenges for the utilization of current versions of RF PASS.

RF PASS utilize radio signal technology. Radio signals react differently in variable and different environments. Different environments present different challenges to radio communications and radio signals. Transmission of radio signals is affected by topography, weather conditions, building layout and design, and construction material, as well as other obstructions that might be in a given area.

In the testing lab environment, alarm systems, monitoring devices, and even personal alert devices, such as PASS, cannot be "tested" in the total environment in which they could be used. Prospective end users, however, can conduct field testing of such devices in the total environment in which they could be used. Devices such as antennas or repeaters are incorporated into radio frequency (RF) systems used in large industrial, commercial, and residential facilities. Realistic and rigorous on-site testing of systems and components will help ensure satisfactory coverage and help the user develop reasonable expectations. Physical testing of personnel safety systems utilizing any form of RF technology should be conducted in an actual or realistic environment. Current RF laboratory tests offer very good indicators regarding the reach and penetration of the RF signal(s). However, no lab test can take into account the variety of construction and obstructions commonly found, such as building layout and design, construction materials, topography, and environmental factors. Users must take local factors into consideration in their immediate response areas and consider such things as local topography, weather conditions, and local forms of construction for the system to meet their expectations.

Based on actual jurisdictional performance testing, appropriate public safety or government officials can make informed decisions regarding the purchase, use, and development of operational procedures to be used in providing the maximum level of personal protection for fire and rescue personnel in their jurisdiction.

Purchasers must be aware that a PASS is only one component of an overall accountability system or program. Purchasers must develop operational procedures to ensure that the system will function as expected.

Recommendations. Considering the factors noted in the preceding paragraphs, the purchaser should develop a testing and performance criteria similar to the following:

(1) Prior to using or purchasing a product or system, the local emergency services organization should select several different typical target hazard test locations in their normal response area for field testing of the product or system.
(2) Consideration should also be given that these target hazard test locations should provide rigorous testing scenarios and should include radio transmission dead spots, unusual topography, unusual building complexes, aboveground and belowground configurations, and construction.
(3) A person(s) designated by the local head of the emergency services organization(s) should participate in site selection and field testing.
(4) Testing should be conducted by simulation of actual emergency operations and conditions.
    (a) The emergency services official should designate an area where the base station receiving components of the RF PASS could be located if the incident were real.
    (b) Emergency responders should wear or carry the devices just as they would during an actual emergency and travel to all areas of the simulated emergency scene test area.
    (c) Alarm signals must be activated from many areas within the test site while the base station is monitored to ensure reception or acknowledgment of each alarm.
    (d) Attempts should be made to make the test scenarios for RF PASS as difficult and challenging as possible so problem areas where an RF signal could have difficulty penetrating a building or structure can be isolated and addressed.
    (e) Testing results should be recorded, with environmental factors such as the type of occupancy (residential, commercial, industrial, etc.), construction features, weather conditions, and location noted.
(5) Enhancement devices (leaky coaxial feeders, repeaters, enhanced radio receivers) can be used, as necessary, with placement and effectiveness recorded.
(6) Fire or emergency responders who would routinely have multiple base stations on the scene of an actual emergency should place multiple base stations in service during field-testing scenarios in accordance with their standard operating procedures.
(7) *NFPA 5000* outlines the eight basic types of construction that should be considered as part of the field-test criteria.
(8) Users should evaluate the effectiveness of the RF PASS as it relates to the developed operational procedures.

By conducting these recommended field tests, the end user can witness the performance of the product in the environment in which it is intended to be used, determine, with reasonable accuracy, whether the product does or does not meet their expectations, and then make an appropriate decision.

The committee clearly understands the benefits of not being able to provide an incident commander with immediate notifi-