ANSI/NFPA 1971 An American National Standard August 16, 1991

# NFPA 1971 Protective Clothing for Structural Fire Fighting 1991 Edition

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The Board of Directors reaffirms that the National Fire Protection Association recognizes that the toxicity of the products of combustion is an important factor in the loss of life from fire. NFPA has dealt with that subject in its technical committee documents for many years.

There is a concern that the growing use of synthetic materials may produce more or additional toxic products of combustion in a fire environment. The Board has, therefore, asked all NFPA technical committees to review the documents for which they are responsible to be sure that the documents respond to this current concern. To assist the committees in meeting this request, the Board has appointed an advisory committee to provide specific guidance to the technical committees on questions relating to assessing the hazards of the products of combustion.

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**NFPA 1971**

**Standard on**

# Protective Clothing for Structural Fire Fighting

**1991 Edition**

This edition of NFPA 1971, *Standard on Protective Clothing for Structural Fire Fighting*, was prepared by the Technical Committee on Fire Service Protective Clothing and Equipment and acted on by the National Fire Protection Association, Inc. at its Annual Meeting held May 19–23, 1991 in Boston, MA. It was issued by the Standards Council on July 19, 1991, with an effective date of August 16, 1991, and supersedes all previous editions.

The 1991 edition of this standard has been approved by the American National Standards Institute.

## Origin and Development of NFPA 1971

The original work on this project was done by the Sectional Committee on Protective Equipment for Fire Fighters that was a part of the Committee on Fire Department Equipment. In 1973, the Sectional Committee released a tentative standard, NFPA 19A-T, *Tentative Standard on Protective Clothing for Fire Fighters*. The Sectional Committee continued its work, and with the cooperation of the Program for Fire Services Technology of the National Bureau of Standards, developed NFPA 1971, *Standard on Protective Clothing for Structural Fire Fighting*. NFPA 1971 was adopted as a standard at the Fall Meeting in Pittsburgh, Pennsylvania on November 18, 1975.

Since that time, the Sectional Committee has been removed from the Committee on Fire Department Equipment and made a full technical committee.

The 1981 edition of NFPA 1971 represented a complete editorial reworking of the 1975 edition to make the document more usable by both the fire service and protective clothing manufacturers. The 1981 edition was acted on at the Annual Meeting in Dallas, Texas on May 19, 1981.

The 1986 edition incorporated a complete revision of the document to include more performance requirements and less specifications. Separate performance and testing chapters were written. The 1986 edition was acted on at the Annual Meeting in Atlanta, Georgia, May 19–22, 1986.

The 1991 edition has incorporated third party certification, labeling, and listing for the protective clothing. Also, a new chapter was added to address interface items, specifically the protective hood and protective wristlets. Appendix material was developed on cleaning of garments and evaluating how materials can affect heat stress.

Since the 1986 edition, the Committee was renamed from the Technical Committee on Protective Equipment for Fire Fighters to the Technical Committee on Fire Service Protective Clothing and Equipment.

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*This list represents the membership at the time the Committee was balloted on the text of this edition. Since that time, changes in the membership may have occurred.*

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

## Contents

# NFPA 1971

## Standard on

# Protective Clothing For Structural Fire Fighting

## 1991 Edition

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

Information on referenced publications can be found in Chapter 7 and Appendix C.

## Chapter 1 Administration

### 1-1* Scope.

**1-1.1** This standard specifies minimum design and performance criteria and test methods for protective clothing designed to protect fire fighters against adverse environmental effects during structural fire fighting.

**1-1.2** This standard does not apply to specialized protective clothing for aircraft rescue and fire fighting, hazardous materials emergencies, or wildland fire fighting and does not provide criteria for proximity, approach, or entry clothing or criteria for protection from chemical, radiological, or biological agents.

**1-1.3** This standard is not intended to be utilized as a detailed manufacturing or purchase specification but can be referenced in purchase specifications as minimum requirements.

### 1-2* Purpose.

**1-2.1** The purpose of this standard is to provide minimum performance requirements for structural fire fighting protective clothing.

**1-2.2** Controlled laboratory tests used to determine compliance with the performance requirements of this standard shall not be deemed as establishing performance levels for all situations to which fire fighting personnel may be exposed.

**1-2.3** Nothing herein is intended to restrict any jurisdiction or manufacturer from exceeding these minimum requirements.

### 1-3 Definitions.

**Approach Clothing.** Protective clothing designed to provide protection from radiant heat.

**Approved.*** Acceptable to the "authority having jurisdiction."

**Authority Having Jurisdiction.*** The "authority having jurisdiction" is the organization, office, or individual responsible for "approving" equipment, an installation, or a procedure.

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

**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 compliance with the requirements of this standard.

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

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

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

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

**Composite.** The layer or layers that provide the protection required of outer shell, moisture barrier, and thermal barrier.

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

**Entry Clothing.** Protective clothing that is designed to provide protection from conductive, convective, and radiant heat and permit entry into flames.

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

**Garment Label.** A label affixed to protective clothing by the manufacturer containing general information, warnings, care, maintenance, or similar data. This garment label is not a certification organization label or identifying mark.

**Hardware.** Nonfabric components of protective clothing including those made of metal or plastic material.

**Interface Area.** An area of the body not protected by a protective garment, helmet, gloves, footwear, or SCBA facepiece; the area where the protective garments and the helmet, gloves, footwear, or SCBA facepiece meet, i.e., the protective coat/helmet/SCBA facepiece area, the protective coat/glove area, and the protective trouser/footwear area.

**Interface Component.** Item(s) designed to provide limited protection to interface areas.

**Labeled.** Equipment or materials to which has been attached a label, symbol, or other identifying mark of an organization 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.

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

**Major A Seams.** See Seams.

**Major B Seams.** See Seams.

**Melt.** To change from solid to liquid, or become consumed, by action of heat.

**Minor Seams.** See Seams.

**Moisture Barrier.*** That portion of the composite designed to prevent the transfer of liquid water from the environment to the thermal barrier.

**Outer Shell.** That outside facing portion of the composite with the exception of trim, hardware, reinforcing material, and wristlet material.

**Protective Clothing.** Protective garments, configured as a coat and trousers or as a coverall, and interface components that are designed to provide protection to the fire fighter's body.

**Protective Coat.** Protective garment designed and configured to provide protection to upper torso and arms, excluding the hands and head.

**Protective Coverall.** Protective garment designed and configured to provide protection to the torso, arms, and legs, excluding the head, hands, and feet.

**Protective Garment.** Protective coat, protective trouser, or protective coverall.

**Protective Hood.** The interface component that provides limited protection to the protective coat/helmet/SCBA facepiece interface area.

**Protective Trouser.** Provides protection to lower torso and legs excluding the feet.

**Protective Uniform Garment.*** A garment designed and configured to be both the thermal barrier or portion of the thermal barrier of a protective garment, and a station/work uniform.

**Protective Wristlet.** The interface component that provides limited protection to the protective coat/glove interface area.

**Proximity Clothing.** Reflective protective clothing that is designed to provide protection against conductive, convective, and radiant heat.

**Seam Assembly.** The composite structure obtained when fabrics are joined by means of a seam.

**Seams.**

*Major A Seams.* Outer shell seam assemblies where rupture could reduce the protection of the garment by exposing the moisture barrier, thermal barrier, the wearer's station/work uniform, other clothing, or skin.

*Major B Seams.* Moisture barrier or thermal barrier 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.

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

**Sewn Seam.** A series of stitches joining two or more separate plies of material(s) of planar structure, such as textile fabrics.

**Sewn Seam Strength.** The maximum resistance to rupture of the junction formed by stitching two or more planar structures, such as textile fabrics.

**Shall.** Indicates a mandatory requirement.

**Should.** This term, as used in the Appendices, indicates a recommendation or that which is advised but not required.

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

**Thermal Barrier.** That portion of the composite designed to provide thermal protection.

**Trim.** Retroreflective and fluorescent material attached to the outer shell for visibility enhancement. Retroreflective materials enhance nighttime visibility, and fluorescent materials improve daytime visibility.

**Winter Liner.** An optional component layer designed to provide added insulation against cold.

**1-4 Units.**

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

## Chapter 2 Certification

### 2-1 General.

**2-1.1** Protective garments and interface components that are labeled as being compliant with this standard shall meet or exceed all applicable requirements specified in this standard and shall be certified.

**2-1.2** All certification shall be performed by an approved certification organization.

**2-1.3** Compliant protective garments and protective hoods shall be labeled and listed. Such protective garments shall also have a garment label that meets the requirements specified in Section 2-4 of this chapter. Such protective hoods shall also have a garment label that meets the requirements specified in 6-1.2 of this standard.

### 2-2 Certification Program.

**2-2.1*** The certification organization shall not be owned or controlled by manufacturers or vendors of the product being certified. The certification organization shall be primarily engaged in certification work and shall not have a monetary interest in the product's ultimate profitability.

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

**2-2.3*** The contractual provisions between the certification organization and the manufacturer shall specify that certification is contingent on compliance with all applicable requirements of this standard. There shall be no conditional, temporary, or partial certifications. Manufacturers shall not be authorized to use any label or reference to the certification organization on products that are not manufactured in compliance with all applicable requirements of this standard.

**2-2.4*** For certification, laboratory facilities and equipment for conducting proper tests shall be available, a program for calibration of all instruments shall be in place and operating, and procedures shall be in use to ensure proper control of all testing. Good practice shall be followed regarding the use of laboratory manuals, form data sheets, documented calibration and calibration routines, performance verification, proficiency testing, and staff qualification and training programs.

**2-2.5** Manufacturers shall be required to establish and maintain a program of production inspection and testing.

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

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

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

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

**2-2.10** The certification organization shall be in a position to use legal means to protect the integrity of its name and label. The name and label shall be registered and legally defended.

### 2-3 Inspection and Testing.

**2-3.1** Sampling levels for testing and inspection shall be established by the certification organization and the manufacturer to assure a reasonable and acceptable reliability at a reasonable and acceptable confidence level that products certified as being compliant with the standard are compliant.

**2-3.2** Inspection for determining compliance with the design requirements specified in Chapter 3 and Chapter 6 of this standard shall be performed on a completed garment.

**2-3.3** Testing for determining material and component compliance with the requirements specified in Chapter 4 and Chapter 6 of this standard shall be performed on samples representative of materials and components used in the actual construction of the protective clothing. The certification organization shall be permitted to also use sample materials cut from a representative protective garment.

### 2-4 Garment Labeling.

**2-4.1*** The outer shell and each separable layer of each protective garment shall have a garment label permanently and conspicuously attached to each layer upon which at least the following warning and information are printed in at least $^{1}/_{16}$-in. (1.5-mm) high letters. At least one garment label shall be conspicuously located inside the garment in all possible configurations of garment utilization.

"THIS STRUCTURAL FIRE FIGHTING PROTECTIVE GARMENT MEETS THE REQUIREMENTS OF NFPA 1971, *STANDARD ON PROTECTIVE CLOTHING FOR STRUCTURAL FIRE FIGHTING*, 1991 EDITION. NFPA 1500, *STANDARD ON FIRE DEPARTMENT OCCUPATIONAL SAFETY AND HEALTH PROGRAM*, PROVIDES USE REQUIREMENTS FOR PROTECTIVE CLOTHING.

WARNING

FOR STRUCTURAL FIRE FIGHTING OPERATIONS, BOTH PROTECTIVE COAT AND PROTECTIVE TROUSERS MUST BE WORN FOR LIMB/TORSO PROTECTION. PROTECTIVE COAT/PROTECTIVE TROUSER OVERLAP IS REQUIRED BY NFPA 1500. OUTER SHELL, MOISTURE BARRIER, AND THERMAL BARRIER MEETING REQUIREMENTS OF NFPA 1971 MUST BE UTILIZED, AND ALL GARMENT CLOSURES MUST BE FASTENED WHEN IN USE. DO NOT USE PROTECTIVE

COAT AND PROTECTIVE TROUSERS ALONE FOR STRUCTURAL FIRE FIGHTING OPERATIONS; OTHER PROTECTIVE EQUIPMENT—HELMET, SCBA, GLOVES, FOOTWEAR, PASS—IS REQUIRED FOR PROTECTION. DO NOT KEEP THIS GARMENT IN DIRECT CONTACT WITH FLAMES. THIS GARMENT ALONE MAY NOT PROVIDE PROTECTION FOR PROXIMITY OR FIRE ENTRY APPLICATIONS OR FOR PROTECTION FROM CHEMICAL, RADIOLOGICAL, OR BIOLOGICAL AGENTS. KEEP THE GARMENT CLEAN AS SOILING WILL REDUCE PROTECTIVE QUALITIES.

—DO NOT USE CHLORINE BLEACH—CHLORINE BLEACH WILL SIGNIFICANTLY COMPROMISE THE PROTECTION AFFORDED BY THE TEXTILE AND FILM MATERIALS UTILIZED IN THE CONSTRUCTION OF THIS GARMENT. USERS MUST CLEAN, MAINTAIN, AND ALTER ONLY IN ACCORDANCE WITH MANUFACTURER'S INSTRUCTIONS. DO NOT STORE IN DIRECT SUNLIGHT. NO PROTECTIVE CLOTHING CAN PROVIDE COMPLETE PROTECTION FROM ALL CONDITIONS—USE EXTREME CARE FOR ALL EMERGENCY OPERATIONS. FAILURE TO COMPLY WITH THESE WARNINGS MAY RESULT IN SERIOUS INJURY OR DEATH."

Manufacturer's Name
Manufacturer's Address
Country of Manufacture
Manufacturer's Garment Identification Number
Date of Manufacture
Size
Cleaning and Drying Instructions
Garment Material(s)

"DO NOT REMOVE THIS LABEL"

**2-4.2** All portions of the required garment labels shall be printed at least in English.

**2-4.3** All garment labels shall be clearly legible to the eye both before and after being subjected to the procedure specified in Section 5-1 of this standard. Garment labels not meeting specimen size requirements for the procedure specified in Section 5-1 shall be sewn to a support fabric of required size.

**2-5* User Information.**

**2-5.1** Protective clothing manufacturers shall provide the following instructions and information with each garment:

(a) Cleaning and instructions
(b) Maintenance criteria
(c) Methods of repair
(d) Warranty information.

**2-5.2** Protective clothing manufacturers shall furnish training materials that address, but are not limited to:

(a) Safety considerations
(b) Storage conditions
(c) Decontamination procedures
(d) Retirement considerations.

## Chapter 3 Design Requirements

**3-1* Protective Garment Requirements.**

**3-1.1** A sample protective garment shall have at least the applicable design requirements specified in this chapter when inspected by the certification organization as specified in Chapter 2 of this standard.

**3-1.2*** Protective garments shall consist of a composite of an outer shell, moisture barrier, and thermal barrier. This composite shall be permitted to be configured as a single layer or multiple layers.

**3-1.2.1** The thermal barrier or portion of the thermal barrier shall be permitted to be configured as a protective uniform garment. When configured in this manner, the assembled protective garment shall meet the requirements specified in 2-1.1 of this standard. Also the protective uniform garment shall meet all applicable requirements specified in NFPA 1975, *Standard on Station/Work Uniforms for Fire Fighters*.

**3-1.3*** Protective garments shall have a means of securing the moisture barrier and thermal barrier to the outer shell.

**3-1.4** Protective garments, including the front closure, shall be constructed in a manner that provides secure and complete moisture and thermal protection. If nonpositive fasteners, such as snaps or hook and pile tape, are utilized in garment closures, a positive locking fastener, such as hooks and dees or zippers, shall also be utilized.

**3-1.5** Snaps shall meet the requirements of MS 27980E, *Fastener, Snap*.

**3-1.6*** Fastener tape shall meet the requirements of MIL-F-21840, *Fastener Tapes, Hook and Pile, Synthetic*.

**3-1.7** Zippers shall meet the requirements of FED-V-F-106F, *Fasteners, Interlocking, Slide*.

**3-1.8** Hooks and dees shall be nonferrous and shall conform to the design of Figure 3-1.8 (figure shown on following page).

**3-1.9** Moisture barriers and thermal barriers shall extend to within 3 in. (76.2 mm) of the outer shell at the cuffs and hems of protective garments. At the neck, the coat moisture barrier and thermal barrier shall extend to the neckline seam. The upper edge of the trouser moisture barrier and thermal barrier shall extend, as a minimum, to the waistline.

**3-1.10*** Cargo pockets, where provided, shall have a means of drainage of water and shall have a means of fastening them in the closed position.

**3-1.11*** Trim utilized to meet visibility requirements shall be permanently attached to the outer shell of protective garments and shall be not less than 2 in. (50.8 mm) wide and shall have both retroreflective and fluorescent surfaces. Retroreflective surface of trim shall be not less than

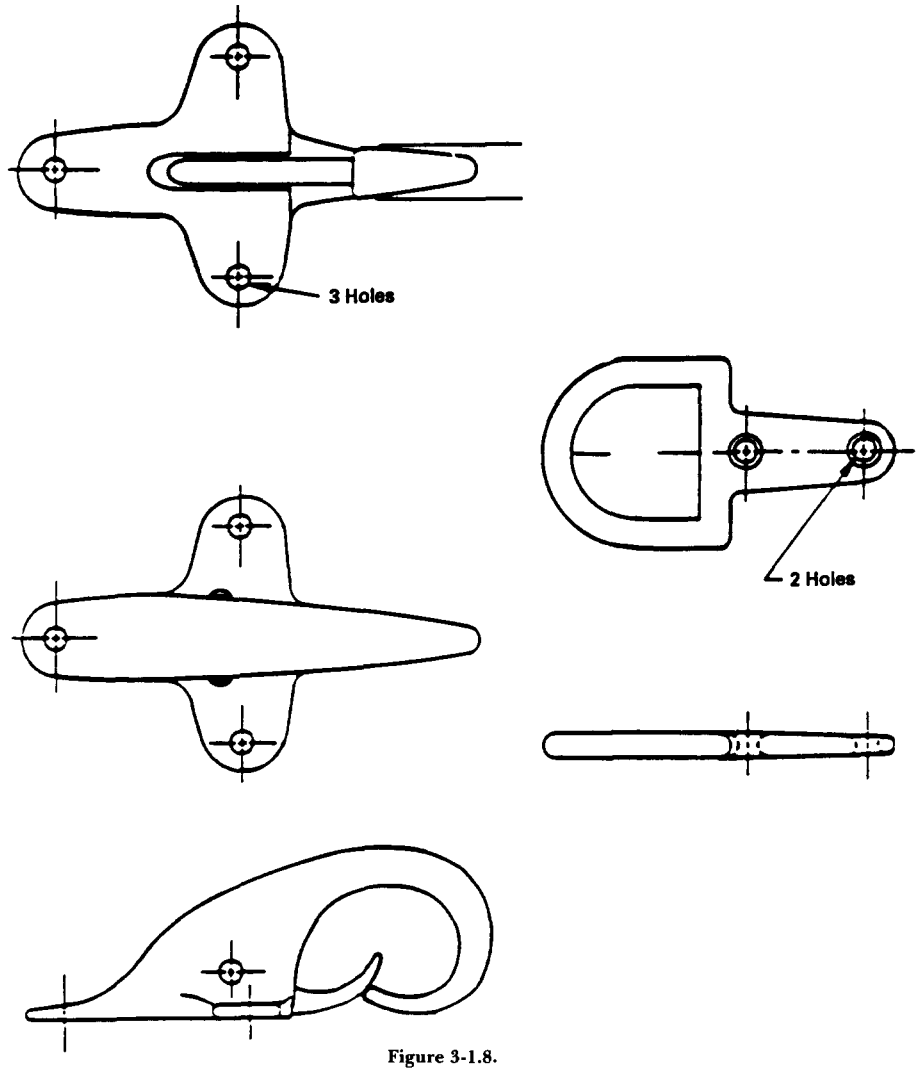


Figure 3-1.8.

0.625 in. (15.9 mm) wide. Fluorescent and retroreflective areas of trim shall appear to be continuous for the length of the trim, with gaps between areas of retroreflectivity of not more than 0.125 in. (3.2 mm).

**3-1.12*** Trim affixed to protective garments exceeding the visibility requirements specified in 4.8.1 and 4-8.2 of this standard shall be permitted to be obscured by components such as, but not limited to, pockets, storm flaps, and reinforcing patches as long as the minimum trim required in 3-2.5, 3-2.6, 3-2.7, 3-3.3, 3-3.4, and 3-3.5 is not obscured.

**3-2 Additional Requirements for Protective Coats.**

**3-2.1*** Protective coats shall provide protection as specified to the upper torso, neck, arms, and wrists, excluding the hands and head.

**3-2.2** Protective 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 closures fastened, unless the hardware is completely covered by external closure flaps.

**3-2.3*** Each protective coat sleeve shall have a protective wristlet meeting requirements specified in Section 6-2 of this standard.

**3-2.4** Protective coats shall have a composite collar not less than 4.0 in. (101.6 mm) in height at any point, with a closure system. Collar and closure system shall consist of outer shell, moisture barrier, and thermal barrier that meet all applicable performance requirements as specified in Chapter 4 of this standard.

**3-2.5*** Protective coat trim configuration shall include a circumferential band around the coat and each wrist. No vertical trim shall be allowed on the front of the protective coat.

**3-2.6** Protective coat trim shall have not less than 325 sq in. (2097 sq cm) of fluorescent area.

**3-2.7** Protective coat trim shall include not less than 125 sq in. (806.5 sq cm) of fluorescent area visible from the front and 125 sq in. (806.5 cm) of fluorescent area visible from the rear when the coat is properly closed and is laid on a flat inspection surface.

**3-3 Additional Requirements for Protective Trousers.**

**3-3.1*** Protective trousers shall provide protection as specified to the lower torso and legs, excluding the ankles and feet.

**3-3.2** Protective trouser hardware shall not penetrate through the outer shell, moisture barrier, and thermal barrier to contact the wearer's body when trouser is worn with closure fastened, unless the hardware is located on or above the waistline or hardware is completely covered by external closure flaps.

**3-3.3** Protective trouser trim shall include a circumferential band around each leg between the hem and knee.

**3-3.4** Protective trouser trim shall have not less than 80 sq in. (520.0 sq cm) of fluorescent area.

**3-3.5** Protective trouser trim shall include not less than 40 sq in. (260.0 sq cm) of fluorescent area visible from the front and not less than 40 sq in. (260.0 sq cm) of fluorescent area visible from the rear when the trouser is properly closed and is laid on a flat inspection surface.

**3-4 Additional Requirements for Protective Coverall.**

**3-4.1** That portion of the protective coverall that corresponds to the protective coat shall meet all requirements of Section 3-2 of this chapter.

**3-4.2** That portion of the protective coverall that corresponds to the protective trouser shall meet all requirements of Section 3-3 of this chapter.

## Chapter 4 Performance Requirements

**4-1 Protective Garment Requirements.**

**4-1.1** The protective garment fabric composite consisting of outer shell, moisture barrier, and thermal barrier shall have an average thermal protective performance (TPP) of not less than 35.0 when tested as specified in Section 5-2 of this standard.

**4-1.2** All seam assemblies shall be tested for breaking strength and shall demonstrate a sewn seam strength equal to or greater than 150 lb (675 N) force for Major A seams, 75 lb (337.5 N) force for Major B seams, and 40 lb (180 N) force for Minor seams when tested as specified in Section 5-7 of this standard.

**4-1.2.1** Seam breaking strength shall be considered acceptable when the fabric strength is less than the required seam strength specified in 4-1.2 of this section, providing the fabric fails without failure of the seam below the applicable forces specified in 4-1.2.

**4-2 Textiles.**

**4-2.1** Outer shell, moisture barrier, thermal barrier, collar linings, winter liner fabric, and trim shall be individually tested for flame resistance and shall have an average char length of not more than 4.0 in. (101.6 mm), an average afterflame of not more than 2.0 sec, and shall not melt or drip when tested as specified in Section 5-8 of this standard.

**4-2.2** Outer shell, moisture barrier, thermal barrier, collar linings, and winter liner fabric shall be individually tested for thermal shrinkage resistance and shall not shrink more than 10.0 percent in any direction when tested as specified in Section 5-3 of this standard.

**4-2.3** Outer shell, moisture barrier, thermal barrier, collar linings, and winter liner fabric, and other materials used in construction—including but not limited to padding, reinforcement, garment labels, interfacing, binding, hanger loops, and emblems, but excluding trim, elastic, and hook and pile fasteners when not placed in direct contact with the body—shall be individually tested for heat resistance and shall not melt, separate, or ignite when tested as specified in Section 5-4 of this standard.

**4-2.3.1** Moisture barrier seam seal materials shall be tested for heat resistance and shall not drip or ignite when tested as specified in Section 5-4 of this standard.

**4-2.4** Outer shell, moisture barrier, thermal barrier, collar linings, and winter liner fabric shall be individually tested for cleaning shrinkage resistance and shall not shrink more than 5.0 percent in any direction when tested as specified in Section 5-9 of this standard.

**4-3 Outer Shell Requirements.**

**4-3.1** Outer shell and collar lining fabrics shall be tested for tear resistance and shall have a tear strength of not less than 22.0 lb (10 kg) when tested as specified in Section 5-5 of this standard.

**4-3.2** Outer shell and collar lining fabrics shall be tested for char resistance and shall not char when tested as specified in Section 5-4 of this standard.

**4-3.3*** Outer shell and collar lining fabrics shall be tested for water absorption resistance and shall have no more than 30 percent water absorption when tested as specified in Section 5-10 of this standard.

**4-4 Moisture Barrier Requirements.**

**4-4.1** Moisture barriers shall be tested for tear resistance and shall have a tear strength of not less than 5.0 lb (2.3 kg) when tested as specified in Section 5-5 of this standard.

**4-4.2** The moisture barrier fabric shall be tested for water penetration resistance and shall have a minimum water penetration resistance of 25 psi (1.76 kg/cm$^2$) when tested as specified in 5-11.2 of this standard, and 1 psi (0.07 kg/cm$^2$) when tested as specified in 5-11.3 of this standard. Appearance of water drops shall constitute failure.

**4-4.3** Moisture barrier seams shall be tested for water penetration resistance and shall have a minimum water penetration resistance of not less than 1 psi (0.07 kg/cm$^2$) when tested as specified in 5-11.3 of this standard. Appearance of water drops shall constitute failure.

**4-5 Thermal Barrier Requirements.**

**4-5.1** Thermal barrier shall be tested for tear resistance and shall have a tear strength of not less than 5.0 lb (2.3 kg) when tested as specified in Section 5-5 of this standard.

**4-6 Winter Liner Requirements.**

**4-6.1** When provided, the winter liner shall be tested for tear resistance and shall have a tear strength of not less than 5.0 lb (2.3 kg) when tested as specified in Section 5-5 of this standard.

**4-7 Thread Requirements.**

**4-7.1** All thread utilized in the construction of the protective garments shall be tested for heat resistance and shall not ignite, melt, or char when tested as specified in Section 5-12 of this standard.

**4-8 Visibility Requirements for Trim.**

**4-8.1** Protective coat trim shall have a total coefficient of luminous intensity (CIL) of not less than 270 candelas/foot candle when tested as specified in Section 5-6 of this standard.

**4-8.2** Protective trouser trim shall have a total coefficient of luminous intensity (CIL) of not less than 75 candelas/foot candle when tested as specified in Section 5-6 of this standard.

**4-9 Hardware Requirements.**

**4-9.1** All hardware finish shall be free of rough spots, burrs, or sharp edges.

**4-9.2** All metal hardware and hardware that includes metal parts shall be tested for corrosion resistance as specified in Section 5-13 of this standard. Metals inherently resistant to corrosion, including but not limited to stainless steel, brass, copper, aluminum, and zinc shall show no more than light surface-type corrosion or oxidation. Ferrous metals shall show no corrosion of the base metal.

**4-9.3** All hardware shall be tested for heat resistance and shall not ignite and shall remain functional when tested as specified in Section 5-4 of this standard.

## Chapter 5 Test Methods

**5-1 Washing and Drying Procedure.**

**5-1.1** Specimens shall be subjected to 5 cycles of washing and drying in accordance with the procedure specified in Machine Cycle 1, Wash Temperature V, Drying Procedure Ai, of AATCC 135, *Dimensional Changes in Automatic Home Laundering of Woven and Knit Fabrics*. A laundry bag shall not be used.

**5-2* Thermal Protective Performance Test.**

**5-2.1** Specimens shall be tested both before and after being subjected to the procedure specified in Section 5-1 of this chapter.

**5-2.1.1** Specimens of protective hoods shall consist of materials from the portion of the protective hood that covers the neck and facial area.

**5-2.2** All specimens to be tested shall be preconditioned by placement in a circulating air oven for not less than 4 hr at 120°F, ±5°F (49°C, ±2°C) and then conditioned in accordance with Section 4, "Atmospheric Conditions for Testing," of Federal Test Method Standard 191A, *Textile Test Methods*, with a relative humidity of 65 percent, ±5 percent. Specimens shall be tested not more than 5 min after removal from conditioning.

**5-2.3** Thermal protective performance (TPP) testing shall be performed in accordance with ASTM D 4108, *Thermal Protective Performance of Materials for Clothing by Open-Flame Method*, with the following modifications:

**5-2.3.1** Specimens shall consist of protective clothing composites measuring 6 × 6 in., ±1/16 in. (152.4 × 152.4 mm, ±1.6 mm), consisting of outer shell, moisture barrier, and thermal barrier. Collar lining fabric shall be permitted to be included in the protective garment collar fabric composite specimen. Winter liners shall not be included in the test composite.

**5-2.3.2** Apparatus shall consist of specimen holder assembly, specimen holder assembly support, thermal flux source, protective shutter, sensor assembly, and recorder.

**5-2.3.3** Specimen holder assembly shall consist of upper and lower mounting plates. Specimen holder mounting plates shall be 8 × 8 in., ±1/16 in. × 1/4 in., ±1 1/32 in. (203.2 × 203.2 mm, ±1.6 mm × 6.4 mm, ±0.8 mm). The lower specimen mounting plate shall have centered a 4 × 4 in., ±1/16 in. (101.6 × 101.6 mm, ±1.6 mm) hole. The upper specimen mounting plate shall have centered a 5 1/8 × 5 1/8 in., ±1/16 in. (130.2 × 130.2 mm, ±1.6 mm) hole. The lower specimen mounting plate shall have a 1 in., ±1/16 in. high × 1/8 in., ±1/32 in. (25.4 mm, ±1.6 mm × 3.2 mm, ±0.8 mm) thick steel post welded to each corner 1/4 in., ±1/16 in. (6.4 mm, ±1.6 mm) from each side and perpendicular to the plane of the plate. The upper sample mounting plate shall have a corresponding hole in each corner so that the upper specimen mounting plate fits over the lower specimen mounting plate.

**5-2.3.4** Specimen holder assembly support shall consist of a steel frame that rigidly holds and positions in a reproducible manner the specimen holder assembly and specimen relative to the thermal flux. Specimen holder assembly support shall be securely clamped at the edges such that specimen shrinkage is prevented. Sensor assembly shall consist of 5 1/4 × 5 1/4 × 1/2 in. (133.3 × 133.3 × 12.8 mm) heat-resistant block that fits without binding into the hole of the upper specimen mounting plate and shall be uniformly weighted such that complete sensor assembly, including copper calorimeter, weighs 1000 grams, ±10 grams (2.2 lb, ±.022 lb).

**5-2.3.5** Thermal flux source shall consist of a convective thermal flux source and a radiant thermal flux source. The convective thermal flux source shall consist of two Meker or Fisher burners affixed beneath the specimen holder assembly opening, and subtended at a nominal 45-degree angle from the vertical so that the flames converge at a point immediately beneath the specimen. The radiant thermal flux source shall consist of 9 quartz infrared tubes affixed beneath and centered between the burners.

**5-2.3.6** A protective shutter shall be placed between the thermal flux source and the specimen. The protective shutter shall be capable of completely dissipating thermal load from thermal flux source for the time periods before and after specimen exposure. The protective shutter shall be controlled by means of an automatic timer with a resolution of not less than .10 sec.

**5-2.3.7** Specimens shall be exposed to a thermal flux of 2.0 cal/cm$^2$, ±0.1 cal/cm$^2$/sec as measured with the copper calorimeter. The copper calorimeter shall be the only heat sensor used in setting the 2.0 cal/cm$^2$ sec exposure condition. The total heat flux shall be calculated directly from the temperature response of the copper calorimeter and calorimeter constants. Other heat-sensing devices shall not be used to reference or adjust the heat flux read by the copper calorimeter. The 2.0 cal/cm$^2$/sec exposure shall be determined directly and only from the voltage output of the thermocouples, using the measured temperature rise of the copper calorimeter, the area and mass of the calorimeter, and the heat capacity of copper to calibrate the incoming heat flux. The radiant load shall be set on 1.0 cal/cm$^2$/sec as measured using a calibrated commercial radiometer.

**5-2.3.8** The sensor assembly shall be fitted into the opening in the top plate of the specimen holder and shall be in contact with the surface of the thermal barrier normally facing the wearer.

**5-2.3.9** If the individual results vary more than ±8 percent from the average result, the result shall be discarded and another set of specimens shall be tested.

**5-2.3.10** The individual test results of each specimen shall be reported. The average value for each sample and the pass/fail result shall be calculated and reported.

**5-3* Thermal Shrinkage Resistance Test.**

**5-3.1** Thermal shrinkage resistance testing shall be conducted on 3 specimens of each fabric, and each fabric shall be tested separately.

**5-3.2** Specimens shall be tested both before and after being subjected to the procedure specified in Section 5-1 of this chapter.

**5-3.3** Specimens to be tested shall be conditioned in accordance with Section 4, "Atmospheric Conditions for Testing," of Federal Test Method Standard 191A, *Textile Test Methods*, at a relative humidity of 65 percent, ±5 percent. Specimens shall be tested not more than 5 min after removal from conditioning.

**5-3.4** Each specimen shall be 15 × 15 in., ±0.5 in. (381 × 381 mm, ±13 mm) and shall be cut from the fabric to be utilized in the construction of the garment.

**5-3.5** Specimen marking and measurements shall be conducted in accordance with the procedure specified in AATCC 135, *Dimensional Changes in Automatic Home Laundering of Woven and Knit Fabrics*.

**5-3.6** The forced circulating air oven shall achieve and maintain an air temperature of 500°F, +10/−0°F (260°C, +3/−0°C) for a period of not less than 5 min. Oven recovery time after door is closed shall not exceed 1 min.

**5-3.7** The specimen shall be suspended by 2 metal hooks near each top corner with a 12 in., ±0.5 in. (305 mm, ±12.7 mm) separation between hooks. The entire specimen shall be exposed to the circulating air so that it is not less than 2 in. (50.8 mm) from any oven surface or other specimen, and airflow is parallel to the plane of the material.

**5-3.8** Specimens, mounted as specified in 5-3.7 of this section, shall be placed in the circulating air oven for 5 min, +0.15/−0 min. Specimen exposure time shall begin when oven has recovered to an air temperature of 500°F, +10/−0°F (260°C, +3/−0°C).

**5-3.9** After removal from the oven, knit fabric shall be pulled to original dimensions and shall be allowed to relax for 1 min prior to measurement to determine pass/fail.

**5-3.10** Results shall be reported as the average of all 3 specimens.

**5-4* Heat, Char, and Ignition Resistance Test.**

**5-4.1** Specimens shall be tested both before and after being subjected to the procedure specified in Section 5-1 of this chapter.

**5-4.2** The fabric specimen to be tested shall be conditioned in accordance with Section 4, "Atmospheric Conditions for Testing," of Federal Test Method Standard 191A, *Textile Test Methods*, at a relative humidity of 65 percent, ±5 percent. Specimens shall be tested not more than 5 min after removal from conditioning.

**5-4.3** Specimen length shall be 6 in. (152.4 mm), except for textiles utilized in the garment in lengths less than 6 in. (152.4 mm), where length shall be the same as utilized in the garment. Specimen width shall be 6 in. (152.4 mm), except for textiles utilized in the garment in widths less than 6 in. (152.4 mm), where widths shall be the same as utilized in the garment. Specimens shall be suspended in the oven utilizing metal clips.

**5-4.3.1** Oven testing of seam seal materials shall be done on a specimen consisting of two 3 × 6 in. (76.2 × 152.4 mm) pieces of moisture barrier fabric utilized in the garment, sewn together, and with seam sealing material applied.

**5-4.4** The forced circulating air oven shall achieve and maintain an air temperature of 500°F, +10/−0°F (260°C, +3/−0°C) for a period of not less than 5 min. Oven recovery time after the door is closed shall not exceed 1 min.

**5-4.5** The fabric specimen shall be suspended by metal hooks at the top and centered in the oven so that the entire specimen is not less than 2 in. (50.8 mm) from any oven surface or other specimen and airflow is parallel to the plane of the material.

**5-4.6** Hardware and accessory material specimens shall be supported or freely suspended in the center of the oven so that they are not less than 2 in. (50.8 mm) from any oven surface or other specimen and are exposed to the circulating air.

**5-4.7** Specimens, mounted as specified in 5-4.5 of this Section, shall be placed in the circulating air oven for 5 min, +0.15/−0 min. Specimen exposure time shall begin

when the oven has recovered to an air temperature of 500°F, +10/−0°F (260°C, +3/−0°C).

**5-4.8** Results shall be reported as pass or fail.

**5-5 Tear Resistance Testing.**

**5-5.1** The specimen shall be a 3 × 6 in. (76.2 × 152.4 mm) rectangle. The long dimension shall be parallel to the warp for warp tests and parallel to the filling for filling tests. No 2 specimens for warp tests shall contain the same warp yarns, nor shall any 2 specimens for filling tests contain the same filling yarns. The specimen shall be taken no nearer the selvage than one-tenth of the width of the cloth. An isosceles trapezoid having an altitude of 3 in. (76.2 mm) and bases of 1 and 4 in. (25.4 and 101.6 mm) in length, respectively, shall be marked on each specimen, with the aid of a template. A cut ⅜ in. (9.5 mm) in length shall then be made in the center of a line perpendicular to the 1-in. (25.4-mm) edge.

**5-5.2** Apparatus shall consist of a straining mechanism, 2 clamps for holding specimens, and load and elongation recording mechanisms, wherein the specimen is held between 2 clamps and strained by a uniform movement of the pulling clamp. The test machine shall be operated at a rate of 12 in./min (304.8 mm/min).

**5-5.2.1** Straining mechanism shall be of such capacity that the maximum load required to break the specimen shall be not greater than 85 percent or less than 15 percent of the manufacturer's rated capacity.

**5-5.2.2** Clamps shall be designed such that the 6 oz (170 g) of weight are distributed evenly across the complete width of the sample. The clamps shall have 2 jaws on each clamp. The design of the clamps shall be such that one gripping surface or jaw shall be permitted to be an integral part of the rigid frame of the clamp or be fastened to allow a slight vertical movement, while the other gripping surface or jaw shall be completely moveable. The dimensions of the immovable jaw of each clamp parallel to the application of the load shall measure 1 in. (25.4 mm), and the dimension of the jaw perpendicular to this direction shall measure 3 in. (76.2 mm) or more. The face of the moveable jaw of each clamp shall measure 1 × 3 in. (25.4 × 76.2 mm). Each jaw face shall have a flat, smooth gripping surface. All edges that might cause a cutting action shall be rounded to a radius of not more than 1/64 in. (0.4 mm). In cases where a cloth tends to slip when being tested, the jaws shall be faced with rubber or other material to prevent slippage. The distance between the jaws shall be 1 in. (25.4 mm) at the start of the test.

**5-5.2.3** Recorder shall consist of a calibrated dial, scale, or chart used to indicate applied load and elongation. Error shall not exceed 2 percent up to and including a 50-lb (22.7-kg) load and 1 percent over a 50-lb (22.7-kg) load at any reading within its loading range. All machine attachments for determining maximum loads shall be disengaged during test.

**5-5.3** The specimen shall be clamped along the nonparallel sides of the trapezoid so that these sides lie along the lower edge of the upper clamp and the upper edge of the lower clamp with the cut halfway between the clamps. The short trapezoid base shall be held taut, and the long trapezoid base shall lie in the folds. The strain mechanism shall be started, and the force necessary to tear the cloth shall be observed by means of the recording device. Five specimens in each of the warp and filling directions shall be tested from each sample unit. If a specimen slips between the jaws, breaks in or at the edges of the jaws, or, if for any reason attributable to faulty technique, an individual measurement falls markedly below the average test results for the sample unit, such result shall be discarded and another specimen shall be tested.

**5-5.4** The tear strength shall be the average of the 5 highest peak loads of resistance registered. The tear strength shall be reported to the nearest 0.1 lb (45.4 g).

**5-6 Retroreflectivity Test.**

**5-6.1** Trim to meet visibility requirements of this standard shall be tested for Coefficient of Retroreflectivity (CPL) in accordance with ASTM E 809, *Standard Practice for Measuring Photometric Characteristics of Retroreflectors*, with a test distance of 50 ft (15.2 m), observation angle of 0.2 degree, entrance angle of −4.0 degree, and a photoreceptor angular aperture and source angular aperture of 0.1 degree. Projector exit aperture shall be a circle with a diameter of 1 in. (25.4 mm). Retroreflector reference angle shall be 90 degrees. Datum mark shall be placed as specified by the trim manufacturer. The trim test sample shall consist of a 12 × 12 in. (305 × 305 mm) composite made up of multiple strips of trim. The measured value shall be in units of candelas/foot candle/square foot.

**5-6.2** Coefficient of luminous intensity (CIL) for trim shall be calculated by the following equation where coefficient of retroreflectivity (CPL) is measured in accordance with 5-6.1 of this section:

CIL = CPL × (Total area in sq ft of trim utilized on garment)

**5-6.3** The measured value shall be in units of candelas/foot candle.

**5-7 Seam Breaking Strength.**

**5-7.1** All seam assemblies shall be tested in accordance with ASTM D 1683, *Standard Test Method for Failure in Sewn Seams of Woven Fabric*.

**5-7.2** The test machine shall be operated at a rate of 12 in./min (304.8 mm/min).

**5-8 Flame Resistance.**

**5-8.1** Specimens shall be tested both before and after being subjected to the procedure specified in Section 5-1 of this chapter.

**5-8.2** The specimen shall be a rectangle of cloth 2¾ in. (70 mm) by 12 in. (305 mm) with the long dimension parallel to either the warp or filling direction of the cloth. No two warp specimens shall contain the same warp yarns, and no two filling specimens shall contain the same filling yarns.

**5-8.3** Five specimens from each of the warp and filling directions shall be tested and shall constitute a unit.

**5-8.4*** A cabinet and accessories that meet the requirements specified in Figures 5-8.4(a), 5-8.4(b), and 5-8.4(c) shall be used. Galvanized sheet metal or other suitable metal shall be used. The entire inside back wall of the cabinet shall be painted black to facilitate the viewing of the test specimen and pilot flame.

**5-8.5** The burner shall be equipped with a variable orifice to adjust the flame height, a barrel having a 3/8-in. (10-mm) inside diameter, and a pilot light.

**5-8.5.1** The burner shall be permitted to be constructed by combining a 3/8-in. (10-mm) inside diameter barrel that is 3 in., ± 1/4 in. (76 mm, ±6 mm) long from a fixed orifice burner with a base from a variable orifice burner.

**5-8.5.2** The pilot light tube shall have a diameter of 1/16 in. (2 mm) and shall be spaced 1/8 in. (3 mm) away from the burner edge with a pilot flame 1/8 in. (3 mm) long.

**5-8.5.3** The necessary gas connections and the applicable plumbing shall be as specified in Figure 5-8.5.3. A solenoid valve shall be permitted to be used in lieu of the stopcock valve to which the burner is attached. The stopcock valve or solenoid valve, whichever is used, shall be capable of being fully opened or fully closed in 0.1 sec.

**5-8.5.4** On the side of the barrel of the burner, opposite the pilot light, there shall be a metal rod of 1/8-in. (3-mm) diameter spaced 1/2 in. (13 mm) from the barrel and extending above the burner. The rod shall have two 5/16-in. (8-mm) prongs marking the distances of 3/4 in. (19 mm) and 1 1/2 in. (38 mm) above the top of the burner for adjusting flame height.

**5-8.5.5** The burner shall be fixed in a position so that the center of the barrel of the burner is directly below the center of the specimen.

**5-8.6*** A control valve system with a delivery rate designed to furnish gas to the burner under a pressure of 2 1/2 psi, ± 1/4 psi (17.2 kPa, ± 1.7 kPa) at the burner inlet. The manufacturer's recommended delivery rate for the valve system shall include the required presure.

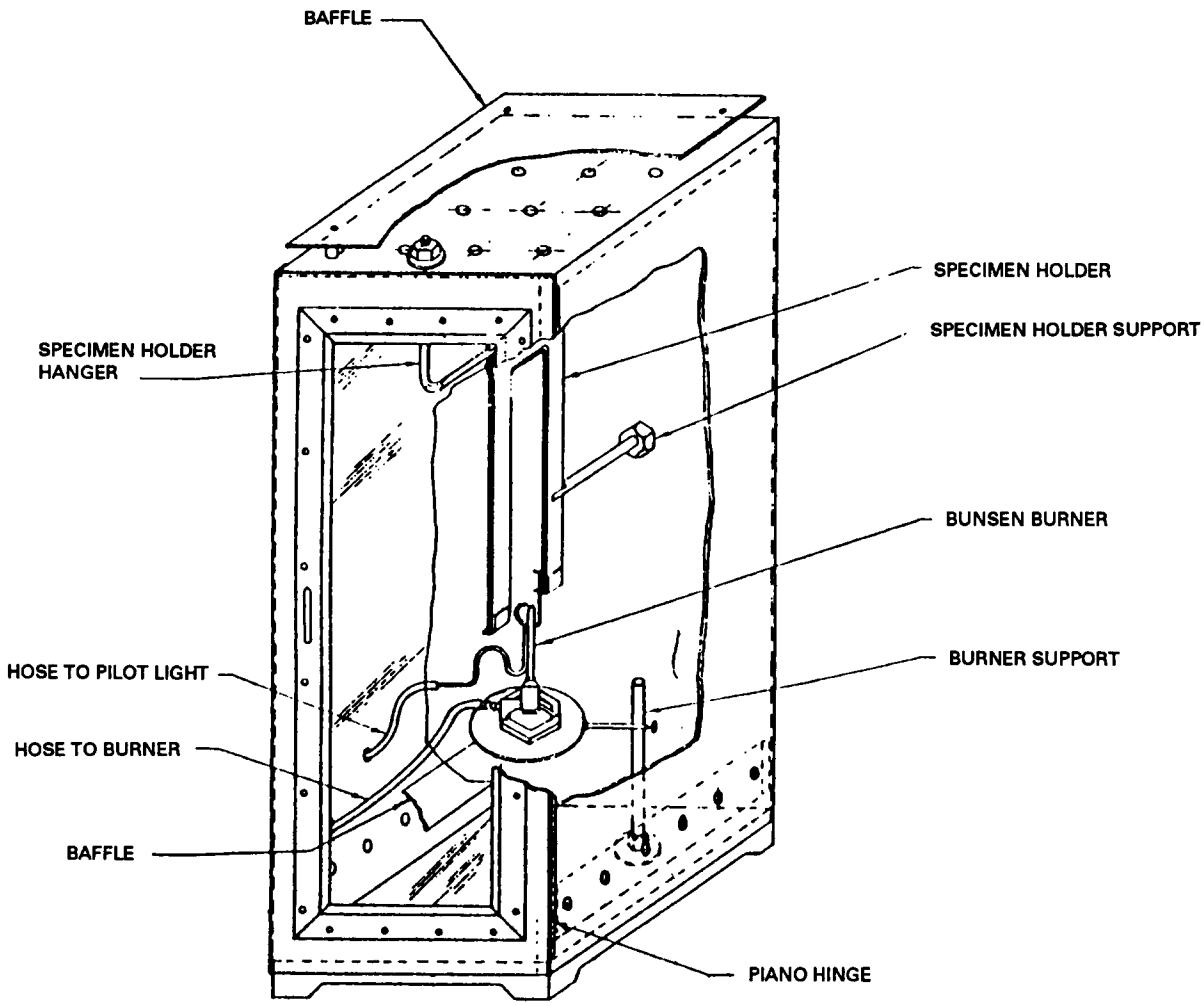


**Figure 5-8.4(a) Vertical flame resistance textile apparatus.**

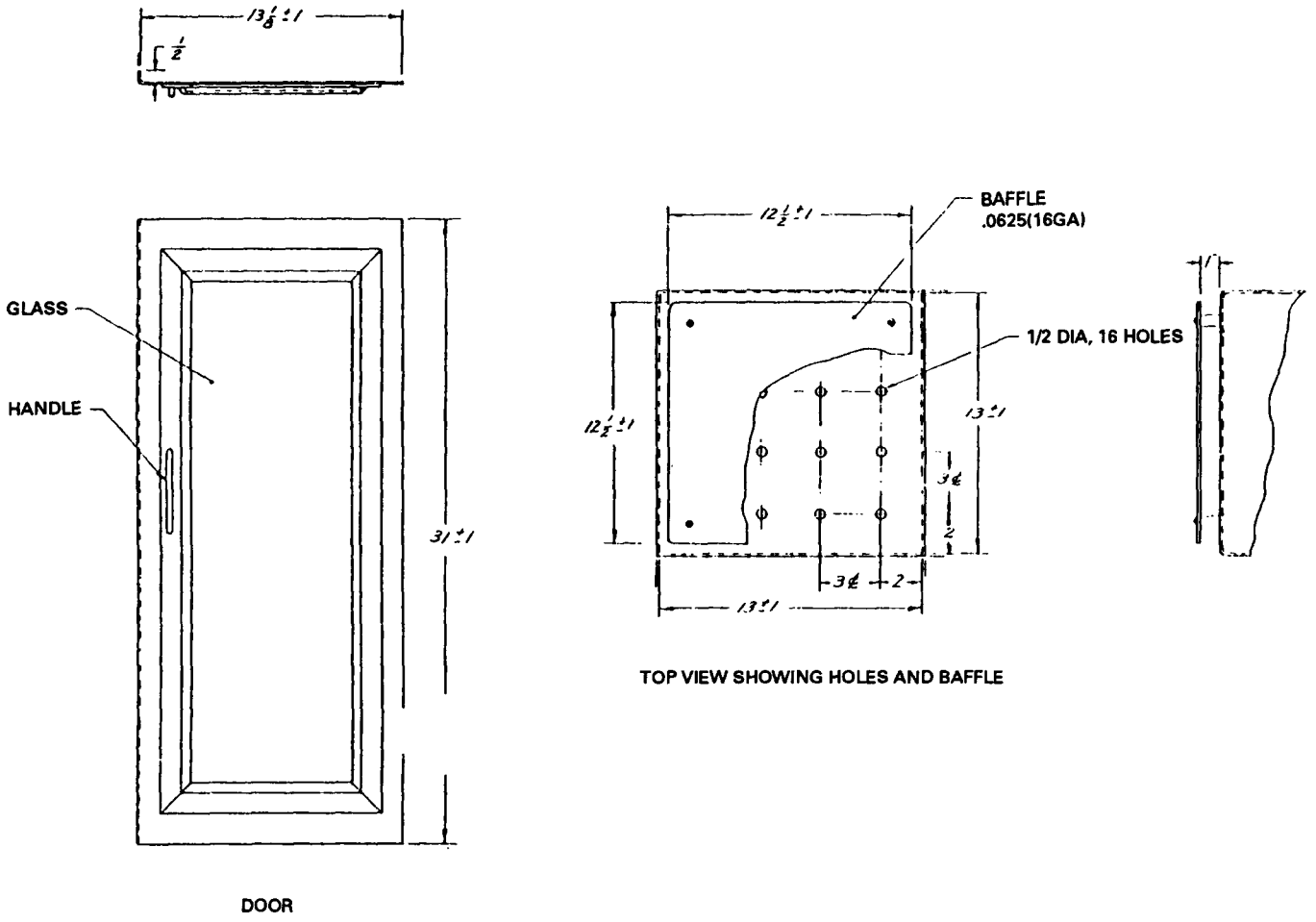


**Figure 5-8.4(b) Vertical flame resistance textile apparatus, door and top view with baffle.**

**5-8.7*** A synthetic gas mixture of the following composition within the following limits analyzed at standard conditions shall be provided:

(a) 55, ±3 percent hydrogen,
(b) 24, ±1 percent methane,
(c) 3, ±1 percent ethane,
(d) 18, ±1 percent carbon monoxide that will give a specific gravity of 0.3865 Btu, ±0.018 (air = 1),
(e) A Btu content of 540 Btu ±20 Btu per cubic foot
(f) Dry basis, at 70°F (21°C).

**5-8.8** Metal hooks and weights shall be used to produce a series of total loads to determine length of char. The metal hooks shall consist of No. 19 gage steel wire or equivalent and shall be made from 3-in. (76-mm) lengths of the wire and bent ½ in. (13 mm) from one end to a 45-degree hook. One end of the hook shall be fastened around the neck of the weight to be used.

**5-8.9** A stopwatch or other device to measure the burning time to 0.2 sec shall be used.

**5-8.10** Measuring scale or metal tape graduated in increments of ⅛ in. (3 mm) to measure the length of char shall be used.

**5-8.11** All specimens to be tested shall be at moisture equilibrium under standard atmospheric conditions in accordance with Section 4 of Federal Test Method, Standard 191A, *Textile Test Methods*. Each specimen to be tested shall be exposed to the test flame within 20 sec after removal from the standard atmosphere. In case of dispute all testing will be conducted under Standard Atmospheric Conditions in accordance with Section 4 of Federal Test Method Standard 191A, *Textile Test Methods*.

**5-8.12** The specimen in its holder shall be suspended vertically in the cabinet in such a manner that the entire length of the specimen is exposed and the lower end is ¾ in. (19 mm) above the top of the gas burner. The apparatus shall be set up in a draft-free area.

**5-8.13** Prior to inserting the specimen, the pilot flame shall be adjusted to ⅛ in. (3 mm) in height measured from its lowest point to the tip. The burner flame shall be adjusted by means of the needle valve in the base of the burner to give a flame height of 1½ in. (38 mm) with the stopcock fully open and the air supply to the burner shut off and taped. The 1½-in. (38-mm) flame height shall be obtained by adjusting the valve so that the top of the flame is level with the tip of the metal prong that is specified in 5-8.5.4 of this section, for adjustment of flame height. After

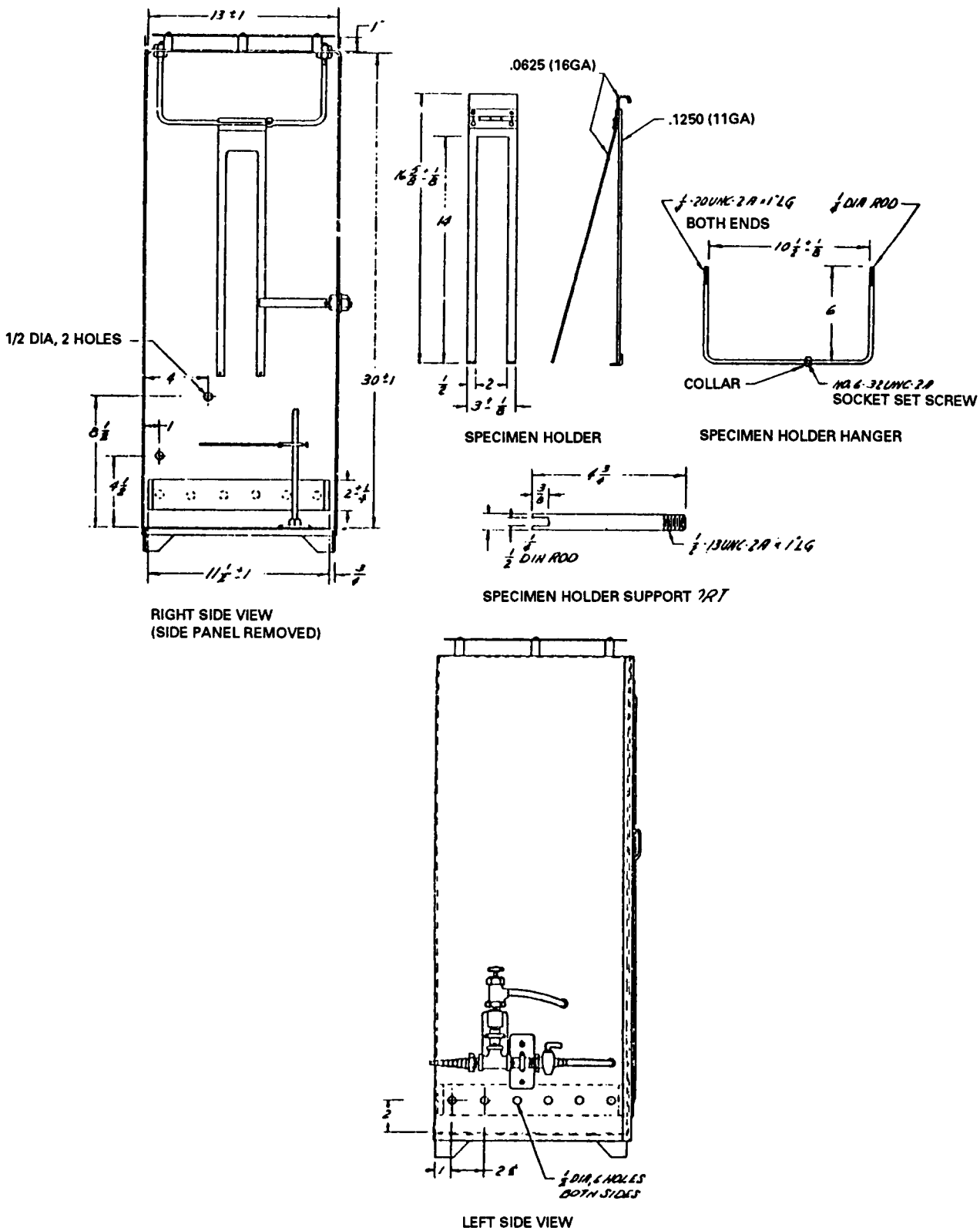


Figure 5-8.4(c) Vertical flame resistance textile apparatus, views with details.

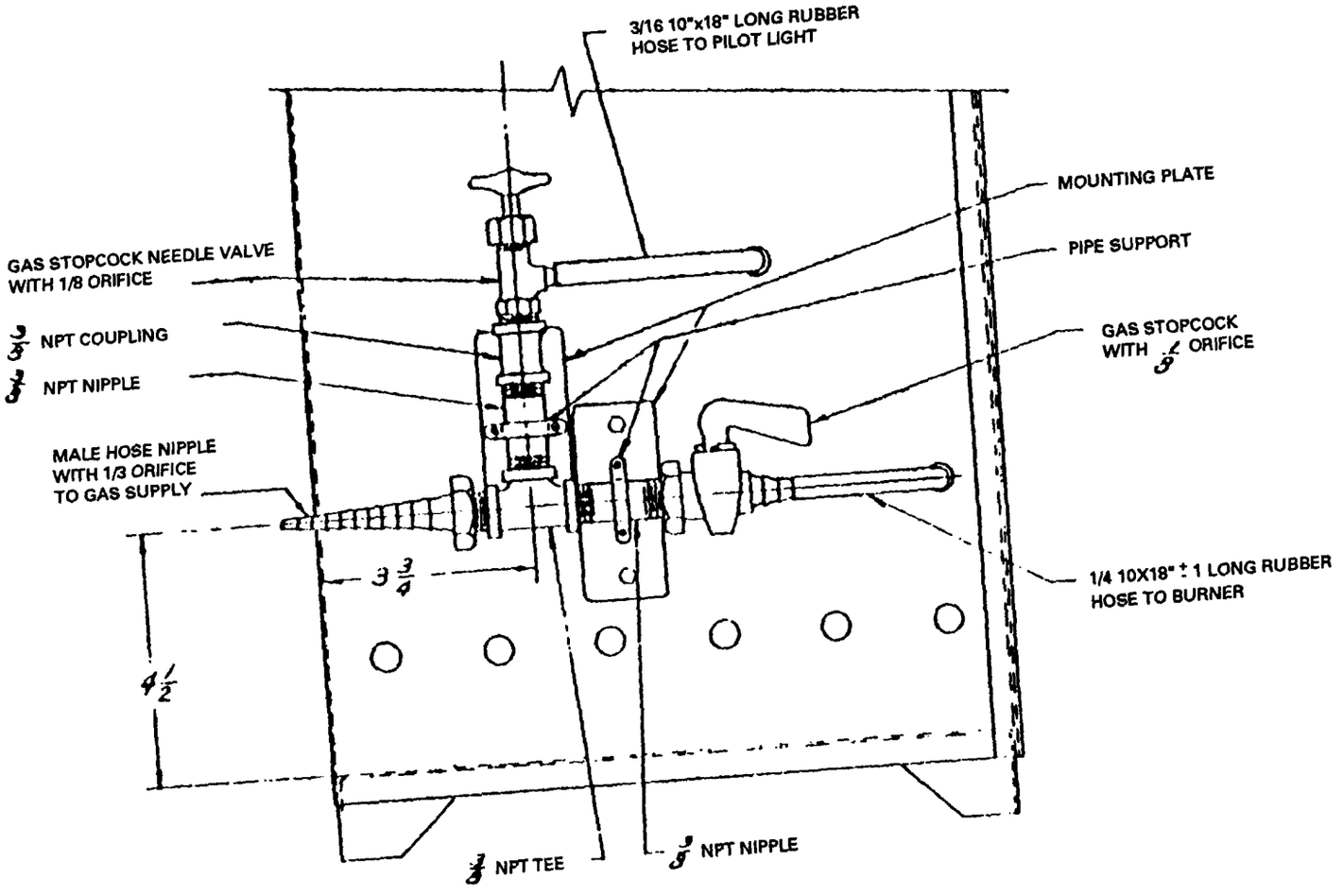


Figure 5-8.5.8 Side view of wi[illegible]

inserting the specimen, the stopcock shall be fully opened and the burner flame applied vertically at the middle of the lower edge of the specimen for 12 sec and the burner turned off. The cabinet door shall remain shut during testing.

**5-8.14** The after-flame time shall be the time the specimen continues to flame after the burner flame is shut off.

**5-8.15** The after-flame time of the specimen shall be recorded to the nearest 0.2 sec and the char length to the nearest ⅛ in. (3 mm) for determining pass/fail.

**5-8.16** After each specimen is removed, the test cabinet shall be cleared of fumes and smoke prior to testing the next specimen.

**5-8.17** After flaming has ceased, the char length shall be measured. The char length shall be the distance from the end of the specimen that was exposed to the flame, to the end of a tear, made lengthwise, of the specimen through the center of the charred area as follows:

(a) The specimen shall be folded lengthwise and creased by hand along a line through the highest peak of the charred area.

(b) The hook shall be inserted in the specimen, or in a hole, ¼-in. (6-mm) diameter or less, punched out for the hook at one side of the charred area ¼ in. (6 mm) from the adjacent outside edge and ¼ in. (6 mm) in from the lower end.

(c) A weight of sufficient size such that the weight and hook together shall equal the total tearing load specified in 5-8.18.1 shall be attached to the hook.

**5-8.18** A tearing force shall be applied gently to the specimen by grasping the corner of the cloth at the opposite edge of the char from the load and raising the specimen and weight clear of the supported surface. The end of the tear shall be marked off on the edge and the char length measurement made along the undamaged edge for determining pass/fail.

**5-8.18.1** The specific load applicable to the weight of the test cloth for determining char length shall be as follows:

| **Specified weight per square yard of cloth before any fire retardant treatment or coating** | | **Total tearing weight for determining the charred length** | |
|---|---|---|---|
| **Ounces per square yard** | **($g/m^2$)** | **Pounds** | **(kg)** |
| 2.0 to 6.0 | (68 to 203) | 0.25 | (0.1) |
| Over 6.0 to 15.0 | (Over 203 to 508) | 0.5 | (0.2) |
| Over 15.0 to 23.0 | (Over 508 to 780) | 0.75 | (0.3) |
| Over 23.0 | (Over 780) | 1.0 | (0.45) |

**5-8.19** Each specimen shall be examined for melting or dripping for determining pass/fail.

**5-8.20** The after-flame time and char length of the sample unit shall be the average of the results obtained from the individual specimens tested. All values from the individual specimens shall be recorded.

**5-8.21** The after-flame time shall be reported to the nearest 0.2 sec and the char length to the nearest ⅛ in. (1 mm).

**5-9 Shrinkage Resistance.**

**5-9.1** Specimens to be tested shall be subjected to the procedure as specified in Section 5-1 of this chapter.

**5-9.2** Knit fabric specimens shall be pulled to original dimensions and shall be allowed to relax for 1 min prior to measurement.

**5-9.3** Specimens shall then be measured to determine pass/fail.

**5-10 Water Absorption Test.**

**5-10.1** Specimens shall be tested both before and after being subjected to the procedure specified in Section 5-1 of this chapter.

**5-10.2** Specimens shall be tested with the outer surface of the composite face-up as oriented in the protective garment in accordance with Method 5504, "Water Resistance of Coated Cloth; Spray Absorption Method," of Federal Test Method Standard 191A, *Textile Test Methods.*

**5-11 Water Penetration Resistance.**

**5-11.1** Specimens shall be tested both before and after being subjected to the procedure specified in Section 5-1 of this chapter.

**5-11.2** Specimens shall be tested at 25 psi (1.76 $kg/cm^2$) in accordance with Method 5512, "Water Resistance of Coated Cloth; High Range, Hydrostatic Pressure Method," of Federal Test Method Standard 191A, *Textile Test Methods.*

**5-11.3** Specimens shall also be tested at 1 psi (0.07 $kg/cm^2$) for 5 min when tested in accordance with Method 5516, "Water Resistance of Cloth; Water Permeability; Hydrostatic Pressure Method," of Federal Test Method Standard 191A, *Textile Test Methods.*

**5-12 Thread Heat Resistance.**

**5-12.1** Specimens shall be tested to a temperature of 500°F (260°C) in accordance with Method 1534, "Melting Point of Synthetic Fibers," of Federal Test Method Standard 191A, *Textile Test Methods.*

**5-13 Corrosion Resistance.**

**5-13.1** Specimens shall be tested in accordance with ASTM B 117, *Standard Method of Salt Spray (Fog) Testing.* Salt spray shall be 5 percent saline solution, and test exposure shall be for 20 hr.

**5-13.2** Immediately following the test exposure and prior to examination, specimens shall be rinsed under warm, running tap water and dried with compressed air.

**5-13.3** Specimens shall then be examined visually with the unaided eye to determine pass/fail.

## Chapter 6 Interface Components

### 6-1 Protective Hoods.

#### 6-1.1 Design Requirements.

**6-1.1.1** The protective hood shall be designed to cover and provide the limited protection specified within this section to the head, face, and neck, which are not protected by the protective coat, helmet, or SCBA facepiece.

**6-1.1.2** The protective hood shall be designed to contact the sides of the SCBA facepiece, when worn, to cover all exposed facial areas. The protective hood shall be designed so that it does not interfere with the proper use of SCBA and the SCBA facepiece-to-face seal, as specified by the SCBA manufacturer.

**6-1.1.3** The protective hood shall be designed so that it does not interfere with the proper use and fit of helmets, as specified by the helmet manufacturer.

#### 6-1.2 Garment Labeling.

**6-1.2.1** The protective hood shall have a garment label permanently and conspicuously attached to the inside of the garment upon which at least the following warning and information are printed in at least 1/16-in. (1.5-mm) high letters.

"THIS PROTECTIVE HOOD INTERFACE COMPONENT MEETS THE REQUIREMENTS OF NFPA 1971, *STANDARD ON PROTECTIVE CLOTHING FOR STRUCTURAL FIRE FIGHTING*, 1991 EDITION.

WARNING

FOR FIRE FIGHTING OPERATIONS, THIS PROTECTIVE HOOD PROVIDES LIMITED PROTECTION TO THE PROTECTIVE COAT/HELMET/SCBA FACEPIECE INTERFACE AREA. DO NOT USE ALONE FOR ANY FIRE FIGHTING OPERATIONS. THIS PROTECTIVE HOOD MAY NOT PROVIDE PROTECTION FROM CHEMICAL, RADIOLOGICAL, OR BIOLOGICAL AGENTS. KEEP THIS GARMENT CLEAN AS SOILING WILL REDUCE PROTECTIVE QUALITIES.

—DO NOT USE CHLORINE BLEACH— CHLORINE BLEACH WILL SIGNIFICANTLY COMPROMISE THE PROTECTION AFFORDED BY THE TEXTILES UTILIZED IN THE CONSTRUCTION OF THIS GARMENT. DO NOT STORE IN DIRECT SUNLIGHT. USE EXTREME CARE FOR ALL EMERGENCY OPERATIONS. FAILURE TO COMPLY WITH THESE WARNINGS MAY RESULT IN SERIOUS INJURY OR DEATH."

Manufacturer's Name
Manufacturer's Address
Country of Manufacture
Manufacturer's Garment Identification Number
Date of Manufacture
Size
Cleaning and Drying Instructions
Garment Material(s)

"DO NOT REMOVE THIS LABEL"

**6-1.2.2** All portions of the required garment label shall be printed at least in English.

**6-1.2.3** All garment labels shall be clearly legible to the eye both before and after being subjected to the procedure specified in Section 5-1 of this standard. Garment labels not meeting specimen size requirements for the procedure specified in Section 5-1 shall be sewn to a support fabric of required size.

#### 6-1.3 Performance Requirements.

**6-1.3.1** The protective hood shall have a thermal protective performance (TPP) of not less than 20.0 when tested as specified in Section 5-2 of this standard.

**6-1.3.2** The protective hood material(s), including labels, but excluding hook and pile fasteners and elastic when not placed in direct contact with the body, shall be individually tested for flame resistance and shall have an average char length of not more than 4.0 in. (101.6 mm), an average afterflame of not more than 2.0 sec, and shall not melt or drip when tested as specified in Section 5-8 of this standard. Garment labels not meeting the specimen size requirements for the procedure specified in 5-8.2 of this standard shall be sewn to a support fabric of required size.

**6-1.3.3** The protective hood material(s), including labels, but excluding hook and pile fasteners and elastic when not placed in direct contact with the body, shall be individually tested for thermal shrinkage and shall not shrink more than 10.0 percent in any direction when tested as specified in Section 5-3 of this standard.

**6-1.3.4** The protective hood material(s), including labels, but excluding hook and pile fasteners and elastic when not placed in direct contact with the body, shall be individually tested for heat resistance and shall not melt, separate, or ignite when tested as specified in Section 5-4 of this standard.

**6-1.3.5** The protective hood material(s), including labels, but excluding hook and pile fasteners and elastic when not placed in direct contact with the body, shall be individually tested for cleaning shrinkage resistance and shall not shrink more than 5.0 percent in any direction when tested as specified in Section 5-9 of this standard.

**6-1.3.6** All thread utilized in the construction of the protective hood shall be tested for heat resistance and shall not ignite, melt, or char when tested as specified in Section 5-12 of this standard.

### 6-2 Protective Wristlets.

#### 6-2.1 Design Requirements.

**6-2.1.1** The protective wristlet shall be designed to cover and provide the limited protection specified within this section to the wrist areas.

**6-2.1.2** The protective wristlet shall be permanently attached to the protective coat.

**6-2.2 Performance Requirements.**

**6-2.2.1** The protective wristlet shall have a thermal protective performance (TPP) of not less than 20.0 when tested as specified in Section 5-2 of this standard.

**6-2.2.2** The protective wristlet material(s) shall be individually tested for flame resistance and shall have an average char length of not more than 4.0 in. (101.6 mm), an average afterflame of not more than 2.0 sec, and shall not melt or drip when tested as specified in Section 5-8 of this standard.

**6-2.2.3** The protective wristlet material(s) shall be individually tested for thermal shrinkage and shall not shrink more than 10.0 percent in any direction when tested as specified in Section 5-3 of this standard.

**6-2.2.4** The protective wristlet material(s) shall be individually tested for heat resistance and shall not melt, separate, or ignite when tested as specified in Section 5-4 of this standard.

**6-2.2.5** The protective wristlet material(s) shall be individually tested for cleaning shrinkage resistance and shall not shrink more than 5.0 percent in any direction when tested as specified in Section 5-9 of this standard.

**6-2.2.6** All thread utilized in the construction of the protective wristlet shall be tested for heat resistance and shall not ignite, melt, or char when tested as specified in Section 5-12 of this standard.

## Chapter 7 Referenced Publications

**7-1** The following documents or portions thereof are referenced within this standard and shall be considered part of the requirements of this document. The edition indicated for each reference is the current edition as of the date of the NFPA issuance of this document.

**7-1.1 NFPA Publications.** NFPA publications can be obtained from National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program*, 1987 edition

NFPA 1975, *Standard on Station/Work Uniforms for Fire Fighters*, 1990 edition

**7-1.2 AATCC Publication.** AATCC publications can be obtained from American Association of Textile Chemists and Colorists, P.O. Box 12215, Research Triangle Park, NC 27709.

AATCC 135, *Dimensional Changes in Automatic Home Laundering of Woven and Knit Fabrics*, 1989

**7-1.3 ASTM Publications.** ASTM publications can be obtained from American Society for Testing and Materials (ASTM), 1916 Race Street, Philadelphia, PA 19103.

ASTM B 117, *Standard Method of Salt Spray (Fog) Testing*, 1985

ASTM D 1683, *Standard Test Method for Failure in Sewn Seams of Woven Fabrics*, 1990

ASTM D 4108, *Standard Test Method for Thermal Protective Performance of Materials for Clothing by Open-Flame Method*, 1978

ASTM E 809, *Standard Practice for Measuring Photometric Characteristics of Retroreflectors*, 1981

**7-1.4 GSA Publications.** GSA publications can be obtained from General Services Administration, Specifications Activity, Printed Materials Supply Division, Building 197, Naval Weapons Plant, Washington, DC 20407. Single copies are generally available without charge at the General Services Administration Business Centers in cities throughout the U.S.

Federal Specification FED-V-F-106F, *Fasteners, Interlocking, Slide*, 23 June 1987.

Federal Test Method Standard 191A, *Textile Test Methods*, 20 July 1978.

**7-1.5 Navy Publications.** Navy publications can be obtained from Navy Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120.

MS 27980E, *Fastener, Snap*, 30 November 1984.

MIL-F-21840, *Fastener Tapes, Hook and Pile, Synthetic*, 30 September 1981.

## Appendix A

*This Appendix is not part of the requirements of this NFPA document, but is included for information purposes only.*

**A-1-1** Organizations responsible for specialized functions, including wildland fire fighting, hazardous materials response, and crash/fire/rescue, should use protective clothing and equipment specifically designed for those activities.

**A-1-2** This standard is not designed to be utilized as a purchase specification. It is prepared as far as practical in terms of required performance, avoiding restricting design of garments. Purchasers should specify departmental requirements for closures, pockets, trim patterns, etc. Tests specified in this standard should not be deemed as defining or establishing performance levels for protection from all structural fire fighting environments.

**A-1-3 Approved.** The National Fire Protection Association does not approve, inspect, or certify any installations, procedures, equipment, or materials nor does it approve

or evaluate testing laboratories. In determining the acceptability of installations 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 concerned with product evaluations which is in a position to determine compliance with appropriate standards for the current production of listed items.

**A-1-3 Authority Having Jurisdiction.** The phrase "authority having jurisdiction" is used in NFPA documents in a broad manner since jurisdictions and quote "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, 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 designated agent assumes the role of the "authority having jurisdiction"; at governmental installation, the commanding officer or departmental official may be the "authority having jurisdiction."

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

**A-1-3 Moisture Barrier.** The term "vapor barrier" utilized in past editions of NFPA 1971 was changed to "moisture barrier" in the 1986 edition to represent more accurately the test methods, Methods 5512 and 5516 of Federal Standard Test Method 191A, specified in this standard. Purchasers wishing to specify additional requirements for vapor resistance should contact fabric suppliers for assistance with establishing specifications. Moisture barriers might not prevent the passage of chemical, biological, or radiological agents through the garment; such incidents should be handled with appropriate chemical protective clothing and procedures.

**A-1-3 Protective Uniform Garment.** The term refers specifically to station/work uniform garments that satisfy the applicable requirements of NFPA 1975, *Standard on Station/Work Uniforms for Fire Fighters*, and that also satisfy in part or in full the thermal barrier requirements of this standard. Not all materials that are in compliance with NFPA 1975, *Standard on Station/Work Uniforms for Fire Fighters*, will meet the thermal barrier requirements of this standard. Purchasers should understand that the station/work uniform might not be able to entirely replace the protective garment thermal barrier and that some additional thermal barrier material may be required to satisfy the minimum TPP requirements.

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

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

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

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

**A-2-4.1** Purchasers might wish to include a requirement in purchase specifications for an additional label containing certain information such as date of manufacture, manufacturer's name, garment identification number, etc., to be located in a protected location in the garment to reduce the chance of label degradation and as a backup source of information to aid in garment tracking or an investigation.

**A-2-5** Some components of these garments are inherently flame resistant but lose their physical integrity on exposure to chlorine bleach. Other components will actually lose their flame resistant properties and thermal insulation on exposure to chlorine bleach. In either case, the protection provided by the garment will be compromised.

Clean protective clothing reduces health and safety risks; it is recommended that clothing be cleaned frequently to reduce the level of and bodily contact with contaminants. User agencies should establish guidelines for frequency and situations for garment cleaning. For gross contamination with products of combustion, fire debris, or body fluids, removal of contaminants by flushing with water as soon as practical is necessary, followed by appropriate cleaning.

Decontamination may not be possible when protective clothing is contaminated with chemical, radiological, or biological agents. When decontamination is not possible, garments should be discarded in accordance with local, state, and federal regulations.

Cleaning services are available for cleaning, maintenance, and decontamination (where possible). Contact your manufacturer for more information.

Contact your protective clothing manufacturer for specific cleaning instructions. Where not explicitly outlined by the manufacturer, the following procedures are recommended for cleaning fire fighter protective clothing.

### Cleaning Procedures for Structural Fire Fighting Protective Clothing

#### Section 1 Washing Instructions.

Protective clothing should be washed separately from other garments. All hooks and dees should be fastened and the garment turned inside out or placed in a large laundry bag that can be tied shut to avoid damage to the wash tub. A stainless steel tub should be utilized if available.

These instructions can be used for cleaning any of the following wash loads in a large capacity (16-gal) top loading or front loading washing machine.

(a) One protective coat and one protective trouser

(b) Two protective coats

(c) Two protective trousers.

Prior to washing, heavily soiled garments should be pretreated using procedures outlined in Section 2.

1. While the washing machine is filling with hot water [temperature between 120°F (54.5°C) and 130°F (49°C)] add ½ cup (4 oz) of liquid oxygenated bleach (do not use chlorine bleach) and 1 cup (8 oz) of liquid detergent. These products are readily available in supermarkets around the country.

2. Fill washing machine to highest water level.

3. Add garments to be washed.

4. Set washing machine for normal cycle, cotton/white, or similar setting.

5. Machine should be programmed for double rinse. If the machine will not automatically double rinse, a complete second cycle can be run without adding detergent or oxygenated bleach. Double rinsing helps remove any residual dirt and ensures detergent removal.

6. Remove garments from washing machine and dry by hanging in a shaded area that receives a good cross ventilation, or hang on a line and use a fan to circulate the air. A water extractor may be utilized.

7. After the garments have been removed, run the laundry machine empty or with a dummy (rags) load with detergent at least once, but preferably several times, to purge the machine of any residue.

#### Section 2 Spot Cleaning and Pretreating

**Spot Cleaning.** Precleaners can be used to clean light spots and stains on protective clothing. Squirt precleaner one or two times onto the soiled areas. Gently rub fabric together until a light foam appears on the surface. Carefully rinse off with cool water.

**Pretreating.** Apply liquid detergent directly from the bottle onto the soiled areas. Gently rub fabric together until a light foam appears on the surface. Place garment into washing machine as instructed in Section 1 and add the remaining amount of the recommended detergent. To clean garments that are heavily soiled, use a liquid detergent or precleaner solution, prior to laundering, in the following manner:

1. Air dry garment before applying product.

2. Squirt the liquid detergent or precleaner directly onto the stain and the surrounding areas (use 3-4 squirts). Make sure that the soiled area is soaked with the product.

3. Use a soft bristle brush (toothbrush or fingernail type dipped in water) to gently scrub the soiled area for about 1½ min.

4. Reapply liquid detergent or precleaner onto the soiled areas again (use 1 or 2 squirts).

5. Place garment into washing machine as instructed in Section 1.

**Laundering and Cleaning Products.** There are industrial cleaner/degreaser products available for protective clothing that the user may wish to purchase for cleaning. Contact the manufacturer or a local fire equipment distributor for additional information. Confirm use instructions with the manufacturer in any case. Some examples of household products that may be utilized for cleaning, spot cleaning, and pretreating are as follows:

Cleaning

| | |
|---|---|
| Liquid Wisk | Liquid Cheer |
| Liquid Tide | Liquid Fab |

Oxygenated Bleaches

| | |
|---|---|
| Liquid Clorox 2 | Liquid Vivid |

DO NOT USE CHLORINE BLEACH ON FIRE FIGHTER PROTECTIVE CLOTHING

Spot Cleaning and Pretreating

| | |
|---|---|
| Liquid Spray & Wash | Liquid Tide |
| Liquid Shout | Liquid Dishwashing Detergent |

Purchaser should maintain protective clothing only in accordance with manufacturer's instructions. Maintenance should include regular inspection, proper repair, and retirement when appropriate. Storage in direct sunlight may substantially reduce the useful life of the garment and reduce protective qualities of the garment that might not be visually apparent. However, color fading or color change of the garment may be the beginning signs of UV degradation. Protective clothing that is retired should be destroyed.

Inspect and examine the trim as to the effectiveness of the trim performance under daytime and nighttime conditions and replace as necessary. It is important that high visibility be maintained at all possible orientations to the light source.

**A-3-1** Purchasers of protective clothing should realize that fire fighters must wear many items of protective clothing and equipment. Any interference by one item with

another's use 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; chest girth, sleeve length, waist girth, outseam length from underarm to pant cuff, and trunk length from base of neck to crotch fold should be required for protective coveralls. Since manufacturers' patterns vary, to assure proper fit, measurement for sizing should be done by the manufacturer's representative or by a trained person in accordance with the manufacturer's instructions.

**A-3-1.2** 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 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.

**A-3-1.3** Fastener system should be specified by the purchaser. Fastener system methods can include (but are not limited to) stitching the thermal barrier and moisture barrier into the coat in the neck, or into the trouser in the waist area with snap or hook and pile fasteners securing the remainder; entirely stitching the thermal barrier and moisture barrier to the outer shell; entirely securing the thermal barrier and moisture barrier to a component part of the outer shell with snap fasteners or fastener tape; or zipping the thermal barrier and vapor barrier to the outer shell.

**A-3-1.6** Purchasers should consider including in the specifications requirements for hook and pile fastener service life for dry and wet operation and thermal stability including shrinkage, melt, char, and drip requirements when tested in accordance with 5-2.2 and 5-3 of this standard.

**A-3-1.10** Purchasers should specify pockets large enough to carry tools and items normally carried. Placement should allow for access to the pockets while wearing SCBA. Specifying ballooned pockets will increase capacity but could interfere with maneuverability. Ballooning only the back edges could minimize the maneuverability problem. Divided pockets could be desired, as well as pockets for specific items, such as SCBA facepieces and radios.

**A-3-1.11** Users of protective clothing should be aware that reflective trims have varying durability under field use conditions. Trim may be damaged by heat but appear to be in good condition when in fact it may have lost retroreflective properties. Trim may become soiled and lose fluorescing and retroreflective qualities. Trim may lose retroreflective qualities in rain or fire fighting water exposures.

Trims should be checked periodically by using a flashlight to determine retroreflective performance. The trim should be bright. Samples of new trim may be obtained from the manufacturer for comparison if needed.

**A-3-1.12** Purchasers of protective clothing should realize that trim patterns can materially affect the visibility of the fire fighter. Trim patterns should be evaluated on live models as the models proceed through a series of arm and leg motions, bending, stooping, and turning.

**A-3-2.1** A protective ensemble consisting of both protective coat and protective trousers is required to be utilized for structural fire fighting in order to assure better protection for the fire fighter's torso and limbs by 5-2.6 of NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program*. An overlap of not less than 8 in. (203.2 mm) of coat and trousers is also required by 5-2.1 of NFPA 1500 and should be specified to assure better protection.

**A-3-2.3** Purchasers should consider specifying wristlets with a thumb hole or bartack creating a thumb hole for wearer's thumb in order to assure protection when arms are in raised position.

**A-3-2.5** A possible configuration for trim on coats or coveralls, in addition to the minimum requirements specified herein, is two 25-in. (635-mm) vertical stripes on the coat back intersecting the circumferential stripe (forming a "U"). Use of vertical trim on protective garment fronts has been shown to be capable of detrimentally affecting the performance of SCBA in flashover heat/flame conditions.

**A-3-3.1** Protective ensemble consisting of both protective coat and protective trousers is required to be utilized for structural fire fighting in order to assure better protection for the fire fighter's torso and limbs in accordance with 5-2.6 of NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program*. An overlap of not less than 8 in. (203.2 mm) of coat and trousers is also required by 5-2.1 of NFPA 1500 and should be specified to assure adequate protection. Utilizing ¾ length boots instead of protective trousers will significantly reduce leg, groin, and buttock protection and is prohibited by 5-2.6 of NFPA 1500.

**A-4-3.3** Purchasers specifying garments with coated outer shells should investigate the following additional test methods for establishing purchasing requirements;

Method 5306, *Taber Abrasion*

Method 5512, *Water Resistance*

Method 5516, *Seam Water Leakage*

Method 5970, *Adhesion of Coatings*

All are Methods of Federal Test Method Standard 191A.

**A-5-2** The requirements in Sections 5-2, 5-3, and 5-4 are not intended to establish the limitations of the working environment for fire fighting but are intended to establish material performance requirements. However, fire fighters should understand that when they feel a continual increase of heat, the protective garments may be nearing their maximum capability and injury may be imminent.

**A-5-3** See A-5-2.

**A-5-4** See A-5-2.

**A-5-8.4** Possible sources for the test cabinet are:

(a) U.S. Testing Company
1941 Park Avenue
Hoboken, NJ 07030

(b) The Govmark Organization, Inc.
P.O. Box 807
Bellmore, NY 11710.

**A-5-8.6** Possible sources for gas mixture and regulator valve system:

(a) Matheson Gas Products
P.O. Box 85
East Rutherford, NJ 07073

(b) Air Products and Chemicals, Inc.
P.O. Box 538
Allentown, PA 18105.

**A-5-8.7** Possible sources for gas mixture and regulator valve system:

(a) Matheson Gas Products
P.O. Box 85
East Rutherford, NJ 07073

(b) Air Products and Chemicals, Inc.
P.O. Box 538
Allentown, PA 18105.

## Appendix B

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

The Subcommittee on Protective Clothing Ensemble organized a Task Force on Heat Stress to address test methods suitable for evaluating materials used in fire fighter protective clothing. The Task Force has developed and standardized the test methodology below based on the heated sweating flat plate apparatus. The Task Force established a calibration procedure to assess comparability of fabric measurements of insulation and permeability from different laboratories. Four independent laboratory groups (Comfort Technology, W. L. Gore & Associates, Inc., Kansas State University, and North Carolina State University) have used the test method and its calibration procedure in evaluating the insulation and evaporative heat transfer of 4 three-layer composites representing a range of available structural fire fighting protective clothing ensembles. A simple criterion—the watts/$m^2$ of heat transferred through the composite by the combined dry and evaporative heat exchanges from a 95°F (35°C), fully sweating test plate surface in a 77°F (25°C), 65 percent RH environment—provides a single number for comparing each fabric ensemble. The actual differences in garments made up from these fabric ensembles will be much smaller because the insulation of the garments will be 2 to 3 times greater due to the air layers in garments that are not accounted for on the flat test plate. Therefore, the actual watts/$m^2$ of heat transfer will be between one-half to one-third of the values obtained by the test method. The actual heat transfer will be decreased even farther by environmental temperatures and humidities that are higher than those used in the test procedure. These considerations led the Task Force to the following conclusions that should be remembered when using the results from the following test method.

1. It is only in mild environments or at low work levels that differences in protective clothing materials are likely to have any appreciable effect on heat stress.

2. In the most stressful situations of high temperature or high work rates, material changes are unlikely to make any significant improvements in tolerance time.

3. Heat stress should be addressed through other means in addition to, or instead of, material specifications.

"NOTICE TO THE READER"

The following test method is given so that persons who are interested in evaluating and comparing the heat transfer qualities of fabrics can do so to an established method. This test method is NOT a requirement of this document, and nothing contained herein can be construed to be a part of the mandatory requirements of this document. The use of the term "shall" in this test method is to emphasize critical procedures that are part of the test and not to indicate a mandatory requirement of this document.

Total Heat Loss Test

NOTE: Practitioners of this method should be intimately familiar with ASTM D 1518, although this Total Heat Loss Test contains significant differences.

1. The test plate and guard ring shall have a wettable surface.

NOTE: One useful sweating hot plate apparatus is available from Holometrix, Inc., 99 Erie Street, Cambridge, MA 02139; (telephone 617-868-8050). An environmental chamber with air temperature, humidity, and air velocity control is also required.

2. The test plate shall have a temperature of 35°C, ±0.5°C (95°F, ±1°F). The guard ring and bottom plate shall be controlled to eliminate lateral and downward heat from the test plate.

3. The local environmental climate shall be 25°C, ±0.5°C (77°F, ±1°F) and 65 percent RH, ±4 percent RH. The air velocity shall be the same for all calibrations and tests. These conditions shall be measured continuously in the free flow air stream uninfluenced by the boundary of the test plate. Apparatus used to measure temperature shall be accurate to within ±0.25°C. Apparatus used to measure humidity shall be accurate to within ±4 percent RH.

4. The average bare plate thermal resistance, including the air layer and any apparatus contribution (Rcbp), shall be an average of at least 3 measurements with nothing mounted on the test plate.

5. The average intrinsic thermal resistance of the sample alone (Rcf) shall be determined by subtracting the average bare plate resistance (Rcbp) from the average of the total thermal resistance (Rct) of the specimens tested.

6. The total thermal resistance (Rct) of the specimen shall be calculated from the following equation:

$$Rct = \frac{(T_s - T_a)A}{H}$$

where

Rct = total thermal resistance of the specimen and surface air layer (°C/m²/W)

$T_s$ = temperature at the plate surface (°C)

$T_a$ = temperature in the local environment (°C)

A = area of the test plate (m²)

H = power input (watts)

7. Data shall be collected when equilibrium is reached. Data shall be collected every 5 min. Equilibrium shall be a rate of change of less than 3 percent per hour of calculated thermal resistance over a period not less than 30 min. The standard deviation of the calculated thermal resistance shall be less than 1 percent.

8. A sample shall include at least 3 individual specimens.

9. The specimens shall be mounted on the test plate in the orientation it has in the finished garment from the skin surface (plate surface) to the outside.

10. The apparatus shall be calibrated to meet the following constraints:

(a) A graph of total thermal resistance versus number of layers of 7.5 oz/sq yd Nomex duck shall be linear for the bare plate value, one, two, three, and four layers.

(b) The slope of the linear regression shall be 0.0206°C/m²/W, ±10 percent.

(c) No individual data measurement shall be outside ±10 percent of the value predicted by the linear regression.

(d) The intrinsic thermal resistance of four layers of 7.5-oz Nomex duck shall be 0.082°C/m²/W, ±10 percent.

NOTE: The standard sample of 7.5 oz/sq yd Nomex duck should be obtained from Office of Standard Reference Materials, National Institute of Standards and Technologies, Gaithersburg, Maryland 20899; (301) 975-6776.

11. The average intrinsic thermal resistance of the specimens shall be determined by averaging all values obtained over the equilibrium period (minimum of 6). The average intrinsic thermal resistance of the sample shall be determined by averaging the values for all specimens. If the results for any of the 3 individual specimens vary more than ±10 percent from the average of all 3, then the test shall be repeated on the specimen(s) lying outside the ±10 percent limit. If the retest produces a value(s) within the ±10 percent limit, then the new value(s) shall be used instead. If the retest remains outside the ±10 percent limit, then an additional 3 specimens shall be tested, and all original and retest results shall be reported along with the average and standard deviation for intrinsic thermal resistance and a statement identifying this sample as having a high variability.

12. Water shall be fed to the test plate and guard ring so that water uniformly wets the test plate and guard ring surface.

13. The test plate and guard ring shall be covered with a liquid barrier that prevents wetting of the test specimen by the liquid water. The permeability index of the bare plate with the liquid barrier in place shall be greater than 0.7.

NOTE: The permeability index of the bare plate should be calculated from the following equation:

$$i_m = .061 \times Rcbp/Rebp$$

where

$i_m$ = permeability index

Rcbp = average bare plate thermal resistance (without liquid barrier) described in paragraph 4 (°C/m²/W)

Rebp = average bare plate evaporative resistance (with liquid barrier in place) described in paragraph 14 (kPa/m²/W)

One source for uncoated cellophane that will be suitable for this purpose is Olin, Ecusta Paper and Film Group, NC 28768.

14. The average bare plate evaporative resistance, including the air layer, the liquid barrier, and any apparatus contribution, (Rebp) shall be an average of at least 3 measurements with only the liquid barrier mounted on the plate. The local environmental climate may be increased above 25°C (77°F) if necessary to maintain test plate temperature at 35°C (95°F).

15. The apparent total evaporative resistance (ARet) of the specimen shall be calculated from the following equation:

$$ARet = \frac{(P_s - P_a)A}{H - \frac{(T_s - T_a)A}{Rct}}$$

where

ARet = apparent total evaporative resistance of the specimen and surface air layer (kPa/m²/W)

$P_s$ = water vapor pressure at the plate surface (kPa)

$P_a$ = water vapor pressure in the local environment (kPa)

A = area of the test plate (m²)

H = power input (watts)

$T_s$ = temperature at the plate surface (°C)

$T_a$ = temperature in the local environment (°C)

Rct = total thermal resistance of the specimen and surface air layer (°C/m²/W)