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NFPA 1977 Protective Clothing and Equipment for Wildland Fire Fighting 1993 Edition

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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 1977

Standard on

Protective Clothing and Equipment for Wildland Fire Fighting

1993 Edition

This edition of NFPA 1977, *Standard on Protective Clothing and Equipment for Wildland 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 24-27, 1993, in Orlando, FL. It was issued by the Standards Council on July 23, 1993, with an effective date of August 20, 1993.

The 1993 edition of this document has been approved by the American National Standards Institute.

Origin and Development of NFPA 1977

The Technical Committee on Fire Service Protective Clothing and Equipment began work on this standard in April, 1989 in answer to requests from the wildland fire service to establish a standard covering the protective clothing and equipment used by fire fighters during wildland fire fighting operations. A subcommittee was formed, the Subcommittee on Wildland Fire Fighting Protective Clothing and Equipment, to develop the document. Based on information studied by this subcommittee, the majority of documented injuries to wildland fire fighters are related to heat stress. The goal of this standard is to provide thermal protection for the wildland fire fighter against external heat sources with flame-resistant clothing and equipment while not inducing an extraordinary internal heat stress load.

The protection package encompassed by this standard consists of protective clothing and equipment for normal exposure limits, and an emergency fire shelter for severe exposure situations where serious injury or death can result.

At the time this document was under development, there was insufficient data available to develop criteria for respiratory protection as a required element of wildland fire fighter protective equipment. A limited number of studies of air samples collected on wildland fire fighters and workers involved with prescribed burning indicate potential for hazardous exposure (e.g., respirable particulate, carbon monoxide, formaldehyde, and acrolein). Studies of the respiratory effects of smoke exposure on wildland fire fighters indicate that exposure during a fire season may result in changes in lung function. The health implications of short-term exposures and the potential health effects of long-term exposures are yet to be quantified.

The developmental work for this document was completed by the subcommittee in the spring of 1992 and presented to the Technical Committee for their action. This first edition was presented at the Annual Meeting in Orlando, FL, and issued with an effective date of August 20, 1993.

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

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

Contents

Chapter 1 Administration 1977– 5
1-1 Scope 1977– 5
1-2 Purpose 1977– 5
1-3 Definitions 1977– 5

Chapter 2 Certification 1977– 8
2-1 General 1977– 8
2-2 Certification Program 1977– 8
2-3 Sample Testing 1977– 8
2-4 Manufacturer's Quality Assurance Program 1977– 8
2-5 User Information 1977– 9

Chapter 3 Protective Clothing 1977– 9
3-1 Design Requirements 1977– 9
3-2 Product Labeling Requirements 1977–11
3-3 Performance Requirements 1977–12
3-4 Testing Requirements 1977–12

Chapter 4 Protective Shelters 1977–20
4-1 Design Requirements 1977–20
4-2 Product Label Requirements 1977–20
4-3 Carrying Case and Liner 1977–20

Chapter 5 Protective Footwear 1977–20
5-1 Design Requirements 1977–20
5-2 Product Labeling Requirements 1977–21
5-3 Performance Requirements 1977–21
5-4 Testing Requirements 1977–22

Chapter 6 Protective Gloves 1977–25
6-1 Design Requirements 1977–25
6-2 Product Labeling Requirements 1977–27
6-3 Performance Requirements 1977–27
6-4 Testing Requirements 1977–28

Chapter 7 Protective Helmets 1977–32
7-1 Design Requirements 1977–32
7-2 Product Labeling Requirements 1977–32
7-3 Performance Requirements 1977–33
7-4 Testing Requirements 1977–33

Chapter 8 Referenced Publications 1977–36

Appendix A Explanatory Material 1977–37

Appendix B Referenced Publications 1977–41

Index 1977–42

NFPA 1977

Standard on

Protective Clothing and Equipment for Wildland Fire Fighting

1993 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 8 and Appendix B.

Chapter 1 Administration

1-1 Scope.

1-1.1 This standard specifies the minimum design and performance criteria, and test methods, for protective clothing, helmets, gloves, footwear, and fire shelters to protect fire fighters against adverse effects to the fire fighter's body during wildland fire fighting.

1-1.2* This standard does not provide criteria for respiratory protection; nor does it provide criteria for protection from structural, proximity, approach, or entry fire fighting situations; nor does it provide criteria for protection from chemical, radiological, or biological agents.

1-1.3 This standard is not intended to serve 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 set minimum requirements for protective apparel and equipment utilized during wildland fire fighting operations. Organizations responsible for other emergency functions, including structural, proximity, approach, and entry fire fighting operations; or hazardous materials, biological or radiological agents; or emergency medical operations, use protective clothing and equipment specifically designed for these activities.

1-2.2* Controlled laboratory tests used to determine compliance with the performance requirements of this standard shall be deemed as establishing performance levels for all situations to which wildland fire fighting personnel can be exposed.

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

1-3 Definitions.

1-3.1 For purposes of this standard, the terms in this section shall have the definitions herein stated, and terms that are exclusive to a specific chapter of this standard are noted by the chapter number in parentheses following the term.

Accessories.* Those items and equipment that are carried on the person of the wildland fire fighter in such a manner that they are located outside of the protective garments. These items include, but are not limited to, utility belts and harnesses, backpacks, radio packs, goggles, chain saw chaps, fire shelter packs, and over-the-ear hearing protective devices, excluding closure devices.

Approach Fire Fighting. Limited, specialized exterior fire fighting operations at incidents involving fires producing very high levels of conducted, convective, and radiant heat, such as bulk flammable gas and bulk flammable liquid fires. Speciality thermal protection from exposure to high levels of radiant heat is necessary for the persons involved in such operations due to the limited scope of these operations and the greater distance from the fire that these operations are conducted. Not entry, proximity, structural, or wildland fire fighting. (*See also Entry Fire Fighting, Proximity Fire Fighting, Structural Fire Fighting, and Wildland Fire Fighting.*)

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.

Back Length (3). Upper torso measurement at center back from bottom collar to bottom edge of garment.

Back Rise (3). Lower torso measurement from crotch seam to top of waistband at back center.

Bottom Circumference (3). Upper torso measurement along bottom edge of upper torso garment from folded edge to folded edge. Multiply this measurement by 2 to obtain circumference.

Brim (7). A part of the shell of the helmet extending around the entire circumference of the helmet.

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 of 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 labeling/listing/follow-up program.

Char. The formation of a brittle residue where the material is exposed to thermal energy.

Chest Circumference (3). Upper torso measurement from folded edge to folded edge, at base of armholes. Multiply this measurement by 2 to obtain circumference.

Chin Strap (7). An adjustable strap that fits under the chin to secure the helmet to the head.

Collar Length (3). Upper torso measurement along top of collar from point-to-point.

Collar Width (3). Upper torso measurement at center back from top edge of unfolded collar to the bottom collar seam.

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

Components. All materials used in the construction of wildland fire fighting apparel, including but not limited to thread, trim, bindings, zippers, buttons, labels, and hardware, but excluding textile fabrics, interlinings, and emblems.

Composite. The layer or layers of material or materials that provide the required protection used in the garment construction.

Crown. The domed portion of the helmet that covers the head.

Crown Straps (7). That part of the suspension that passes over the head.

Cuff (3). Finished edge of sleeve and leg openings.

Cuff Circumference (3). Torso garment cuff measurement along bottom of opening from folded edge to folded edge. Multiply this measurement by 2 to obtain circumference.

Drip. To run or fall in drops or blobs.

Entry Fire Fighting. *Extraordinarily* specialized fire fighting operations that can include the activities of rescue, fire suppression, and property conservation at incidents involving fires producing very high levels of conducted, convective, and radiant heat; such as aircraft fires, bulk flammable gas fires, and bulk flammable liquid fires. Highly specialized thermal protection from exposure to extreme levels of conducted, convective, and radiant heat is necessary for persons involved in such extraordinarily specialized operations due to the scope of these operations and that *direct entry into flames is made*. Usually these operations are exterior operations. Not structural fire fighting or wildland fire fighting. (*See also Approach Fire Fighting, Proximity Fire Fighting, Structural Fire Fighting, and Wildland Fire Fighting.*)

Eyerow. The row of eyelets.

Face/Neck Shroud (7). A protective device that attaches to the helmet and closes to protect the face and neck area.

Fire Shelter. An aluminized tent utilized for protection, by means of reflecting radiant heat, in a fire entrapment situation.

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

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

Footwear Upper (5). That part of the protective footwear including but not limited to the toe, vamp, quarter, shaft, topline, and other than the sole with heel and insole.

Front Length (3). Upper torso measurement from bottom collar seam to the bottom edge of the garment at front edge.

Front Rise (3). Lower torso measurement from crotch seam to top of waistband at front center.

Front Waist Pocket (3). Slanted or side seam opening pockets that open to the exterior, located at or near the front waist of the garment.

Garment. An item of clothing that covers the torso, limbs, or portions thereof.

Gloves (6). An article of protective clothing designed to provide limited protection to the fingers and thumb, and hand and wrist.

Hardware (3). Non-fabric components of protective clothing, including those made of metal or plastic material.

Headform (7). A test device that simulates the configuration of the human head.

Heel Breast. The forward face of the heel.

Helmet. An article of protective equipment designed to provide limited protection to the head.

Inherent Flame Resistance (3). Flame resistance that is derived from the essential characteristics of the fiber or polymer.

Inseam Length (3). Lower torso measurement along inseam from crotch seam to bottom edge of cuff.

Insole (5). The part of the protective footwear next to the bottom of the foot.

Interlining (3). Any textile that is intended for incorporation into any article of wearing apparel as a layer between the protective layers.

Knee Circumference (3). Lower torso measurement 14 in. (35.6 cm) below crotch seam, from folded edge to folded edge. Multiply this measurement by 2 to obtain circumference.

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.

Lower Torso (3). Area of body below the waist including the legs, but excluding the ankles and feet.

Major "A" Seams (3).* Those seams assembly constructions where rupture exposes the wearer to immediate danger.

Major "B" Seams (3).* Those seam assembly constructions where rupture does not expose the wearer to immediate danger.

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

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

Neck Shroud. See "Face/Neck Shroud."

Patch Pockets (3). Pockets located on the exterior of a protective garment.

Peak (7). An integral part of the helmet shell extending forward over the eyes only.

Product Label. A label or marking affixed to the item of wildland fire fighting protective clothing or equipment by the manufacturer containing general information, warnings, care, maintenance, or similar data. This product label is not the certification organization's label, symbol, or identifying mark; however, the certification organization's label, symbol, or identifying mark can be attached to it or be part of it.

Protective Footwear. An article of protective clothing designed to provide limited protection to the foot, ankle, and lower leg.

Protective Garment. An article, or articles, of protective clothing designed to provide limited protection to the upper and lower torso, including arms and legs.

Protective One-Piece Garment (3). A single-piece protective garment designed and configured to protect the torso, arms, and legs.

Protective Padding (7). A material used to absorb the kinetic energy of impact.

Protective Shirt (3). Upper torso protective garment designed to protect the chest, back, arms, and shoulders, and worn over undergarments or other clothing.

Protective Trouser (3). Lower torso protective garment designed to protect the waist, hips, thighs, and legs, and worn over undergarments or other clothing.

Proximity Fire Fighting. Specialized fire fighting operations that can include the activities of rescue, fire suppression, and property conservation at incidents involving fires producing very high levels of conducted, convective, and radiant heat; such as aircraft fires, bulk flammable gas fires, and bulk flammable liquid fires. Speciality thermal protection from exposure to high levels of radiant heat, as well as thermal protection from conductive and convective heat, is necessary for persons involved in such operations due to the scope of these operations and the close distance to the fire that these operations are conducted although direct entry into flame is NOT made. Usually these operations are exterior operations, but might be combined with interior operations. Not structural fire fighting, but might be combined with structural fire fighting operations. Not entry or wildland fire fighting. (*See also Approach Fire Fighting, Entry Fire Fighting, Structural Fire Fighting, and Wildland Fire Fighting.*)

Radiant Protective Performance (RPP). The resistance of a fabric to radiant heat, measured in seconds, when exposed to a vertically oriented radiant heat source, positioned at a specific horizontal distance from the vertical placement of the protective fabric, sufficient to cause a second-degree burn to human tissue.

Retroreflective Markings (7). A material that reflects light back to the light source.

Sample. Protective clothing or equipment items taken from a manufacturer's current production lot; or specimens that are identical to the items or protective clothing or equipment; or materials used in actual construction of the item of protective clothing or equipment.

Sample Specimen. A single layer or composite of the materials used in actual construction of an item of protective clothing or equipment proposed for labeling as compliant with the requirements of this standard.

Seam Assembly (3). The composite structure obtained where fabric(s) are joined by the means of a sewn seam.

Seat Circumference (3). Lower torso measurement from 1 in. (2.5 cm) above bottom of fly curve from folded edge to folded edge. Multiply this measurement by 2 to obtain circumference.

Separate. A material response evidenced by splitting or delamination.

Sewn Seam Strength (3). The maximum resistance to rupture of the junction formed by stitching together 2 or more planar structures, such as textile fabrics.

Shall. This term indicates a mandatory requirement.

Shank (5). Reinforcement to the shank area of protective footwear designed to provide additional support to the instep.

Shell (7). A helmet without its suspension system, accessories, and fittings.

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

Sleeve Length (3). Upper torso measurement from center back at bottom of collar seam diagonally across back and down sleeve to bottom edge of cuff. In other specified instances, it is a measurement from center sleeve setting seam at shoulder to bottom edge of sleeve.

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

Textile Fabric (3). A planar structure consisting of yarns or fibers.

Thermal Protective Performance (TPP). The resistance, measured in seconds, of a sample specimen to a combination of convective and radiant heat sufficient to cause second-degree burns to human tissue when the sample specimen is exposed to a convective and radiant heat source positioned at a specific vertical distance from a horizontal placement of the sample specimen.

Thigh Circumference (3). Lower torso measurement at crotch line from folded edge to folded edge. Multiply this measurement by 2 to obtain circumference.

Throat. The center of the boot entrance area behind the gusset, from its top line to the lowest point where it attaches to the vamp.

Top Line. The line around the top of the boot that includes the top of the gusset.

Upper Torso (3). Area of body above the waist to shoulder, including the arms and wrists, but excluding the hands.

Vertical Circumference (3). One-piece torso garment measurement from junction of shoulder/collar seam down to the bottom of the crotch. Multiply this measurement by 2 to obtain circumference.

Waist Circumference (3). Measurement from top edge of waistband from folded edge to folded edge. Multiply this measurement by 2 to obtain circumference.

Wear Surface (5). A footwear term for the bottom of the sole, including heel.

Welt. A strip of material stitched or cemented onto the seam between the boot upper and sole.

Wildland Fire Fighting. The activities of fire suppression and property conservation in vegetation that is not within structures, but that is involved in a fire situation.

Chapter 2 Certification

2-1 General.

2-1.1 Garments, gloves, footwear, helmets, and protective shelters that are labeled as being compliant with this standard shall meet or exceed all 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 garments, gloves, footwear, helmets, and protective shelters shall be labeled and listed. Such protective clothing and equipment items shall also have a product label that meets the requirements specified within the individual product chapters 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 the requirements of this standard.

2-2.3* The contractual provisions between the certification organization and the manufacturer shall specify that a listing 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 used to ensure proper control of all testing. Good practice shall be followed regarding the use of laboratory manuals, form data sheets, documented 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 product inspection and testing.

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

2-2.7* Product certifications shall include a follow-up inspection program, with a 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 Sample 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 design requirements specified in this standard shall be performed on a completed item of protective clothing or equipment.

2-3.3 Testing for determining material and component compliance with performance requirements specified in this standard shall be performed on samples representative of materials and components used in the actual construction of that particular item of protective clothing or equipment. The certification organization shall be permitted to also use sample materials cut from representative items of protective clothing or equipment.

2-3.4 Any change in design, construction, or material shall necessitate new certification of compliance to all requirements of this standard that the certification organization determines can be affected by such change. This recertification shall be conducted before labeling the modified item of protective clothing or equipment as being compliant with this standard.

2-4 Manufacturer's Quality Assurance Program.

2-4.1 The manufacturer shall provide and maintain a quality assurance program that includes a documented inspection and product recall system. The manufacturer shall have an inspection system to substantiate conformance to this standard.

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

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

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

2-4.5 The manufacturer shall, as a part of the quality assurance program, maintain a calibration program of all instruments used to ensure proper control of testing. The calibration program shall be documented as to the date of calibration and performance verification.

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

2-4.7 The manufacturer shall establish and maintain a system for controlling non-conforming material, including procedures for the identification, segregation, and disposition of rejected material. All non-conforming materials or products shall be identified to prevent use, shipment, and intermingling with conforming materials or products.

2-4.8 The manufacturer's quality assurance program shall be audited by a third-party certification agency to determine that the program is sufficient to ensure continued product compliance with this standard.

2-5 User Information.

2-5.1 The manufacturer of protective clothing or equipment certified as compliant with this standard shall provide, with each item, instructions for user marking, storage, maintenance, frequency and details of inspection, criteria for retirement or removal from service, and any other information regarding to serviceability.

2-5.2 The manufacturer of protective clothing or equipment certified as compliant with this standard shall provide, with each item, instructions for cleaning and drying, including applicable warnings regarding detergents, soaps, cleaning additives, and bleaches.

Chapter 3 Protective Clothing

3-1* Design Requirements.

3-1.1 All collars shall remain upright after extension into a vertical position.

3-1.2* Protective garments shall not have turn-up cuffs. Sleeve cuffs shall have a closure system that can be adjusted to provide a snug and secure fit around the wrist while wearing a glove that meets the requirements of Chapter 6.

3-1.3 Inseam lengths shall be provided in lengths from 26 in. to 35 in. (66 cm to 89 cm) in 1.0-in. (2.5-cm) increments, or shall be cut to order. Inseam lengths shall be finished to lengths specified within tolerances of +0.5/–0.0 in. (+1.27/–0.0 cm).

3-1.4* All pockets that open to the exterior of the garment, other than front waist pockets, shall have a cover or closure system.

3-1.5* Pass-through openings of protective garments shall have a means of fastening them in a closed position.

3-1.6 Bottoms of upper torso garments shall be flat without curving upwards at the side seams.

3-1.7 All snaps shall meet the requirements of MS 27980E, *Fasteners, Snaps, Style 2.*

3-1.8 All fastener tape shall meet the requirements of MIL-F-21840G, *Fastener Tapes, Hook and Pile, Synthetic.*

3-1.9 All zippers shall meet the requirements of FED-V-F-106F, *Fasteners, Slide Interlocking.*

3-1.10 All protective garments that encompass the neck area shall have a closure system at the neckline.

3-1.11 One-piece garment torso closure systems shall be continuous from the top of crotch area to top of garment at neck.

3-1.12 Closure systems shall not come in direct contact with the body.

3-1.13 Any metal components of the garments shall not come in direct contact with the body.

3-1.14* Size Requirements.

3-1.14.1 Manufacturers shall produce garments in accordance with minimum equivalents as indicated in Tables 3-1.14.1(a), 3-1.14.1(b), 3-1.14.1(c), and 3-1.14.1(d).

Table 3-1.14.1(a) Protective Upper Torso Garment Sizing Requirements (Inches)

*	Garment Size	13½ x 31	14½ x 32	15½ x 33	16½ x 34	17½ x 35	18½ x 36	Δ	Tol**
A	Collar Length	14¾	15¾	16¾	17¾	18¾	19¾	1	+ 1
B	Collar Width	3	3	3	3	3	3	0	+ 1
C	Front Length	26	27	28	29	30	31	1	+ 1
D	Back Length	28	29	30	31	32	33	1	+ 1
E	Sleeve Length	30½	31½	32½	33½	34½	35½	1	+ 1
F	Cuff	12½	13	13½	14	14½	15	½	+½
G	Chest	39	43	47	51	55	59	4	+ 1
H	Waist	33	37	41	45	49	53	4	+ 1
I	Bottom	39	43	47	51	55	59	4	+ 1

* See upper torso measurements in Figure 3-1.14.5(a).
** All minus tolerances shall be zero (0).
Δ The amount of change between two consecutive garment sizes for the dimension measured.
To convert measurements to centimeters multiply by 2.54.
Note: For tall sizes add 1.0 in. to sleeve length and 1½ in. to front and back lengths.

Table 3-1.14.1(b) Men's and Women's Protective Garment Lower Torso Sizing Requirements (Inches)

*	Garment Size	26	28	30	32	34	36	38	40	Δ	Tolerance**
A	Waist	26	28	30	32	34	36	38	40	2	+ 1
B	Seat	37	39	41	43	45	47	49	51	2	+ 1
C	Thigh	25	26	27	28	29	30	31	32	1	+ 1
D	Knee	17 1/2	18 1/4	19	19 3/4	20 1/2	21 1/4	22	22 3/4	3/4	+ 1
E	Cuff	17	18	18 1/2	19	19 1/2	20	20 1/2	21	1/2	+ 1
F	Front Rise	11 1/8	11 7/16	11 3/4	12 1/16	12 5/16	12 5/8	12 15/16	13 1/4	5/16	+ 1/2
G	Back Rise	16 5/8	16 15/16	17 1/4	17 9/16	17 7/8	18 3/16	18 1/2	18 13/16	5/16	+ 1/2
H	Inseam	Shall be cut to order or provided in 1-inch increments between 28-36 in.									+ 1/2

* See lower torso measurements in Figure 3-1.14.5(b).
** All minus tolerances shall be zero (0).
Δ The amount of change between two consecutive garment sizes for the dimension measured.
To convert measurements to centimeters multiply by 2.54.

Table 3-1.14.1(c) Women's Protective Garment Lower Torso Sizing Requirements (Inches)

*	Garment Size	23	25	27	29	31	33	35	37	Δ	Tolerance**
A	Waist	23	25	27	29	31	33	35	37	2	+ 1
B	Seat	37	39	41	43	45	47	49	51	2	+ 1
C	Thigh	25	26	27	28	29	30	31	32	1	+ 1
D	Knee	17 1/2	18 1/4	19	19 3/4	20 1/2	21 1/4	22	22 3/4	3/4	+ 1
E	Bottom	17 1/2	18	18 1/2	19	19 1/2	20	20 1/2	21	1/2	+ 1
F	Front Rise	11 1/8	11 7/16	11 3/4	12 1/16	12 3/8	12 11/16	13	13 5/16	5/16	+ 1/2
G	Back	16 11/16	17	17 5/16	17 5/8	17 15/16	18 1/4	18 9/16	18 7/8	5/16	+ 1/2
H	Inseam	Shall be cut to order or provided in 1-inch increments between 28-36 in.									+ 1/2

* See lower torso measurements in Figure 3-1.14.5(b).
** All minus tolerances shall be zero (0).
Δ The amount of change between two consecutive garment sizes for the dimension measured.
To convert measurements to centimeters multiply by 2.54.

Table 3-1.14.1(d) Protective One-Piece Garment Sizing Requirements (Inches)

*	Garment Size		32	36	40	44	48	Δ	Tolerance**
A	Collar Length		14 3/4	15 3/4	16 3/4	17 3/4	18 3/4	1	+ 1
B	Collar Width		3	3	3	3	3	0	+ 1
E	Sleeve Length		30 1/2	31 1/2	32 1/2	33 1/2	34 1/2	1	+ 1
F	Cuff, Sleeve		12 1/2	13	13 1/2	14	14 1/2	1/2	+ 1/2
G	Chest		39	43	47	51	55	4	+ 1
B	Seat		37	41	45	49	53	4	+ 1
C	Thigh		25	27	29	31	33	2	+ 1
D	Knee		17 1/2	19	20 1/2	22	23 1/2	1 1/2	+ 1
E	Cuff, Length		17 1/2	18 1/2	19 1/2	20 1/2	21 1/2	1	+ 1
	Vertical	S	—	—	69	71 1/2	74		
	Circumference	R	63 1/2	63 1/2	71	73 1/2	76	—	+ 2
		T	65 1/2	65 1/2	73	75 1/2	78		
	Height Range	S	—		64 - 67				
		R	63 - 66		67 1/2 - 72			—	—
		T	66 1/2 - 69		72 1/2 - 75				

* See respective upper and lower torso measurements in Figures 3-1.14.5(a) and (b).
**All minus tolerances shall be zero (0).
Δ The amount of change between two consecutive garment sizes for the dimensions measured.
To convert measurements to centimeters multiply by 2.54.
S - Small size.
R - Regular size.
T - Tall size.

3-1.14.2 Size requirements for tall sizes for upper torso garments shall have an additional 1.0 in. (2.5 cm) added to the sleeve length dimension and an additional 1.5 in. (3.8 cm) added to the front and back length dimensions.

3-1.14.3 Garments shall be permitted for sizes midway between those specified, provided that they meet dimensional requirements that are midway between the respective values for corresponding even sizes specified in Tables 3-1.14.1(b), 3-1.14.1(c), and 3-1.14.1(d).

3-1.14.4 Protective garments shall be permitted to be custom made, provided that the individual is measured for all dimensions cited in the sizing tables and that the garment provides the minimum ease specified in Table 3-1.14.4.

3-1.14.5 Garments shall be closed, laid flat, smoothed, and gently stretched while measuring as defined in Section 1-3 and in Figures 3-1.14.5(a) and 3-1.14.5(b).

3-1.15 The minimum seam allowance for all seams shall be $^3/_8$ in. (9.5 mm).

Table 3-1.14.4 Ease

Dimension	Men	Women
Upper Torso Garment		
Neck Circumference	+ 1	+ 1
Chest Circumference	+ 6	+ 6
Hip Circumference	+ 6	+ 6
Bottom Circumference	+ 6	+ 6
Cuff Circumference	+ 6	+ 6
Amount of Front & Back Length extending below top of hip line	+ 6	+ 6
Lower Torso Garment		
Waist Circumference	+ 1	+ 1
Seat Circumference	+ 6	+ 7
Thigh Circumference	+ 6	+ 6
Knee Circumference	+ 6	+ 6
Cuff Circumference	+11	+11
(Front + Back) Rise	+ 6	+11
One-Piece Garment		
Vertical Circumference	+10	+10

3-2 Product Labeling Requirements.

3-2.1 Product labels for garments that can be laundered shall be clearly legible to the eye before and after 50 cycles of washing and drying in accordance with the procedures 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*.

3-2.2 Product labels utilized in wildland fire fighting protective garments specified to be dry-cleaned shall be clearly legible before and after 25 dry-cleaning cycles.

3-2.3 Each garment shall have 1 or more product labels permanently and conspicuously attached to the item, upon which at least the following warning and information are printed in letters at least $^1/_{16}$ in. (1.6 mm) in height:

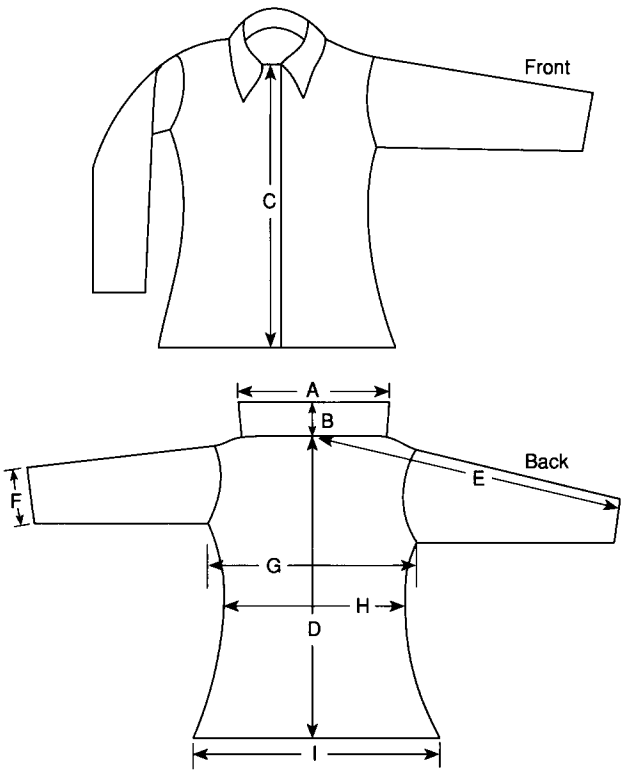


Figure 3-1.14.5(a) Upper torso measurements.

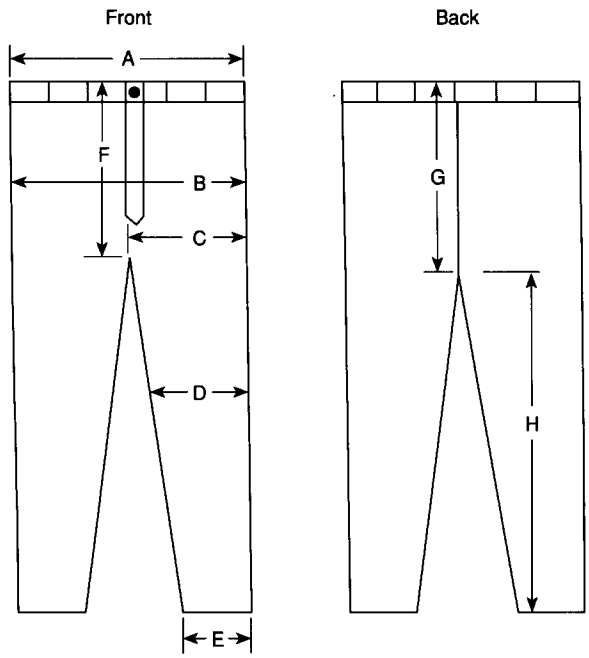


Figure 3-1.14.5(b) Lower torso measurements.

"THIS WILDLAND FIRE FIGHTING PROTECTIVE GARMENT MEETS THE REQUIREMENTS OF NFPA 1977, *STANDARD ON PROTECTIVE CLOTHING AND EQUIPMENT FOR WILDLAND FIRE FIGHTING*, 1993 EDITION.

WARNING

THIS PROTECTIVE GARMENT IS DESIGNED FOR WILDLAND FIRE FIGHTING ONLY. DO NOT USE PROTECTIVE GARMENTS ALONE FOR WILDLAND FIRE FIGHTING OPERATIONS; OTHER PROTECTIVE EQUIPMENT — HELMET, GLOVES, FOOTWEAR, FIRE SHELTER — IS REQUIRED FOR PROTECTION. FOR OTHER FIRE FIGHTING OPERATIONS, PROTECTIVE CLOTHING AND EQUIPMENT APPROPRIATE FOR THE TYPE OF FIRE FIGHTING OPERATION MUST BE WORN. USERS MUST CLEAN, MAINTAIN, AND ALTER ONLY IN ACCORDANCE WITH MANUFACTURER'S INSTRUCTIONS. NO PROTECTIVE GARMENTS CAN PROVIDE COMPLETE PROTECTION FROM ALL CONDITIONS; USE EXTREME CARE FOR ALL EMERGENCY OPERATIONS. FAILURE TO COMPLY WITH THIS WARNING MAY RESULT IN SERIOUS INJURY OR DEATH."

Manufacturer's name
Manufacturer's address
Manufacturer's number, cut/lot, or serial number
Country of manufacture
Country of origin of materials
Style, name, or design
Date of manufacture (uncoded)
Size
Cleaning and drying instructions, including applicable warnings regarding detergents, soaps, cleaning additives, and bleaches
Material contents
Authorized mark of certifying organization
Date of certification

"DO NOT REMOVE THIS LABEL."

3-2.4 All portions of the required garment label shall be printed at least in English.

3-3* Performance Requirements.

3-3.1 Textile fabrics used for protective clothing or protective garment composites shall have an average radiant protective performance (RPP) of not less than 7.0 when tested as specified in 3-4.2 before and after 5 cycles of washing and drying in accordance with 3-4.10.

3-3.2 Textile fabrics and interlinings used for protective clothing shall be individually tested for flame resistance and shall have an average char length of not more than 4 in. (102 mm), an average afterflame of not more than 2 seconds, and shall not melt or drip when tested as specified in 3-4.3.

3-3.3 Textile fabrics and interlinings utilized in wildland fire fighting protective garments shall be individually tested for thermal shrinkage resistance and shall not shrink more than 10 percent in any direction when tested as specified in 3-4.4.

3-3.4 Textile fabrics used for protective clothing or protective garment composites in wildland fire fighting shall have a total heat loss of not less than or equal to 450 W/m^2 when tested in accordance with 3-4.5.

3-3.5* Outer textile fabric used for protective clothing shall be tested for tear resistance and shall have a tear resistance of not less than 5 lb (2.27 kg) when tested in accordance with 3-4.6.

3-3.6 The outer textile fabrics used for protective clothing shall be individually tested for cleaning shrinkage resistance and shall not shrink more than 5 percent in any direction after 5 wash cycles when tested as specified in 3-4.7.

3-3.7 All seams shall demonstrate a sewn seam strength equal to or greater than that stipulated for each seam type listed below when tested in accordance with 3-4.8.

(a) Major "A" seams shall have a minimum seam breaking strength of 70 lb (315 N), either fabric or thread.

(b) Major "B" seams shall have a minimum seam breaking strength of 50 lb (225 N), either fabric or thread.

3-3.8 All thread used in protective garments shall be tested for heat resistance and shall not ignite, melt, or char when tested in accordance with 3-4.9.

3-3.9 Textile fabrics, interlinings, and other materials used in wildland fire fighting uniform construction — including but not limited to padding, reinforcement, wristlets, collars, garment labels, hanger hooks, buttons, fasteners, and closures, but excluding hook and pile fasteners and trim where not in direct contact with the skin — shall be individually tested for heat resistance in their original form and shall not melt, drip, separate, or ignite when tested as specified in 3-4.4.

3-4 Testing Requirements.

3-4.1 Preconditioning.

3-4.1.1 Samples to be tested shall be preconditioned in accordance with Section 4, "Atmospheric Conditions for Testing," of Federal Test Method Standard 191A, *Textile Test Methods*, at a temperature of 70°F, ±2°F (21°C, ±1°C) and a relative humidity of 65 percent, ±5 percent. Samples shall be tested not more than 5 minutes after removal from preconditioning.

3-4.2 Radiant Protective Performance Test.

3-4.2.1 Specimens shall be tested both before and after being subjected to 5 cycles of washing and drying as specified in 3-4.10.

3-4.2.2 All specimens to be tested shall be preconditioned by placement in a circulating air oven for not less than 4 hours at 120°F, ±5°F (49°C, ±2°C) and then conditioned as specified in 3-4.1. Specimens shall be tested not more than 5 minutes after removal from conditioning.

3-4.2.3 Radiant protective performance (RPP) shall be performed in accordance with paragraphs 4.5.1.2 and 4.5.1.4 of MIL-C-24941, *Cloth, Laminated, Aluminized (para-aramid/PBI base)* and in accordance with ASTM D 4108, *Standard Test Method for Thermal Protective Performance of Materials for Clothing; Open Flame Method*, with the following modifications:

3-4.2.3.1 The test specimen shall be 3 in. × 10 in. (7.6 cm × 25.4 cm), with the long dimension in the warp or wale direction, and shall not be conditioned on the oscillating drum abrasion apparatus.

3-4.2.3.2 Apparatus shall consist of a vertical oriented radiant heat source, specimen holder assembly, protective shutter, sensor assembly, and recorder. The sensor block shall consist of a 5¼ in. × 5¼ in. × ½ in. (133.3 mm × 133.3 mm × 12.8 mm) heat-resistant material that fits without binding into a bracket on the rear plate of the specimen holder. The sensor shall be in accordance with paragraph 6.5, the recorder shall be in accordance with paragraph 6.6, and the chart overlay shall be in accordance with all paragraphs of ASTM D 4108, *Standard Test Method for Thermal Protective Performance of Materials for Clothing; Open Flame Method.*

3-4.2.3.3 The vertically oriented radiant heat source shall be in accordance with Figure 3-4.2, and shall consist of a bank of five 500-watt, infrared, tubular, translucent quartz lamps having a 5-in. (12.7-cm) lighted length and a mean overall length of 8 13/16 in. (22.4 cm). The lamps shall be mounted so that the lamps' surfaces are approximately 0.015 in. (0.381 mm) apart. The bank or array shall be mounted and centered behind a 2¼ in. × 5½ in. (5.7 cm × 14.0 cm) cut-out on ½-in. (1.3-cm) transite board. A specimen holder and holder plate with a 2½ in. × 6 in. (6.5 cm × 15.2 cm) center cutout shall be positioned so that the distance from the nearest lamp surface to the test specimen is exactly 1 in. (2.5 cm). The holder plate, as shown in Figure 3-4.2, shall include a bracket to hold the copper calorimeter sensor assembly and shall cover the complete cut-out section. The quartz lamps shall be heated electrically and the power input controlled by means of a variac having a capacity of at least 25 amperes. A voltmeter, accurate to ±1 volt, shall be installed on the load circuit to indicate operating or load voltage to the lamps.

3-4.2.3.4 A protective shutter, as shown in Figure 3-4.2, Detail D, shall be placed between the radiant heat source and the specimen. The protective shutter shall be capable of completely reflecting radiant heat load during the period before specimen exposure.

3-4.2.3.5 The sensor face shall be wiped immediately after each run, while hot, to remove any decomposition products that condense and could be a source of error. If a deposit collects and appears to be thicker than a thin layer of paint, or is irregular, the sensor surface shall be reconditioned. The cooled sensor shall be carefully cleaned with cleaning solution, making certain there is no ignition source nearby. If bare copper is showing, the surface shall be repainted with a thin layer of flat black spray paint. At least 1 calibration run shall be conducted before using the repainted sensor in a test run. The sensor shall be recali-

1	Cast aluminum apparatus body
2	Toggle switch-DPST
3	Transite-smooth surfaces
4	5 quartz lamps-500T3 115-125V
5	Screw-10-24 3/4"
6	Legs for horizontal test position
7	Tapped 10-24
8	1/2" D imbedded magnet
	center screw fastening
9	Holder– 20-gauge cold rolled steel
10	Bolt– 3/16" D 1/2" brazed flush
11	Test sample
12	Holder plate – 20-gauge cold rolled steel
13	Drilled holes – 3/8" D

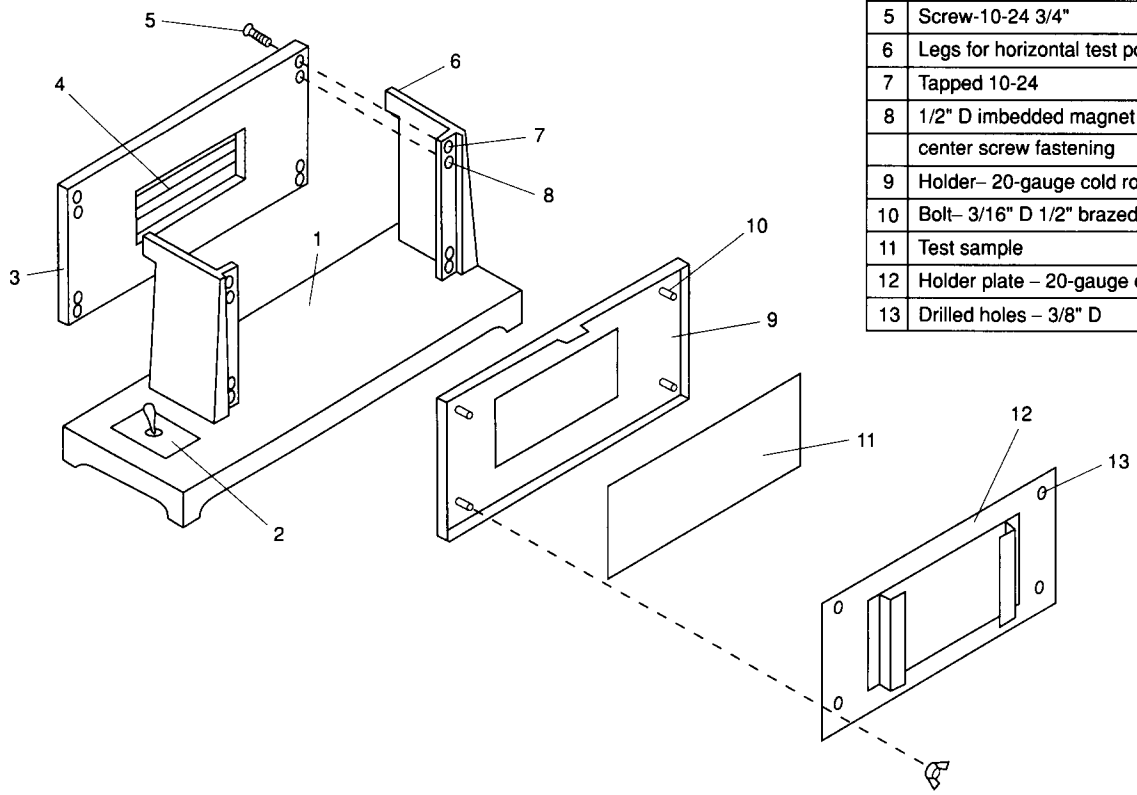


Figure 3-4.2.

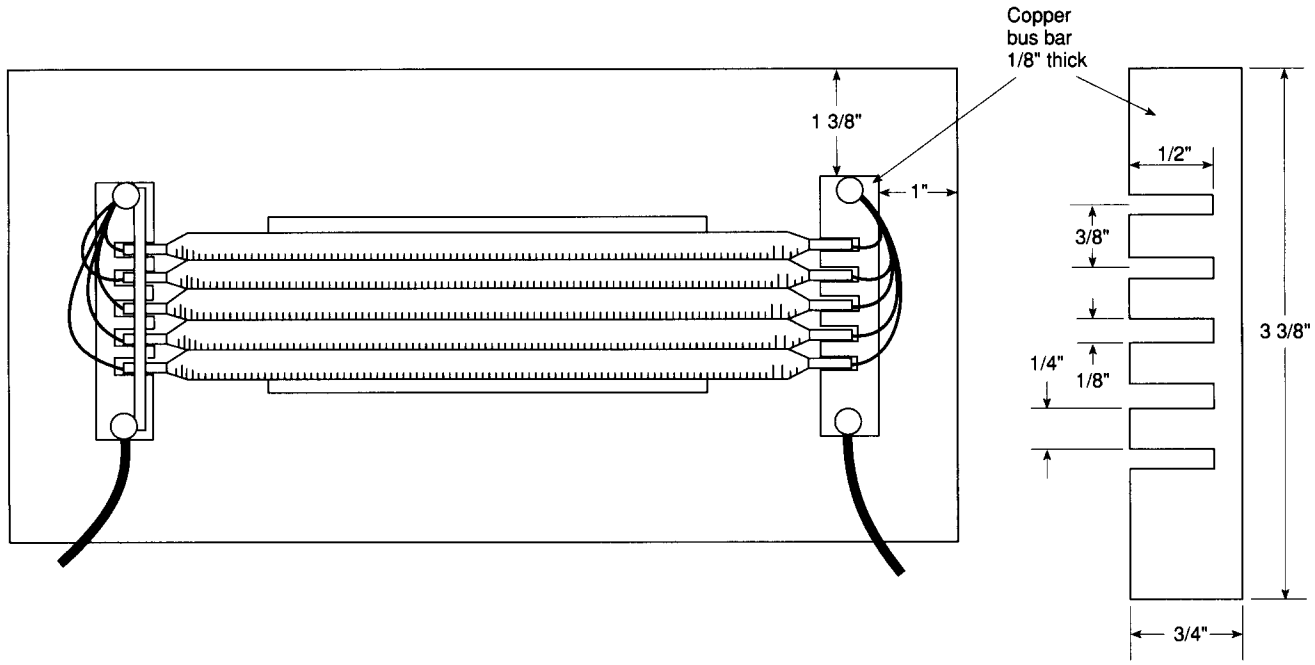


Figure 3-4.2 Detail A Position of quartz lamps on transite.

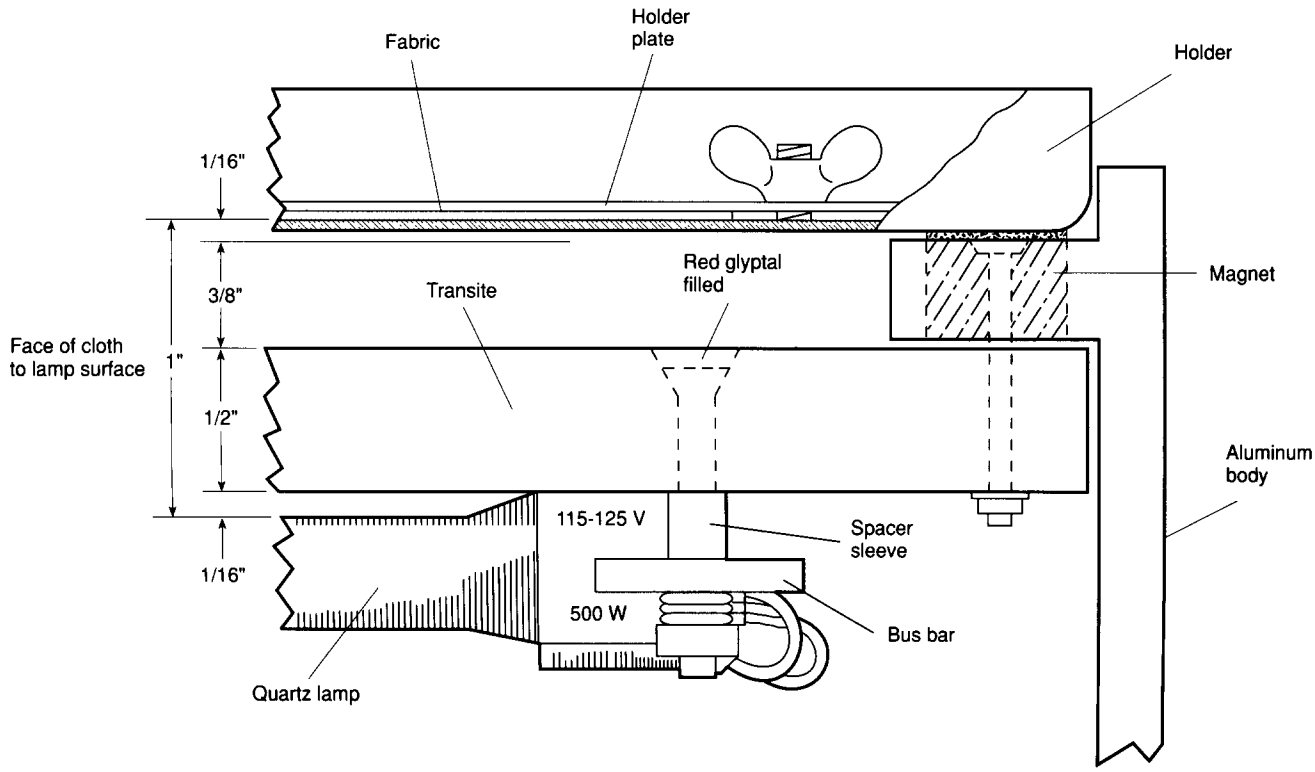


Figure 3-4.2 Detail B Sample position top view enlargement.

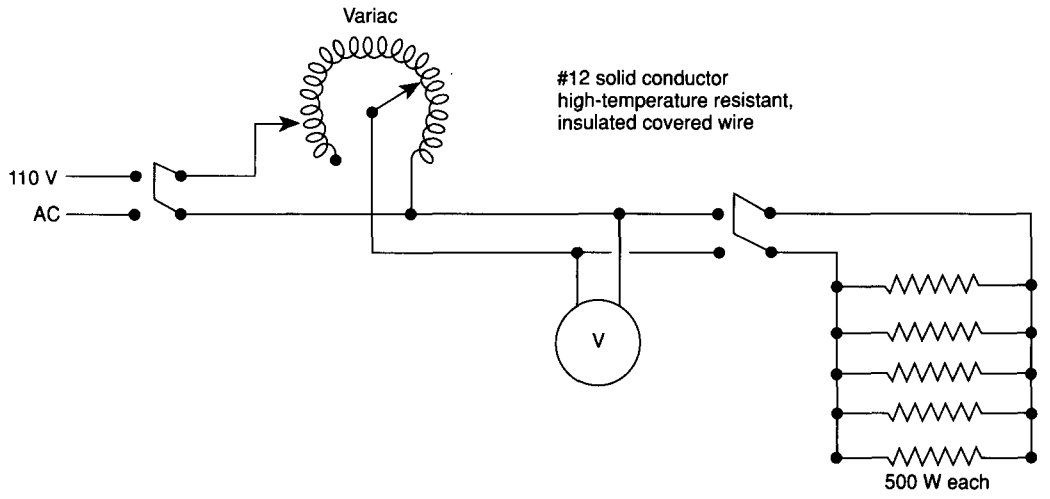


Figure 3-4.2 Detail C Schematic of electrical circuit.

brated after every sample run of 5 specimens. The sensor shall always approximate body temperature by contact with the hand prior to placing on the apparatus.

3-4.2.3.6 Specimens shall be exposed to a thermal flux of 0.5 cal/cm^2/sec, $\pm$0.1 cal/cm^2, as measured with a copper calorimeter. The copper calorimeter shall be the only heat sensor used in setting the 0.5 cal/cm^2/sec exposure condition. The total heat flux shall be calculated directly from the temperature response of the copper calorimeter constants. Other heat-sensing devices shall not be used to reference or adjust the heat flux read by the copper calorimeter. The 0.5 cal/cm^2/sec exposure shall be determined directly and only from the voltage output of the thermocouple, 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.

3-4.2.3.7 The specimen shall then be placed in the specimen holder so that the specimen is centered in the opening of the specimen holder. The sensor assembly shall be placed in contact with the back of the specimen holder, and then both shall be placed in front of the heat source so that the distance from the specimen to the nearest edge of the lamp surface is exactly 1 in. (2.5 cm). A hand- or mechanically-operated shutter device shall be placed between the specimen holder containing the test specimen and the lamps to completely block the heat from reaching the specimen when lamps are first turned on. The lamps shall be turned on for a 60-second warm-up period. With the lamps still turned on, the shutter shall be removed from the front of the test specimen, and the recorder started. The specimen shall be exposed to the heat for a minimum of 25 seconds, and then the current shall be turned off.

3-4.2.3.8 The radiant value shall be determined from the graph produced by the recorder chart of the sensor response and the overlay, prepared as specified in 3-4.2.3.1. The overlay shall be positioned on the recorder chart, matching the zero of the overlay with the start of the exposure. The horizontal axis shall be placed in line with the initial trace of the pen. While keeping the overlay square with the recorder chart, the time in seconds shall be read from the overlay chart where the sensor response curve and the overlay curve intersect. The time in seconds shall be used to calculate the radiant protective performance (RPP) value for the test specimen using the basic formula defined in paragraphs 11-1.2 and 11-1.3 of ASTM D 4108, *Standard Test Method for Thermal Protective Performance of Materials for Clothing; Open Flame Method.*

3-4.2.3.9 Five specimens shall be run, and the radiant value determined. If the individual test results vary more than -0/+5 percent from the average result, the result shall be discarded and another set of specimens shall be tested.

3-4.2.3.10 The individual test results of each specimen shall be reported. The average value of the 5 specimens shall be calculated and reported to determine pass/fail.

3-4.3 Flame Resistance Test.

3-4.3.1 For textile fabrics specified to be laundered, flame resistance testing shall be conducted both before and after 50 cycles of washing and drying, as specified in 3-4.10.

3-4.3.1.1* For textile fabrics that are specified as sensitive to high-phosphate AATCC 124 detergent, and so specified, a substitute test detergent shall be permitted to be used for the washings.

3-4.3.2 For textile fabrics specified to be dry-cleaned, the flame resistance testing shall be conducted both before and after 25 cycles of commercial dry-cleaning.

3-4.3.3 Samples to be tested shall be preconditioned as specified in 3-4.1.

3-4.3.4 Flame resistance tests shall be conducted in accordance with Method 5903.1, "Flame Resistance of Cloth; Vertical," of Federal Test Method Standard 191A, *Textile Test Methods.*

3-4.4 Thermal Shrinkage and Heat Resistance Test.

3-4.4.1 Testing shall be conducted on 3 component specimens. Fabric specimens shall be tested separately.

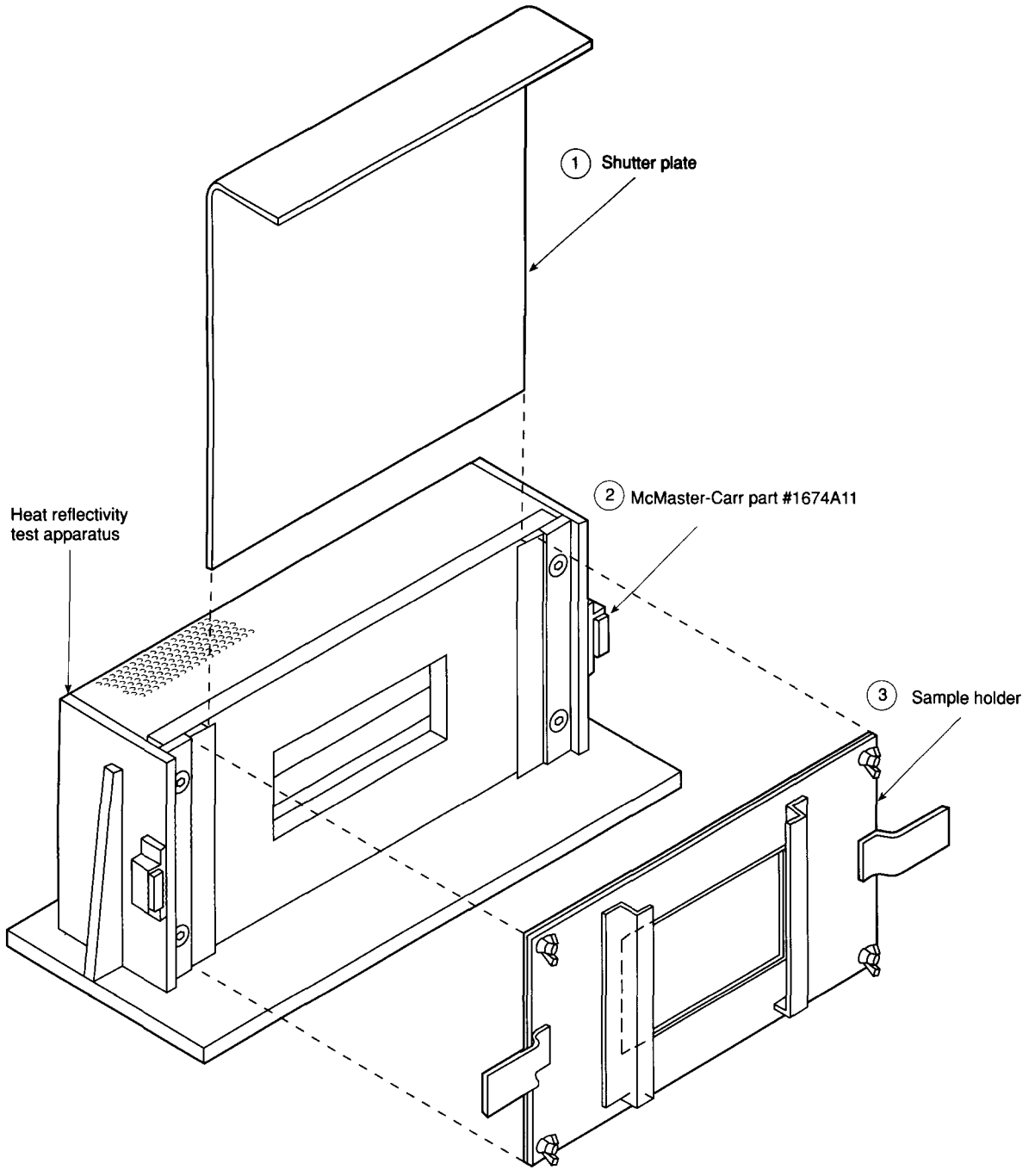


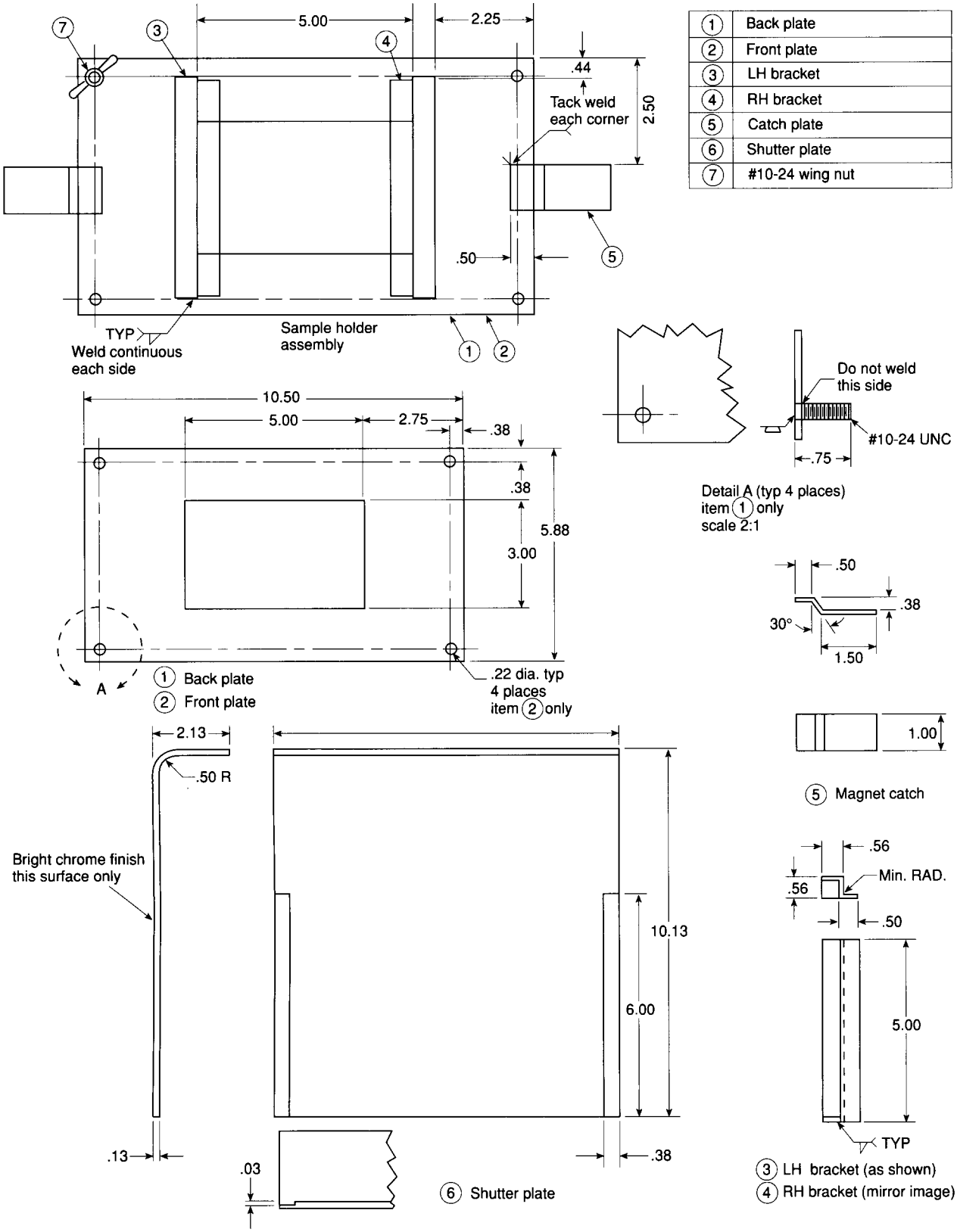
Figure 3-4.2 Detail D.

3-4.4.2 Specimen length shall be 6 in. (152.4 mm). Where the length of textile specimens is less than 6 in. (152.4 mm), the sample shall be required to be the same length as the fabric utilized in the garment. Specimen width shall be 6 in. (152.4 mm). Where the width of textile specimens is less than 6 in. (152.4 mm), the sample shall be required to be the same width as the fabric utilized in the garment. For the purpose of testing, labels and buttons shall be sewn to a support fabric in the manner in which they appear in the constructed garment.

3-4.4.3 Fabric specimens shall be tested both before and after being subjected to 5 cycles of laundering as specified in 3-4.10.

3-4.4.4 All specimens to be tested shall be preconditioned as specified in 3-4.1.

3-4.4.5 The test oven shall be a horizontal flow circulating oven with minimum interior dimensions of 24 in. × 24 in. × 24 in. (61 cm × 61 cm × 61 cm). The test oven shall have an airflow rate of 125 to 250 linear ft/min (38 m to 76 m)



(1)	Back plate
(2)	Front plate
(3)	LH bracket
(4)	RH bracket
(5)	Catch plate
(6)	Shutter plate
(7)	#10-24 wing nut

Figure 3-4.2 Detail E.

at the standard temperature and pressure of 70°F (21°C) at 1 atmosphere (21°C at 1 atmosphere), measured at the center point of the oven. A test thermocouple shall be positioned so that it is level with the horizontal centerline of a mounted sample or sample specimen. The thermocouple shall be equidistant between the vertical centerline of a mounted sample or sample specimen placed in the middle of the oven and the oven wall where the airflow enters the test chamber. The thermocouple shall be an exposed bead, Type J or K 30 AWG thermocouple. The test oven shall be heated and the test thermocouple stabilized at 500°F, +10°/-0°F (260°C, +6°/-0°C) for a minimum of 30 minutes.

3-4.4.6 The fabric specimen shall be suspended by metal clips at the top and centered in the oven so that the entire specimen is not less than 2 in. (5.08 mm) from any other oven surface or other specimen, and airflow is parallel to the plane of the material.

3-4.4.7 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. (5.08 mm) from any oven surface or other specimen and are exposed to circulating air.

3-4.4.8 Specimens, mounted as specified, shall be placed in a circulating oven for not less than 5 minutes at 500°F, ±10°F (260°C, ±2°C). Specimen exposure time shall begin when oven has recovered to an air temperature of 500°F, +10°/-0°F (260°C, +6°/-0°C).

3-4.4.9 Fabric specimens shall be measured to determine thermal shrinkage as specified in 3-3.3 to determine pass/fail. Fabric specimens and garment components shall be examined for compliance with 3-3.9 to determine pass/fail.

3-4.5 Total Heat Loss Test.

3-4.5.1 Test specimens of all textile fabrics shall be tested as specified in this section using the test equipment specified in ASTM D 1518, *Standard Test Method for Thermal Transmittance of Textile Materials*.

3-4.5.2* The test plate and guard ring shall have a wettable surface.

3-4.5.3 The test plate shall have a temperature of 95°F, ±1°F (35°C, ±0.5°C). The guard ring and bottom plate shall be controlled to eliminate lateral and downward heat loss from the test plate.

3-4.5.4 The local environment shall be 77°F, ±1°F (25°C, ±0.5°C) and 65 percent, ±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 airstream, uninfluenced by the boundary of the test plate. Apparatus used to measure temperature shall be accurate to within ±0.5°F (±0.25°C). Apparatus used to measure humidity shall be accurate to within ±4 percent RH.

3-4.5.5 The average bare plate thermal resistance, including the air layer and any apparatus contribution (Rcbp), shall be the average of at least 3 measurements with nothing mounted on the test plate.

3-4.5.6 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.

3-4.5.7 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 (W)

3-4.5.8 Data shall be collected when equilibrium is reached. Data shall be collected every 5 minutes. Equilibrium shall be the rate of change of less than 3 percent per hour of calculated thermal resistance over a period not less than 30 minutes. The standard deviation of the calculated thermal resistance shall be less than 1 percent.

3-4.5.9 A sample shall include at least 3 individual specimens.

3-4.5.10 The specimen shall be mounted on the test plate in the same orientation as the finished garment from the skin surface, or plate surface, to the outside.

3-4.5.11* 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/yd² Nomex duck shall be linear for the bare plate value for 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 the 4 layers of 7.5 oz/yd² Nomex duck shall be 0.082°C/m²/W, ±10 percent.

3-4.5.12 The average intrinsic thermal resistance of the specimens shall be determined by averaging all values, shall average a minimum of 6, obtained over the equilibrium period. The average intrinsic thermal resistance of the sample shall be determined by averaging the values for all specimens. If the individual results for any 3 specimens vary more than ±10 percent from the average of the 3, the test shall be repeated on that specimen(s). If the retest produces a value(s) within the ±10 percent limit, the new value(s) shall be used. If the retest value remains outside the ±10 percent limit, 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 shall identify this sample as having a high variability.

3-4.5.13 Water shall be fed to the test plate and guard ring so that water uniformly wets the test plate and guard ring surface.

3-4.5.14* 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. The permeability index of the bare plate shall be calculated from the following equation:

$$i_m = 0.061 \times Rcbp/Rebp$$

where:

i_m = Permeability index
Rcbp = Average bare plate thermal resistance, without liquid barrier (°C/m²/W)
Rebp = Average bare plate evaporative resistance, with liquid barrier (kPa/m²/W)

3-4.5.15 The average bare plate evaporative resistance, including the air layer, the liquid barrier, and any apparatus contribution (Rebp), shall be the average of at least 3 measurements with only the liquid barrier mounted on the plate. The local environment climate shall be permitted to be increased to above 80°F (25°C), if necessary, to maintain test plate temperature at 95°F (35°C).

3-4.5.16 The apparent total evaporative resistance (ARet) of the specimen shall be calculated from the following equation:

$$ARet = \frac{(Ps - Pa)A}{H - \frac{(Ts - Ta)A}{Rct}}$$

where:

ARet = Apparent total evaporative resistance of the specimen and surface air layer (kPa/m²/W)
Ps = Water vapor pressure at the plate surface (kPa)
Pa = Water vapor pressure in the local environment (kPa)
A = Area of the test plate (m²)
H = Power input (W)
Ts = Temperature at the plate surface (°C)
Ta = Temperature at the local environment (°C)
Rct = Total thermal resistance of the specimen and surface air layer (°C/m²/W)

3-4.5.17 Data shall be collected when equilibrium is reached. Data shall be collected every 5 minutes. Equilibrium shall be a rate of change of less than 3 percent per hour of calculated apparent evaporative resistance over a period not less than 30 minutes. The standard deviation of the calculated apparent evaporative resistance shall be less than 1 percent. If data collection cannot be completed within 4 hours after mounting the specimen on the test plate, the specimen shall be removed from the test plate and allowed to dry at least 24 hours at 60° to 80°F (16° to 25°C) before retesting. Subsequent data reporting shall state that drying was required. If the retest of the specimen still cannot meet these constraints, then it shall be reported that the specimen cannot be tested by this method.

3-4.5.18 The average apparent intrinsic evaporative resistance of the sample alone (ARef) shall be the apparent total evaporative resistance (ARet) minus the average bare plate evaporative resistance (Rebp).

3-4.5.19 The apparatus shall be calibrated to meet the following constraints:

(a) A graph of apparent total evaporative resistance versus number of layers of 7.5 oz/yd² Nomex duck shall be linear for the bare plate value of one, two, three, and four layers.

(b) The slope of the linear regression shall be 0.005 kPa/m²/W.

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

(d) The apparent intrinsic evaporative resistance of 4 layers of 7.5 oz/yd² Nomex duck shall be 0.020 kPa/m²/W, ±10 percent.

3-4.5.20 The apparent intrinsic evaporative resistance of the specimen shall be determined by averaging all values, but shall average a minimum of 6, obtained over the equilibrium period. The average apparent intrinsic evaporative resistance of the sample shall be determined by averaging the values for all specimens. If the individual results for any 3 specimens vary more than ±10 percent from the average of the 3, the test shall be repeated on that specimen. If the retest produces a value(s) within the ±10 percent limit, an additional 3 specimens shall be tested, and all original and retest results shall be reported along with the average and standard deviation for the apparent intrinsic evaporative resistance; and a statement shall identify this sample as having a high variability.

3-4.5.21 The average total heat loss of the sample shall be determined and reported, subject to the reporting requirements in 3-4.5.12, 3-4.5.17 and 3-4.5.20. The total heat loss of the sample shall be calculated from the following equation:

$$Q_t^* = \frac{10°C}{Rcf + 0.04} + \frac{3.57\ kPa}{ARef + 0.0035}$$

where:

Q_t = Total heat loss (W/m²)
Rcf = Average intrinsic thermal resistance of the sample as determined in 3-4.5.6 (°C/m²/W)
ARef = Average apparent intrinsic evaporative resistance of the sample as determined in 3-4.5.18 (kPa/m²/W)

3-4.6 Tear Resistance Test.

3-4.6.1 Sample specimens shall be preconditioned as specified in 3-4.1.

3-4.6.2 Sample specimens of the textile fabrics shall be tested in accordance with ASTM D 1424, *Standard Test Method for the Tear Resistance of Woven Fabrics by Falling Pendulum (Elmendorf) Apparatus.*

3-4.7 Shrinkage Resistance Test.

3-4.7.1 Sample specimens shall be preconditioned as specified in 3-4.1.

3-4.7.2 Sample specimens to be tested shall be subjected to the procedure specified in 3-4.10.

3-4.7.3 Knit fabric sample specimens shall be measured for laundry shrinkage in accordance with AATCC 160, *Dimensional Restoration of Knitted and Woven Fabrics After Laundering.*

* These values are appropriate for a surface air layer at an air temperature of 80°F (25°C), a relative humidity of 65 percent, a skin temperature of 95°F (35°C), and a nominal effective air velocity of 6.5 ft/sec (2 m/s).

3-4.7.4 Specimens shall be measured to determine pass/fail.

3-4.8 Seam Strength Test.

3-4.8.1 Sample specimens shall be preconditioned as specified in 3-4.1.

3-4.8.2 Test specimens of all sewn seams of woven fabric utilized in the garment construction shall be tested in accordance with ASTM D 1683, *Standard Test Method for Failure in Sewn Seams of Woven Fabric.*

3-4.8.3 Test specimens of all sewn seams of knit fabric utilized in the garment construction shall be tested in accordance with ASTM D 3940, *Standard Test Method for Failure in Sewn Seams of Knit Fabric.*

3-4.9 Thread Heat Resistance Test.

3-4.9.1 Sample specimens shall be preconditioned as specified in 3-4.1.

3-4.9.2 All thread used in the construction of the garments 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.*

3-4.10 Laundering.

3-4.10.1 Textile fabrics specified to be laundered shall be laundered and dried for testing in accordance with the procedures specified in Machine Cycle 3, Wash Temperature II, and Drying Procedure B of AATCC Test Method 135, *Dimensional Changes in Automatic Home Laundering of Woven and Knit Fabrics.*

Chapter 4 Protective Shelters

4-1 Design Requirements.

4-1.1* The fire shelter shall conform to USDA Forest Service Specification 5100-320F, *Shelter, Fire.* Protective fire shelter product labels shall meet the requirements of Section 4-2.

4-2 Product Label Requirements.

4-2.1 Protective fire shelters shall have product labels located on the shelter flap as specified and inside the clear polyvinyl shelter package so that the label can be read without opening the polyvinyl shelter package. The product label shall contain at least the following warnings and information printed in letters at least 1/16 in. (1.6 mm) in height:

"THIS WILDLAND FIRE SERVICE PROTECTIVE FIRE SHELTER MEETS THE REQUIREMENTS OF NFPA 1977, *STANDARD ON PROTECTIVE CLOTHING AND EQUIPMENT FOR WILDLAND FIRE FIGHTING*, 1993 EDITION.

WARNING

THIS FIRE SHELTER IS INTENDED FOR EMERGENCY USE DURING WILDLAND FIRE FIGHTING OPERATIONS ONLY. USERS MUST READ THE INSTRUCTIONS PROVIDED WITH THIS SHELTER. USERS MUST BE TRAINED IN FIRE SHELTER DEPLOYMENT AND OPERATION. FIRE SHELTER CARRYING CASES OR POCKETS SHOULD COMPLETELY ENCLOSE AND FIT SNUGLY AROUND THE CARRYING CASE LINER IN WHICH THE FIRE SHELTER IS ENCLOSED. THE CASE OR POCKET MUST BE EASILY REACHED SO A FIRE FIGHTER CAN EXTRACT THE FIRE SHELTER WHILE ON THE RUN. THE PREFERRED METHOD FOR CARRYING A FIRE SHELTER IS IN A CASE FASTENED TO A BELT WORN AROUND THE WAIST. FAILURE TO COMPLY WITH THIS WARNING MAY RESULT IN SERIOUS INJURY OR DEATH."

Manufacturer's name
Manufacturing lot number
Country of manufacture
Country of origin of materials
Date of manufacture
Authorizing mark of certification organization
Date of certification

"DO NOT REMOVE THIS LABEL."

4-2.2 No product label shall be attached to the outside reflective surface of the fire shelter.

4-2.3 All portions of the required fire shelter label shall be printed at least in English.

4-3 Carrying Case and Liner.

4-3.1* The fire shelter shall be enclosed in a carrying case liner. The fire shelter carrying case liner shall conform to USDA Forest Service Specification 5100-00323A, *Liner, Fire Shelter, Carrying Case.*

4-3.2* The fire shelter, enclosed in a carrying case liner, shall be enclosed in a carrying case. The carrying case shall conform to USDA Forest Service Specification 5100-322B, *Case, Carrying, Fire Shelter.*

Chapter 5 Protective Footwear

5-1 Design Requirements.

5-1.1 Configuration.

5-1.1.1* Protective footwear shall consist of a sole with heel, upper, insole, and shank. The quarter section of the boot shall be designed to provide an adjustable, snug fit for support around the ankle and lower leg.

5-1.1.2* Protective footwear height shall be a minimum of 8.0 in. (20.3 cm). The height shall be determined by measuring inside the boot from the center of the heel back at the insole level up to the top line at the center back. Removable insole inserts shall be removed prior to measurement.

5-1.1.3 Heel breast shall not be less than 0.5 in. (12.7 mm). Heel breasting angle shall not be less than 90 degrees nor more than 135 degrees relative to the sole and as shown in Figure 5-1.1.

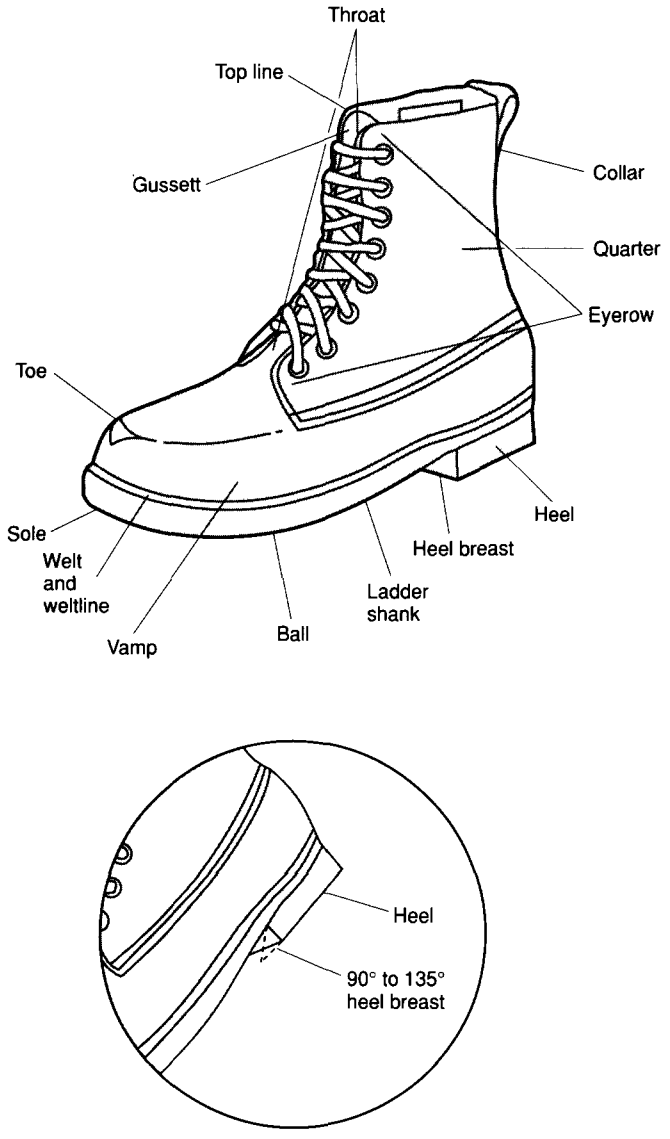


Figure 5-1.1 Footwear terms.

5-1.2 Sizing.

5-1.2.1* Protective footwear shall be available in all of the following sizes:

Men: 5-13, including half sizes, and a minimum of 2 widths.

Women: 5-10, including half sizes, and a minimum of 2 widths.

5-1.2.2 Manufacturers shall be required to establish and provide, upon request, a size conversion chart for each model or style of protective footwear based on toe length, arch length, and foot width as measured on the Brannock Foot Measuring Device.

5-1.3 Construction.

5-1.3.1 Metal parts shall not penetrate from the outside into the inside at any point, unless covered.

5-1.3.2 Where used, there shall be a minimum of 4 metal stud hooks on each side of the eyerow and they shall meet the requirements of 5-3.2 and 5-3.8.

5-1.3.3 Eyelets shall be constructed of coated steel, solid brass, brass-coated nickel, or nickel.

5-2 Product Labeling Requirements.

5-2.1 Protective footwear shall have a product label or labels permanently and conspicuously attached to each boot, upon which at least the following warnings and information are printed in letters at least $^{3}/_{64}$ in. (1.2 mm) in height:

"THIS WILDLAND FIRE FIGHTING PROTECTIVE FOOTWEAR MEETS THE REQUIREMENTS OF NFPA 1977, *STANDARD ON PROTECTIVE CLOTHING AND EQUIPMENT FOR WILDLAND FIRE FIGHTING*, 1993 EDITION.

WARNING

DO NOT USE PROTECTIVE FOOTWEAR ALONE FOR WILDLAND FIRE FIGHTING OPERATIONS; OTHER PROTECTIVE EQUIPMENT — HELMET, GLOVES, PROTECTIVE GARMENTS, FIRE SHELTER — IS REQUIRED FOR PROTECTION. THIS FOOTWEAR ALONE MAY NOT PROVIDE PROTECTION FOR PROXIMITY OR FIRE ENTRY SITUATIONS, OR FOR PROTECTION FROM CHEMICAL, RADIOLOGICAL, OR BIOLOGICAL AGENTS. USERS MUST CLEAN, MAINTAIN, AND ALTER ONLY IN ACCORDANCE WITH MANUFACTURER'S INSTRUCTIONS. NO PROTECTIVE FOOTWEAR 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 lot number
Country of manufacture
Model or stock number
Size and width
Authorized mark of certification organization
Date of certification

"DO NOT REMOVE THIS LABEL."

5-2.2 All portions of the required protective footwear product label(s) shall be printed at least in English.

5-2.3 All product labels shall be permanently affixed to all protective footwear.

5-2.4 Product labels shall remain legible and shall not be torn or otherwise damaged when tested in accordance with 5-4.7, Product Label Permanency.

5-3 Performance Requirements.

5-3.1 Footwear shall be tested in accordance with 5-4.2, Heat Resistance. No part of footwear, other than laces, shall melt, and all accessories shall remain functional.

5-3.2 Metal parts of protective footwear shall be examined for corrosion resistance after testing in accordance

with 5-4.8, Corrosion Resistance Test. 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 metals. Accessories shall remain functional.

5-3.3 The protective footwear upper shall not be cut through the full thickness of the test specimen at any point when tested in accordance with 5-4.3, Upper Cut Resistance.

5-3.4 Protective footwear upper shall be tested for upper puncture resistance and shall not puncture under an average applied force of 13.2 lb (6 kg) when tested in accordance with ASTM F 1342, *Standard Test Method for Resistance of Protective Clothing Materials to Puncture.*

5-3.5 The protective footwear sole and heel, with the exception of caulked boots, shall have an abrasion resistance rating of not less than 100 NBS Index when tested in accordance with FIA Test Method 301, *NBS Abrasion.*

5-3.6 Protective footwear inside sole surface shall not exceed 111°F (44°C) when tested in accordance with 5-4.5, Conductive Heat Resistance.

5-3.7 Protective footwear outsole shall be tested for 150,000 flexes, except caulked boots shall not exceed 350 percent cut growth, and shall be tested in accordance with FIA Test Method 308, *Ross Flex Endurance of Soling Materials, Modified ASTM Procedure.*

5-3.8 Stud hooks shall have a minimum detachment strength of 66 lbf (30 kgf) when tested in accordance with 5-4.6, Eyelet and Stud Post Attachment.

5-4 Testing Requirements.

5-4.1 Preconditioning.

5-4.1.1 Unless otherwise indicated, samples shall be prepared as specified in referenced or included test methods.

5-4.1.2 Where indicated, samples shall be preconditioned in accordance with Section 4, "Atmospheric Conditions for Testing," of Federal Test Method Standard 191A, *Textile Test Methods.* Testing shall begin not more than 5.0 minutes after removal from preconditioning.

5-4.2 Heat Resistance Test.

5-4.2.1 The protective footwear sample specimen to be tested shall be men's size 9, half pair.

5-4.2.2 Sample specimens shall be tested after preconditioning in accordance with 5-4.1.2.

5-4.2.3 Sample specimens shall be filled with dry vermiculite. Any closures shall be fastened.

5-4.2.4 The test oven shall be a horizontal flow circulating oven with minimum interior dimensions of 24 × 24 × 24 in. (61 × 61 × 61 cm). The test oven shall have an air flow rate of 125 to 250 linear feet (38 to 76 m) per minute, at a standard temperature and pressure of 70°F at 1 atmosphere (21°C at 1 atmosphere), measured at the center point of the oven. The test thermocouple shall be positioned so that it is level with the horizontal centerline of the sample specimen. The thermocouple shall be equidistant between the vertical centerline of the sample specimen placed in the middle of the oven and the oven wall where the air flow enters the test chamber. The thermocouple shall be an exposed bead type J or K 30 AWG thermocouple. The oven shall be heated and the test thermocouple temperature stabilized at 500°F, +10/–0°F (260°C, +6/–0°C) for a minimum of 30 minutes.

5-4.2.5 The sample specimen shall be placed in the center of the test oven with the centerline of the front of the sample specimen facing the air flow. The oven door shall not remain open for more than 15 seconds. The air circulation shall be shut off while the door is open and turned on when the door is closed. The test temperature shall be 500°F, +10/–0°F (260°C, +6/–0°C). Sample specimen exposure shall begin when the test thermocouple reading recovers to 500°F (260°C). Total recovery time shall not exceed 30 seconds. Thermocouple reading shall remain at 500°F, +10/–0°F (260°C, +6/–0°C) for the duration of the test.

5-4.2.6 After an exposure time of 5 minutes, +15/–0 seconds, the sample specimen shall be removed from the oven and allowed to cool at room temperature for not less than two minutes. The sample specimen shall then be examined on the outside and inside for melting to determine pass/fail, and all accessories shall be evaluated for function to determine pass/fail.

5-4.3 Upper Cut Resistance Test.

5-4.3.1 Protective footwear shall be tested after preconditioning in accordance with 5-4.1.2.

5-4.3.2 Apparatus shall consist of an L-shaped metal frame and a pivoted arm that lowers a sharp-edged blade onto a specimen, as shown in Figure 5-4.3.2.

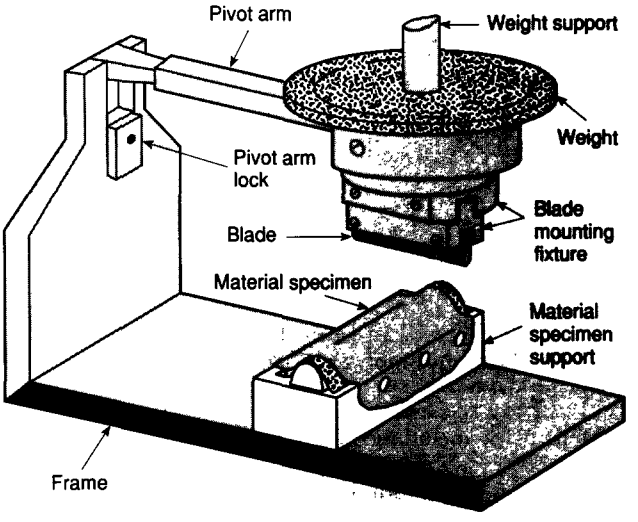


Figure 5-4.3.2 Static cut test apparatus.

5-4.3.3 A locking mechanism shall be mounted on the L-frame upright to engage the pivoted arm and secure it in a neutral position above the material specimen. The locking mechanism shall be used when the blade is being replaced or when the specimen is being moved into or out of the testing position.

5-4.3.4 The blade shall be mounted in a blade holder at the outer end of the pivoted arm, as shown in Figure

5-4.3.4(a). The blade shall be mounted so its sharp edge is tangential to the material specimen. The pivoted arm, blade holder, and blade shall be weighted together to a total of 16.0 lb (7.6 kg). The sharp-edged blade shall be made of hardened tool steel with an edge having a 60-degree included angle and a 0.001-in. (0.025-mm) radius as shown in Figure 5-4.3.4(b). The blade shall measure 1 in. (length) × 1 in. (height) × 1/32 in. (thickness) [(2.5 cm) × (2.5 cm) × (0.8 mm)].

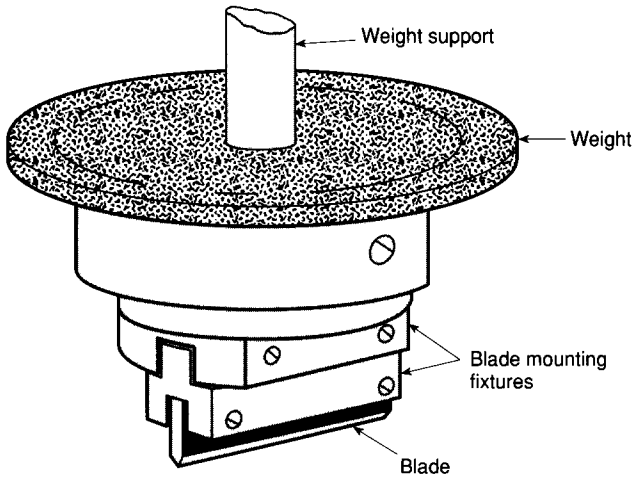


Figure 5-4.3.4(a) Test blade holder.

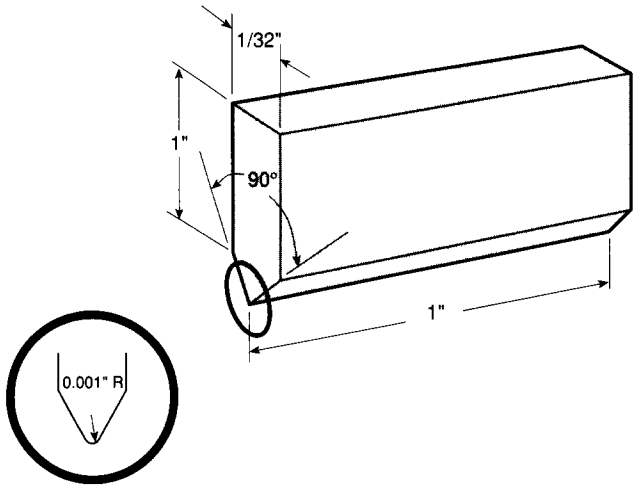


Figure 5-4.3.4(b) Test blade.

5-4.3.5 The specimen support assembly shall consist of a 2.0 in. × 2.0 in. × 4.0 in. (5.1 cm × 5.1 cm × 10.2 cm) soft wood block and a 0.75-in. (1.9-cm) diameter, half-rounded, soft wood rod mounted to the block as shown in Figure 5-4.3.5. A 0.05-in. (0.13-cm) thick soft leather strip shall be draped over the rod and block as shown in Figure 5-4.3.5.

5-4.3.6* The sharpness or geometry of the blade edge shall be closely monitored and controlled to prevent changes in cutting characteristics in order to ensure a consistent baseline for interpreting the cut data. A test blade shall be either replaced or resharpened when the sharpness or geometry of the blade edge changes.

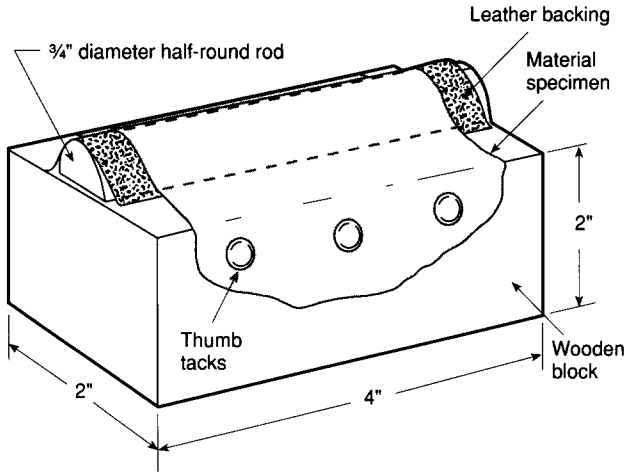


Figure 5-4.3.5 Material specimen support.

5-4.3.7 Specimens shall be taken from vamp and quarter. If different types of thicknesses of materials are utilized for other areas of the upper, excluding gusset, these areas shall also be tested. Specimens shall be 2.0 in. × 4.0 in. (5.1 × 10.2 cm).

5-4.3.8 The specimen shall be oriented so that the normal outer surface is the first to be contacted by the edge of the blade. The material specimen shall be draped over the leather strip covering the rod and block and tacked tightly in place, but not stretched, as shown in Figure 5-4.3.5. The support assembly shall be positioned on the base of the L-frame, as shown in Figure 5-4.3.2. The blade shall be inserted in the holder and the pivoted arm lowered to bring the blade edge into contact with the specimen surface.

5-4.3.9 The specimen-edge contact shall be made 0.125 in. (0.3 cm) from the leading end of the blade. The specimen support assembly shall be drawn smoothly under the weighted blade at a rate of 20.0 in./min (50 cm/min) parallel to the blade edge.

5-4.3.10 The support assembly shall be stopped when the specimen edge contact is 0.125 in. (0.3 cm) from the trailing end of the blade. The pivoted arm shall be lifted to remove the blade edge from the specimen and the locking mechanism engaged to secure the pivoted arm.

5-4.3.11 The sample specimen shall be visually inspected to determine if it was cut completely through at any point by the blade edge. Care shall be taken in inspecting the sample surface for cuts. Grooving can occur, but this shall not constitute a cut.

5-4.3.12 The samples shall be inspected to determine pass/fail.

5-4.4 Upper Puncture Resistance Test.

5-4.4.1 Protective footwear shall be tested after preconditioning in accordance with 5-4.1.2.

5-4.4.2 The apparatus shall consist of a tensile testing machine, such as an Instron or equivalent, that challenges a specimen with a pointed penetrometer. Force shall be detected by a compression cell and shall be indicated by a recorder able to indicate the load at specimen puncture

±1 percent. A penetrometer having the size and dimensions shown in Figure 5-4.4.2(a) shall be mounted on the test apparatus and attached to the compression cell of the machine as shown in Figure 5-4.4.2(b). The specimen support assembly shall consist of 2 flat metal plates that clamp together so the specimen is held tightly between, as shown in Figure 5-4.4.2(c). Each plate shall have three 0.25-in. (0.6-cm) diameter holes as shown in Figure 5-4.4.2(d). The specimen support plates shall be connected to a metal support ring that mounts on the movable arm of the test apparatus, as shown in Figure 5-4.4.2(b).

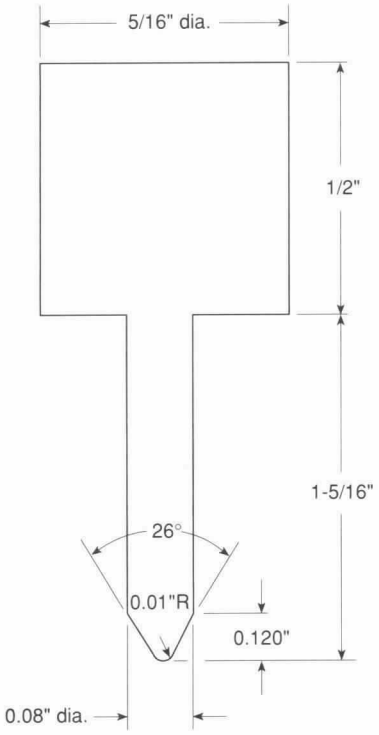


Figure 5-4.4.2(a) Cross section of 4d penetrometer.

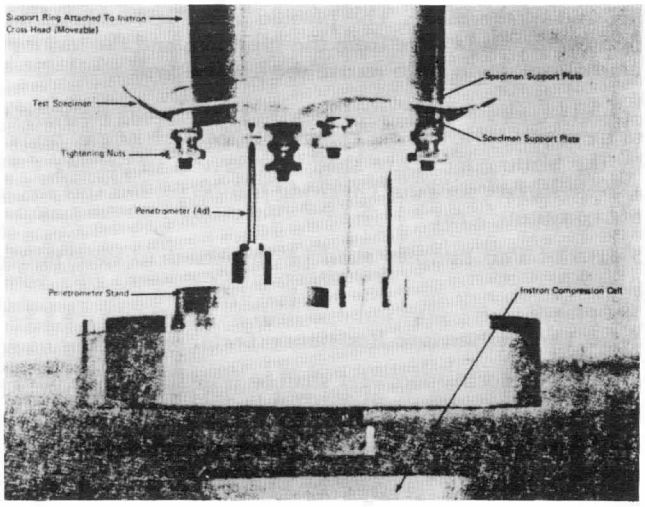


Figure 5-4.4.2(b) Static puncture test apparatus.

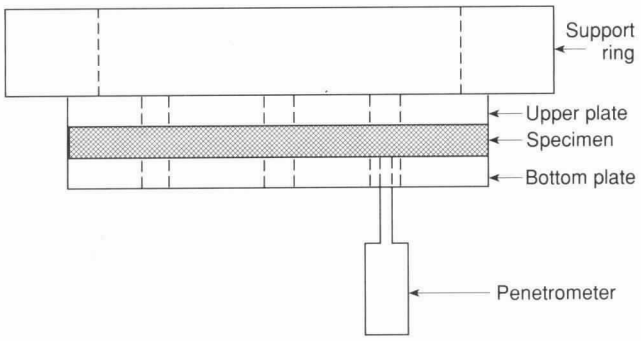


Figure 5-4.4.2(c) Side view of specimen support assembly.

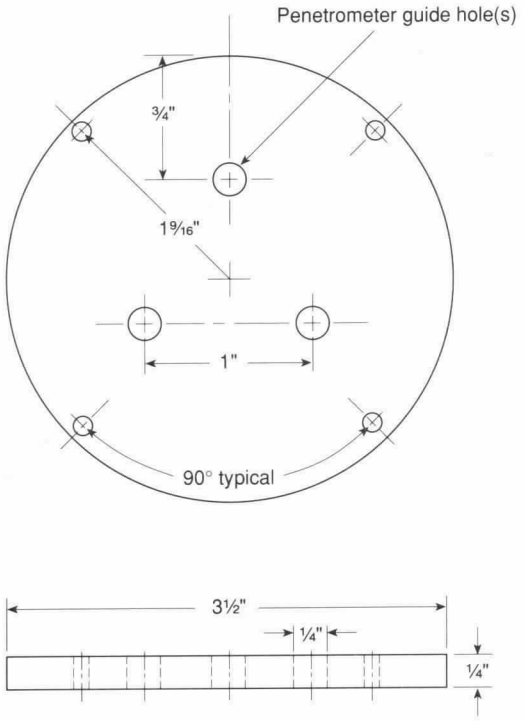


Figure 5-4.4.2(d) Support plate (two required).

5-4.4.3 Specimens shall be taken from the vamp and quarter. If different types or thickness of materials are utilized for other areas of the upper, excluding gusset, these areas shall also be tested. Specimens shall be at least 3.5 in. (8.9 cm) in diameter.

5-4.4.4 Specimens shall be mounted in the support assembly shown in Figure 5-4.4.2(c). The specimen shall be oriented so that the normal outer surface is the first to be contacted by the penetrometer. The support assembly shall be attached to the movable arm of the test apparatus. The penetrometer shall be positioned on the compression cell of the test apparatus as shown in Figure 5-4.4.2(b). The apparatus shall be operated with a uniform velocity of 20.0 in./min (50.0 cm/min) until the penetrometer has been driven through the specimen. The penetrometer shall be repositioned under each of the other guide holes and the test repeated until 3 punctures have been made.

5-4.4.5 The average penetration force for each specimen shall be calculated to determine pass/fail.

5-4.5 Conductive Heat Resistance Test.

5-4.5.1 The apparatus shall consist of a thermocouple connected to a meter and a 1 in. × 6 in. × 18 in. (2.5 cm × 15.2 cm × 45 cm) iron plate.

5-4.5.2 Testing shall be performed after preconditioning in accordance with 5-4.1.2.

5-4.5.3 The thermocouple shall be affixed to the insole wearing surface directly below the ball area of the foot. The plate shall be heated to a uniform temperature of 932°F (500°C). The sample shall be placed on the plate in the upright position for 30.0 seconds.

5-4.5.4 The thermocouple temperature shall be recorded at 30 seconds of exposure to determine pass/fail.

5-4.6 Eyelet and Stud Post Attachment Test.

5-4.6.1 The eyelets or stud post specimens shall be tested after preconditioning in accordance with 5-4.1.2.

5-4.6.2 A tensile testing machine shall be used with a traverse rate of 2 in./min (5.1 cm/min). Clamps measuring 1 in. × 1.5 in. (2.5 cm × 3.8 cm) shall have gripping surfaces parallel, flat, and capable of preventing slippage of the specimen during the test.

5-4.6.3 Specimens shall be removed from the footwear and shall be 1.0 in. × 2.0 in. (2.54 cm × 5.08 cm).

5-4.6.4 The stud post or eyelet puller shall be inserted or attached to the upper position of the tensile machine. The traverse rate shall be set at 2.0 in./min (5 cm/min). The test eyelet or stud post shall be attached using the appropriate puller fixture. The eyelet stay shall be clamped, but clamping the metal portion of the eyelets or stud hook in the lower clamps shall be avoided. The distance between the clamps and stud hooks or eyelets shall be $1/16$ in. to $1/8$ in. (1.6 mm to 3.2 mm). The test shall be started.

5-4.6.5 The force will reach a peak, decline slightly, then increase to complete failure; however, the value at which the force first declines shall be recorded and reported as initial failure point, as this is the separation point of the material around the eyelet or stud post. The force recorded shall be used to determine pass/fail.

5-4.7 Product Label Permanency Test.

5-4.7.1 Specimens shall be tested in accordance with ASTM D 4966, *Standard Test Method for Abrasion Resistance of Textile Fabrics*.

5-4.7.2 Four specimens shall be cut from the label samples. Two specimens shall be tested dry and two specimens shall be tested wet. One dry and one wet test specimen shall include the edge of the label.

5-4.7.3 Two specimens shall be subjected to 160 dry abrasion revolutions (10 cycles) and two specimens shall be subjected to 80 wet abrasion revolutions (5 cycles). One dry and one wet sample specimen shall be edge specimens.

5-4.7.4 Tested specimens shall then be examined visually with the unaided eye to determine pass/fail.

5-4.8 Corrosion Resistance Test.

5-4.8.1 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, +30/–0 min.

5-4.8.2 Immediately following the test exposure and prior to examination, specimens shall be rinsed under warm, running tap water and dried with compressed air.

5-4.8.3 Specimens shall then be examined visually with the unaided eye to determine pass/fail.

Chapter 6 Protective Gloves

6-1 Design Requirements.

6-1.1 Configuration.

6-1.1.1 Protective gloves for wildland fire fighters shall be designed to minimize the effects of flame, heat, sharp or abrasive objects, hand tool operation, and other hazards that are encountered during wildland fire fighting.

6-1.1.2 Gloves shall be designed to minimally interfere with physical movement in the use of wildland fire fighting tools, packs, fire shelters, and other equipment.

6-1.1.3 Glove bodies shall be designed such that they closely conform to the wrist or are adjustable at the wrist and shall extend a minimum of 1.0 in. (2.54 cm) past the wrist crease. The location of the wrist crease shall be as shown in Figure 6-1.1.3.

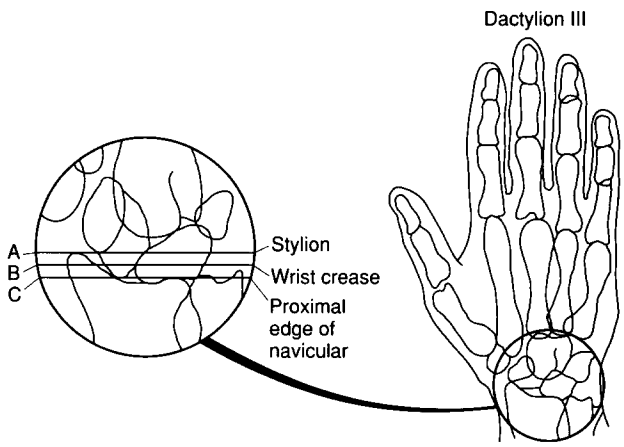


Figure 6-1.1.3 Anatomical landmarks at base of hand.

6-1.2 Sizing.

6-1.2.1 Hand dimensions for selection of proper glove size shall consist of taking 2 dimensions as shown in Figure 6-1.2.1:

(a) Hand circumference

(b) Length of the hand.

6-1.2.1.1 Hand circumference shall be measured by placing the measuring tape on a table or other flat surface with the numerals facing downward. The subject shall place the right hand, palm down and fingers together, in the middle of the tape so that the tape can pass straight across the knuckles (metacarpal). The circumference shall be measured to the nearest eighth of an inch (3.2 mm), as shown in Figure 6-1.2.1.

6-1.2.1.2 Finger circumference shall be measured at the proximal interphalangeal joint (first knuckle). Finger length shall be measured from the tip of the finger to the base of the finger crease on the palm side.

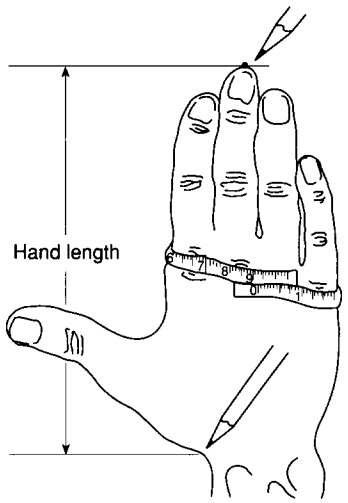


Figure 6-1.2.1 Method of taking hand dimensions for selection of proper glove.

6-1.2.1.3 Hand length shall be measured by placing the subject's hand, palm down, on a piece of paper, with the fingers together and the hand and arm in a straight line. The thumb shall be fully abducted, extended away from the palm as far as possible. The paper shall be marked at the tip of the third or middle finger. The pencil shall be placed in the notch at the base of the thumb where the thumb joins the wrist and the paper shall be marked. The straight line distance between the 2 points shall be measured to the nearest eighth of an inch (3.2 mm), as shown in Figure 6-1.2.1.

6-1.2.2 In order to label or otherwise indicate that a glove complies with the requirements of this standard, the manufacturer shall provide gloves in not less than 5 separate and distinct sizes. The manufacturer shall provide the purchaser with the hand dimension ranges specified in 6-1.2.3.

6-1.2.3 The glove size indicated on the product label shall be determined as follows:

Sizing for Extra-Small (XS) Glove (centimeters)

	CM	IN.
THE RANGE FOR HAND LENGTH:	16.25 - 17.25	(6.40 - 6.79)
THE RANGE FOR HAND CIRCUMFERENCE:	16.25 - 20.25	(6.40 - 7.97)

	Mid-Size Value		Range to Be Accommodated	
	cm	(in.)	cm	(in.)
Digit 1 Circumference	6.17	(2.43)	5.60 - 6.74	(2.20 - 2.65)
Digit 2 Circumference	6.06	(2.39)	5.50 - 6.63	(2.17 - 2.61)
Digit 3 Circumference	6.08	(2.39)	5.53 - 6.63	(2.18 - 2.61)
Digit 4 Circumference	5.69	(2.24)	5.12 - 6.26	(2.02 - 2.46)
Digit 5 Circumference	5.00	(1.97)	4.48 - 5.52	(1.76 - 2.17)
Digit 1 Length	4.94	(1.94)	4.36 - 5.52	(1.72 - 2.17)
Digit 2 Length	6.44	(2.54)	5.75 - 7.12	(2.26 - 2.80)
Digit 3 Length	7.29	(2.87)	6.71 - 7.87	(2.64 - 3.10)
Digit 4 Length	6.78	(2.67)	6.13 - 7.42	(2.41 - 2.92)
Digit 5 Length	5.09	(2.00)	4.52 - 5.66	(1.78 - 2.23)
Hand Circumference	18.25	(7.19)	16.34 - 20.16	(6.43 - 7.94)
Hand Length	16.75	(6.59)	16.27 - 17.23	(6.41 - 6.78)

Sizing for Small (S) Glove (centimeters)

	CM	IN.
THE RANGE FOR HAND LENGTH:	17.25 - 18.25	(6.79 - 7.19)
THE RANGE FOR HAND CIRCUMFERENCE:	17.25 - 21.25	(6.79 - 8.37)

	Mid-Size Value		Range to Be Accommodated	
	cm	(in.)	cm	(in.)
Digit 1 Circumference	6.40	(2.52)	5.82 - 6.97	(2.29 - 2.74)
Digit 2 Circumference	6.29	(2.48)	5.73 - 6.85	(2.26 - 2.70)
Digit 3 Circumference	6.31	(2.48)	5.76 - 6.87	(2.27 - 2.70)
Digit 4 Circumference	5.92	(2.33)	5.35 - 6.49	(2.11 - 2.56)
Digit 5 Circumference	5.22	(2.06)	4.70 - 5.74	(1.85 - 2.26)
Digit 1 Length	5.31	(2.09)	4.74 - 5.89	(1.87 - 2.32)
Digit 2 Length	6.89	(2.71)	6.21 - 7.57	(2.44 - 2.98)
Digit 3 Length	7.71	(3.04)	6.55 - 7.83	(2.58 - 3.08)
Digit 4 Length	7.19	(2.83)	4.87 - 6.01	(1.92 - 2.37)
Digit 5 Length	5.44	(2.14)	4.87 - 6.01	(1.92 - 2.37)
Hand Circumference	19.25	(7.58)	17.34 - 21.16	(6.83 - 8.33)
Hand Length	17.75	(6.99)	17.27 - 18.23	(6.80 - 7.18)

Sizing for Medium (M) Glove (centimeters)

	CM	IN.
THE RANGE FOR HAND LENGTH:	18.25 - 19.25	(7.19 - 7.58)
THE RANGE FOR HAND CIRCUMFERENCE:	18.25 - 22.25	(7.19 - 8.76)

	Mid-Size Value		Range to Be Accommodated	
	cm	(in.)	cm	(in.)
Digit 1 Circumference	7.01	(2.76)	6.36 - 7.65	(2.50 - 3.01)
Digit 2 Circumference	6.82	(2.69)	6.31 - 7.32	(2.48 - 2.88)
Digit 3 Circumference	6.83	(2.69)	6.26 - 7.40	(2.46 - 2.91)
Digit 4 Circumference	6.34	(2.50)	5.78 - 6.90	(2.28 - 2.72)
Digit 5 Circumference	5.63	(2.22)	5.09 - 6.17	(2.00 - 2.43)
Digit 1 Length	5.63	(2.22)	5.00 - 6.26	(1.97 - 2.46)
Digit 2 Length	7.11	(2.80)	6.50 - 7.72	(2.56 - 3.04)
Digit 3 Length	8.07	(3.18)	7.55 - 8.58	(2.97 - 3.38)
Digit 4 Length	7.61	(3.00)	7.14 - 8.08	(2.81 - 3.18)
Digit 5 Length	5.78	(2.28)	5.16 - 6.41	(2.03 - 2.52)
Hand Circumference	20.25	(7.97)	18.34 - 22.16	(7.22 - 8.72)
Hand Length	18.75	(7.38)	18.27 - 19.23	(7.19 - 7.57)

Sizing for Large (L) Glove (centimeters)

			CM	IN.
THE RANGE FOR HAND LENGTH:			19.25 - 20.25	(7.58 - 7.97)
THE RANGE FOR HAND CIRCUMFERENCE:			19.25 - 23.25	(7.58 - 9.15)
	Mid-Size Value		Range to Be Accommodated	
	cm	(in.)	cm	(in.)
Digit 1 Circumference	7.26	(2.86)	6.62 - 7.91	(2.61 - 3.11)
Digit 2 Circumference	7.03	(2.77)	6.53 - 7.54	(2.57 - 2.97)
Digit 3 Circumference	7.10	(2.80)	6.53 - 7.66	(2.57 - 3.02)
Digit 4 Circumference	6.60	(2.60)	6.04 - 7.16	(2.38 - 2.82)
Digit 5 Circumference	5.85	(2.30)	5.31 - 6.39	(2.09 - 2.52)
Digit 1 Length	5.87	(2.31)	5.24 - 6.50	(2.06 - 2.56)
Digit 2 Length	7.49	(2.95)	6.88 - 8.10	(2.71 - 3.19)
Digit 3 Length	8.54	(3.36)	8.03 - 9.06	(3.16 - 3.57)
Digit 4 Length	8.03	(3.16)	7.56 - 8.50	(2.98 - 3.35)
Digit 5 Length	6.13	(2.41)	5.51 - 6.75	(2.17 - 2.66)
Hand Circumference	21.25	(8.37)	19.34 - 23.16	(7.61 - 9.12)
Hand Length	19.75	(7.78)	19.27 - 20.23	(7.59 - 7.96)

Sizing for Extra-Large (XL) Glove (centimeters)

			CM	IN.
THE RANGE FOR HAND LENGTH:			20.25 - 21.25	(7.97 - 8.37)
THE RANGE FOR HAND CIRCUMFERENCE:			20.25 - 24.25	(7.97 - 9.55)
	Mid-Size Value		Range to Be Accommodated	
	cm	(in.)	cm	(in.)
Digit 1 Circumference	7.52	(2.96)	6.87 - 8.16	(2.70 - 3.21)
Digit 2 Circumference	7.25	(2.85)	6.74 - 7.76	(2.65 - 3.06)
Digit 3 Circumference	7.36	(2.90)	6.79 - 7.93	(2.67 - 3.12)
Digit 4 Circumference	6.86	(2.70)	6.30 - 7.42	(2.48 - 2.92)
Digit 5 Circumference	6.06	(2.39)	5.52 - 6.60	(2.17 - 2.60)
Digit 1 Length	6.11	(2.41)	5.48 - 6.75	(2.16 - 2.66)
Digit 2 Length	7.86	(3.09)	7.26 - 8.47	(2.86 - 3.33)
Digit 3 Length	8.44	(3.32)	8.51 - 9.54	(3.35 - 3.76)
Digit 4 Length	6.48	(2.55)	7.97 - 8.91	(3.14 - 3.51)
Digit 5 Length	6.48	(2.55)	5.85 - 7.10	(2.30 - 2.80)
Hand Circumference	22.25	(8.76)	20.34 - 24.16	(8.01 - 9.51)
Hand Length	20.75	(8.17)	20.27 - 21.23	(7.98 - 8.36)

6-2 Product Labeling Requirements.

6-2.1* Protective gloves shall have one or more product labels permanently attached inside each glove upon which at least the following warnings and information are printed in letters at least $^3/_{64}$ in. (1.2 mm) in height.

"THIS WILDLAND FIRE FIGHTING GLOVE MEETS THE REQUIREMENTS OF NFPA 1977, *STANDARD ON PROTECTIVE CLOTHING AND EQUIPMENT FOR WILDLAND FIRE FIGHTING*, 1993 EDITION.

WARNING

DO NOT USE THIS GLOVE ALONE FOR WILDLAND FIRE FIGHTING OPERATIONS; OTHER PROTECTIVE EQUIPMENT—HELMET, FOOTWEAR, PROTECTIVE GARMENTS, FIRE SHELTER—IS REQUIRED FOR PROTECTION. THIS GLOVE ALONE MAY NOT PROVIDE PROTECTION FOR PROXIMITY OR FIRE ENTRY SITUATIONS, OR FOR PROTECTION FROM CHEMICAL, RADIOLOGICAL, OR BIOLOGICAL AGENTS. USERS MUST CLEAN, MAINTAIN, AND ALTER ONLY IN ACCORDANCE WITH MANUFACTURER'S INSTRUCTIONS. NO GLOVE 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."

Name or designation of manufacturer
Model, name, number, or design
Lot or serial number
Country of manufacture
Date of manufacture (uncoded)
Date of certification tests
Authorized mark of certifying organization
Size

"DO NOT REMOVE THIS LABEL."

6-2.2 All product labels shall be clearly legible to the eye before and after 5 cycles of washing and drying in accordance with the procedures specified in Section 5, 1, III, B, of AATCC 135, *Dimensional Changes in Automatic Home Laundering of Woven and Knit Fabrics*. Product labels not meeting specimen size requirements for the procedure listed above shall be sewn to a support fabric of the required size.

6-3 Performance Requirements.

6-3.1 Sample gloves shall be tested for heat resistance in accordance with 6-4.2 and shall not separate, melt, ignite or drip. The glove shall be measured in both length and width and shall not shrink more than 10 percent in either direction. The glove length shall be measured from the tip of the middle finger to the bottom of the glove body, and the width shall be measured from side to side. If the glove is made with a wristlet of a different material, the wristlet shall be measured separately.

6-3.2 Sample specimens shall be tested for flame resistance in accordance with 6-4.3 and shall not melt or drip, shall not have any afterflame of more than 2.0 seconds, and shall not have any char length in excess of 4.0 in. (10.16 cm).

6-3.3 Sample gloves shall be tested for conductive heat resistance in accordance with 6-4.4, and shall have a second-degree burn time of not less than 7 seconds, and the pain time shall not be less than 4 seconds.

6-3.4 Sample specimens shall be tested for thermal protective performance (TPP) in accordance with 6-4.5, and shall have an average TPP of not less than 20.

6-3.5 Sample specimens shall be tested for cut resistance in accordance with 6-4.6. Materials used for the outer surfaces of the glove shall not be cut through under an applied force of 18 lb (8.2 kg).

6-3.6 Sample specimens shall be tested for puncture resistance in accordance with 6-4.7. Glove palm, palm side of the fingers, and glove back shall not puncture under an average applied force of 10 lb (4.6 kg).

6-3.7 Sample gloves shall be tested for dexterity in accordance with 6-4.8. Dexterity test timing shall not exceed 140 percent of baseline time.

6-3.8 Sample gloves shall be tested for grip in accordance with 6-4.9. The weight-pulling capacity shall not be less than 80 percent of the bare hand control values where gloves are conditioned in accordance with 6-4.1.

6-4 Testing Requirements.

6-4.1 Preconditioning.

6-4.1.1 Sample gloves and specimens shall be preconditioned at a temperature of 70°F, ±5°F (21°C, ±3°C) and at a relative humidity of 65 percent, ±5 percent, for at least 24 hours. Sample gloves and specimens shall be tested within 5 minutes after removal from preconditioning.

6-4.2 Heat Resistance Testing.

6-4.2.1 Sample gloves, including label, shall be preconditioned as specified in 6-4.1. Sample gloves and sample specimens shall then be placed in a circulating air oven for not less than 4 hours at 120°F, +5°/-0°F (49°C, +2°/-0°C).

6-4.2.2 The test oven shall be a horizontal flow circulating oven with minimum interior dimensions of 24 in. × 24 in. × 24 in. (61 cm × 61 cm × 61 cm). The test oven shall have an airflow rate of 125 to 250 linear ft/min (38 m to 76 m) at the standard temperature and pressure of 70°F (21°C) at 1 atmosphere, measured at the center point of the oven. A test thermocouple shall be positioned so that it is level with the horizontal centerline of a mounted sample glove or sample specimen. The thermocouple shall be equidistant between the vertical centerline of a mounted sample glove or sample specimen placed in the middle of the oven and the oven wall where the airflow enters the test chamber. The thermocouple shall be an exposed bead, Type J or K No. 30 AWG thermocouple. The test oven shall be heated and the test thermocouple stabilized at 400°F, +10°/-0°F (204°C, +6°/-0°C) for a minimum of 30 minutes.

6-4.2.2.1 When testing sample gloves, the glove opening shall be clamped together and the sample glove shall be suspended by the clamp in the oven so that the entire glove is not less than 2 in. (5.1 cm) from any oven surface, or another sample glove, and the airflow is parallel to the plane of the material.

6-4.2.2.2 When testing sample specimens, the specimen shall consist of the innermost surface of the glove composite measuring 4 in. × 4 in. (10.2 cm × 10.2 cm). The sample specimen shall be suspended by metal hooks at the top and centered in the oven so that the entire sample specimen is not less than 2 in. (5.1 cm) from any oven surface, or other sample specimen, and the airflow is parallel to the plane of the material.

6-4.2.3 The oven door shall not remain open more than 15 seconds. The air circulation shall be shut off while the door is open and turned on when the door is closed. The total recovery time shall not exceed 30 seconds. The thermocouple reading shall remain at 400°F, +10°/-0°F (204°C, +6°/-0°C) for the duration of the test.

6-4.2.4 The sample glove or sample specimen, mounted as specified, shall be exposed in the test oven for 5 minutes, +15/-0 seconds. The test exposure time shall begin when the test thermocouple recovers to 400°F, +10°/-0°F (204°C, +6°/-0°C).

6-4.2.5 After the specified exposure, the sample glove or sample specimen shall be removed and shall be examined and measured to determine pass/fail.

6-4.2.5.1 The sample glove shall also be measured to determine pass/fail. The length of the sample glove shall be measured from the tip of the middle finger to the end of the glove body on the palm side. The width of the sample glove shall be the width measurement on the palm side 1 in. (2.5 cm) below the base of the fingers.

6-4.3 Flame Resistance Testing.

6-4.3.1 Sample specimens shall be preconditioned as specified in 6-4.1.

6-4.3.2 Each sample specimen to be tested shall be a rectangle at least 2 in. (5.1 cm) wide by 4 in. (10.2 cm) long.

6-4.3.3 Sample specimens shall consist of each single layer or the composite used in actual glove construction, including wristlets, with all layers arranged in proper order. In each test the specimen's normal outer surface shall be exposed to the flame.

6-4.3.4 Three sample specimens shall be tested for each material.

6-4.3.5 If a proposed glove construction has stitched-through seams, three additional sample specimens containing these seams shall be tested. The seam shall be in the direction of the 6-in. (15.2-cm) dimension.

6-4.3.6 The flame resistance test apparatus shall consist of a cabinet fabricated in accordance with the requirements of Figure 5903A, Section 4.1, "Test Method Flame Resistance of Cloth; Vertical," of Federal Test Method Standard 191A, *Textile Test Methods*, and Figure 6-4.3.6.

6-4.3.7 The cabinet shall enclose a high-temperature, petroleum-type Fisher burner, as specified in Section 4.1, Test Method 5905, "Flame Resistance of Material; High Heat Flux Flame Contact," of Federal Test Method Standard 191A, *Textile Test Methods*.

6-4.3.8 A pilot flame shall be used to ignite the burner flame. A tube to position the pilot flame adjacent to the burner edge shall be provided as shown in Figure 6-4.3.6. The tube shall have a diameter of approximately 1/16 in. (1.6 mm) and shall be spaced 1/8 in. (3.2 mm) from the burner edge. The pilot flame shall be 1/8 in. (3.2 mm) in height.

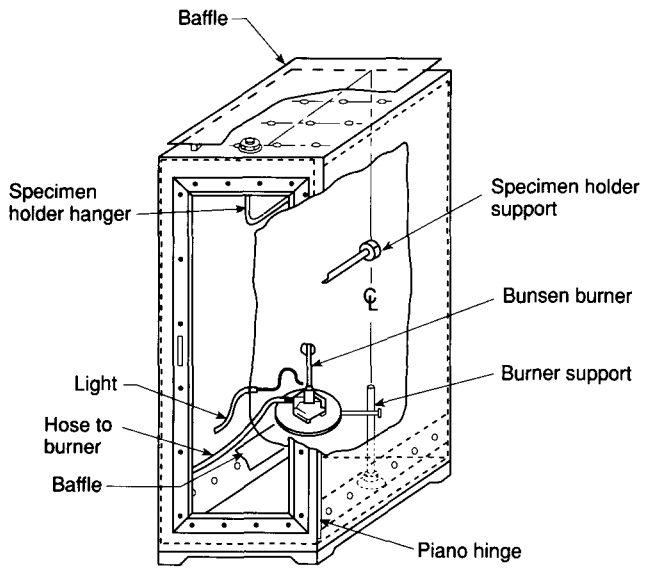


Figure 6-4.3.6 Vertical flame resistance textile apparatus.

6-4.3.9 The fuel gas connection and associated plumbing shall be as specified in Section 4.7, Test Method 5905, Flame Resistance of Material; High Heat Flux Flame Contact, of Federal Test Method Standard 191A, *Textile Test Methods*. A control valve system with a delivery rate designed to furnish butane gas to the burner under a pressure of 2.5 psi ± 0.25 psi (175 g/cm^2 ± 17.5 g/cm^2) at the reducing valve shall be used. The flame height shall be adjusted at the reducing valve, producing a pressure at the burner of 0.1 psi (45 g/cm^2).

6-4.3.10 A free-standing flame height indicator shall be used to assist in adjusting the burner flame height. The indicator shall mark a flame height of 1½ in. (3.8 cm) above the top of the burner, as shown in Figure 6-4.3.6.

6-4.3.11 The specimen support assembly shall consist of a frame and steel rod of 1/16 in. (1.6 mm) diameter to support the specimen in an L-shaped position as shown in Figure 6-4.3.11.

6-4.3.11.1 The horizontal portion of the specimen shall be not less than 2 in. (5.1 cm), and the vertical portion shall be not less than 4 in. (10.2 cm). The specimen shall be held at each end by spring clips under light tension as shown in Figure 6-4.3.11.

6-4.3.12 The burner shall be fixed so that the center of the barrel is ¾ in. (1.9 cm) below the center of the specimen as shown in Figure 6-4.3.11.

6-4.3.13 Laboratory gas for Fisher burners shall be butane gas C.P. as specified in Section 4.6, Test Method 5905, "Flame Resistance of Material; High Heat Flux Flame Contact," of Federal Test Method Standard 191A, *Textile Test Methods*.

6-4.3.14 A stopwatch or other timing device shall be used to measure the testing time to the nearest 0.2 second.

6-4.3.15 A ruled-scale graduated in 1/8 in. (3.2 mm) increments shall be provided to measure char.

6-4.3.16 A balance graduated in 0.1 g (0.04 oz) increments shall be used to determine the weight of each specimen before and after testing.

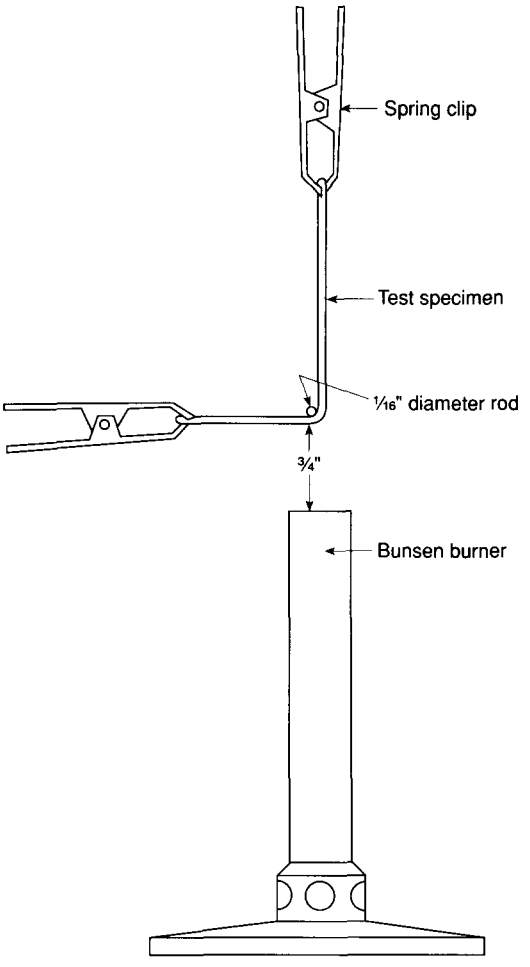


Figure 6-4.3.11 Relationship of test material to Bunsen burner.

6-4.3.17 Each conditioned specimen shall be weighed to the nearest 0.1 g (0.04 oz).

6-4.3.18 Before the first sample specimen is tested, the test flame shall be adjusted to a height of approximately 1½ in. (3.8 cm) with the gas on/off valve fully open and the air supply completely and permanently off, as it is important that the flame height be closely controlled. The 1½-in. (3.8-cm) height shall be obtained by adjusting the orifice in the bottom of the burner so that the top of the flame is level with the marked flame height indicator. The burner gas supply shall then be shut off.

6-4.3.19 With the burner off, the first sample specimen to be tested shall be mounted in the support assembly as shown in Figure 6-4.3.11. The cabinet door shall then be closed and shall remain closed during testing.

6-4.3.20 The burner gas supply shall be turned on, igniting the burner flame by actuating the on/off valve, and the flame shall be applied to the sample specimen for 12 seconds. The gas supply shall then be shut off.

6-4.3.21 A record shall be made of the afterflame time and whether melting or dripping occurred. The afterflame time shall be considered that time, in seconds, to the nearest 0.2 seconds, that the sample specimen continues to flame after the burner flame is shut off.

6-4.3.22 The sample specimen shall then be removed and further examined for char length and shrinkage.

6-4.3.22.1 The char length shall be determined by measuring the length of the tear through the center of the charred area as follows: The sample specimen shall be folded lengthwise and creased, by hand, along a line through the highest peak of the charred area. The hook shall be inserted in the sample specimen; or a hole 1/4 in. (6.4 mm) in diameter or less, punched out for the hook; at one side of the charred area 1/4 in. (6.4 mm) from the adjacent outside edge at the point where the sample specimen contacted the steel rod, and 1/4 in. (6.4 mm) in from the lower end. A weight of sufficient size such that the weight and hook together shall equal the total tearing load required in 6-4.3.22.3 shall be attached to the hook.

6-4.3.22.2 A tearing force shall be applied gently to the sample specimen by grasping the side of the material at the edge of the char opposite from the load and raising the sample specimen and weight clear of the supporting surface. The end of the tear shall be marked off on the edge and the char length measurement made along the undamaged edge.

6-4.3.22.3 The specific load for determining char length applicable to the weight of the test material shall be as follows:

Specified weight per square yard of material before any fire retardant treatment or coating		Total tearing weight for determining the charred length	
ounces/yd^2	g/m^2	pounds	kg
2.0 - 6.0	68 - 203	0.25	0.1
over 6.0 - 15.0	over 203 - 508	0.5	0.2
over 15.0 - 23.0	over 508 - 780	0.75	0.3
over 23.0	over 780	1.0	0.45

6-4.3.23 After each sample specimen is removed, the test cabinet shall be cleared of fumes and smoke before the next sample specimen is tested.

6-4.3.24 Each tested sample specimen shall be reconditioned as specified in 6-4.1 and then weighed to the nearest 0.1 g (0.04 oz).

6-4.3.25 The percent consumed shall be calculated as the weight after testing times 100 divided by the original weight, as shown in the formula:

$$\text{Percent consumed} = \frac{W - R}{W} \times 100$$

Where:

W = original preconditioned weight

R = conditioned weight 24 hours after testing.

6-4.3.26 The afterflame time, char length, and percent consumed shall be reported for each sample specimen. The average afterflame time, char length, and percent consumed for each sample specimen shall then be calculated and reported to determine pass/fail.

6-4.3.27 The afterflame time shall be reported to the nearest 0.2 second, the char length to the nearest 1/10 in. (0.25 cm), and the percent consumed to the nearest 0.1 percent.

6-4.3.28 Observations made on the extent of melting or dripping for each material shall be reported to determine pass/fail.

6-4.4 Conductive Heat Resistance Testing.

6-4.4.1 Sample gloves shall be preconditioned as specified in 6-4.1.

6-4.4.2 Samples shall be tested in accordance with ASTM F 1060, *Standard Test Method for Thermal Protective Performance of Materials for Protective Clothing for Hot Surface Contact.*

6-4.4.3 Samples shall be tested using an exposure temperature of 536°F (280°C). The pressure applied during the test shall be 0.5 psi (35 g/cm^2).

6-4.4.4 The time in seconds to pain and to second-degree burn, as predicted by the Stoll Human Tissue Burn Tolerance Criteria, shall be recorded. The average of the test results of the sample specimens shall be reported.

6-4.5 Thermal Protective Performance (TPP) Testing.

6-4.5.1 Sample specimens shall be preconditioned in accordance with 6-4.1. Sample specimens shall then be placed in a circulating air oven for not less than 4 hours at 120°F, +5°/-0°F (49°C, +2°/-0°C).

6-4.5.2 TPP testing shall be performed in accordance with ASTM D 4108, *Standard Test Method for Thermal Protective Performance of Materials for Clothing; Open Flame Method,* with the following modifications.

6-4.5.3 Sample specimens shall consist of each single layer or composite used in actual glove construction, with all layers arranged in proper order. In each test, the sample specimen's normal outer surface shall be exposed to the heat flux.

6-4.5.3.1 Sample specimens shall measure 6 in. × 5 in., +1/16 in./-0.0 in. (15.2 cm × 12.7 cm, +0.16/-0.0 cm).

6-4.5.4 Apparatus shall consist of specimen holder assembly, specimen holder assembly support, thermal flux source, protective shutter, sensor assembly, and recorder.

6-4.5.5 The specimen holder assembly shall consist of upper and lower mounting plates. Specimen holder mounting plates shall be 8 in. × 8 in., ±1/16 in., × 1/4 in., ±1/32 in. (203.2 mm × 203.2 mm, ±1.6 mm, × 6.4 mm, ±0.8 mm). The lower specimen mounting plate shall have centered a 4 in. × 4 in., ±1/16 in. (102 mm × 102 mm, ±1.6 mm) hole. The upper specimen mounting plate shall have centered a 5 1/8 in. × 5 1/8 in., ±1/16 in. (127.3 mm × 127.3 mm, ±1.6 mm) hole. The lower specimen mounting plate shall have a 1 in., ±1/16 in. (height) × 1/8 in., ±1/32 in. (thickness) (25.4 mm, ±1.6 mm, × 3.2 mm, ±0.8 mm)

steel post welded to each corner 1/4 in., ± 1/16 in., (6.4 mm, ± 1.6 mm) from each side and perpendicular to the plane of the plate. The upper sample mounting plate shall have a corresponding hole in each corner so that the upper specimen mounting plate fits over the lower specimen mounting plate.

6-4.5.6 Specimen holder assembly support shall consist of a steel frame that, in a reproducible manner, rigidly holds and positions 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 in. × 5 1/4 in. × 1/2 in. (133.3 mm × 133.3 mm × 12.8 mm) heat-resistant block that fits without binding into the hole of the upper specimen mounting plate and that shall be uniformly weighed such that the complete sensor assembly, including copper calorimeter, weighs 2.2 lb, ± 0.022 lb (1000 g, ± 10 g).

6-4.5.7 The thermal flux shall consist of both convective and radiant thermal flux sources. 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.

6-4.5.8 A protective shutter shall be placed between the thermal flux sources and the specimen. The protective shutter shall be capable of completely dissipating thermal load from thermal flux sources 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 0.10 second.

6-4.5.9 Specimens shall be exposed to a thermal flux of 2.0 cal/cm^2/sec, ± 0.1 cal/cm^2/sec, as measured with the copper calorimeter. The copper calorimeter shall be the only heat sensor used in setting the 2.0 cal/cm^2/sec exposure condition. The total 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.

6-4.5.10 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.

6-4.5.11 If the individual results vary more than ± 8 percent from the average result, the average result shall be discarded, and another set of specimens shall be tested.

6-4.5.12 The individual test results of each specimen shall be reported. The average value for each specimen and the pass/fail result shall be calculated and reported.

6-4.6 Cut Resistance Testing.

6-4.6.1 Specimens shall be preconditioned as specified in 6-4.1.

6-4.6.2 Each specimen to be tested shall be a rectangle at least 2 in. × 4.5 in. (5.1 cm × 11.4 cm).

6-4.6.3 Each specimen shall consist of each single layer or composite used in actual glove construction, with all layers arranged in proper order.

6-4.6.4 Two specimens of each sample shall be tested and two cuts shall be made on each specimen.

6-4.6.5 The static cut test and apparatus shall conform to the requirements of 5-4.3 with the following modifications.

6-4.6.5.1 The pivoted arm shall be capable of supporting weights above the blade holder. Incremental weights of 2 lb (0.91 kg) each shall be supplied to allow a maximum force of 18 lb (9.1 kg) to be applied during testing. The pivoted arm, blade holder, and blade together shall weigh 2 lb (0.91 kg) and shall contribute to the force applied to the blade.

6-4.6.5.2 A 0.05-in. (0.13-cm) thick soft leather strip shall be draped over the rod and block to simulate the cushioning effects of hand skin and to protect the blade on cut-through.

6-4.6.5.3 The specimen support shall be designed to be freestanding so that several parallel-cut attempts, spaced not less than 1/8 in. (0.3 cm) apart, can be made on each specimen.

6-4.6.5.4 The pivoted arm and blade holder shall be initially loaded with weights to the maximum force of 18 lb (9.1 kg).

6-4.6.5.5 The specimen shall be inspected visually to determine whether the outer shell was cut completely through at any point by the blade edge. Care shall be taken in inspecting the specimen surface for cuts. Grooving can occur, but this shall not constitute a cut.

6-4.6.5.6 If the specimen surface has been cut, the weight shall be reduced by 2 lb (0.91 kg) and the test procedure repeated.

6-4.6.5.6.1 In repeating the test procedure, the specimen shall be repositioned so that the blade edge is 1/8 in. (0.3 cm) to the side of the previous cut attempt.

6-4.6.5.6.2 The weights shall be reduced at 2-lb (0.91-kg) intervals and the test procedure repeated until the point of no-cut is reached or the minimum weight of 2 lb (0.91 kg) is reached.

6-4.6.5.7 If all available test sites on the specimen have been used, testing shall continue on an identical, fresh specimen.

6-4.6.5.8 The minimum force causing cut shall be recorded.

6-4.6.5.9 The test procedure shall be repeated for the remaining specimens, starting with a weight 4 lb (2 kg) greater than the first noted for cut, until 2 cuts have been made on a single specimen.

6-4.6.5.10 If the specimen has not been cut, a force of 18 lb (8.2 kg) shall be recorded.

6-4.6.5.11 The force required for each surface cut shall be reported to the nearest 2 lb (0.9 kg) for each specimen. The average force for each specimen shall then be calculated and reported to determine pass/fail.

6-4.7 Puncture Resistance Testing.

6-4.7.1 Sample specimens shall be preconditioned as specified in 6-4.1.

6-4.7.2 Sample specimens shall be tested in accordance with ASTM F 1342, *Standard Test Method for Resistance of Protective Clothing Materials to Puncture.*

6-4.8 Dexterity Testing.

6-4.8.1 Sample gloves shall be preconditioned as specified in 6-4.1.

6-4.8.2 Dexterity shall be evaluated using the standardized procedure known as the "Bennett Hand-Tool Dexterity Test."

6-4.8.3 Sample gloves shall not receive special softening treatments prior to testing.

6-4.8.4 Three sample gloves shall be tested for each material and construction combination.

6-4.8.5 Each person performing the test shall practice until the baseline times of three consecutive repetitions varies no more than 6 percent.

6-4.9 Grip Testing.

6-4.9.1 Sample gloves and ropes shall be preconditioned as specified in 6-4.1.

6-4.9.2 Grip testing shall be evaluated with the use of a 3/8-in. (9.5-mm) diameter, 3-strand, prestretched polyester rope attached to a spring scale.

6-4.9.3 Bare-handed weight-lift capability shall be baseline weight.

6-4.9.4 All sample gloves shall be tested on a dry rope.

6-4.9.5 Weight-lift capability for bare hand tests and all performance tests shall be recorded.

Chapter 7 Protective Helmets

7-1 Design Requirements.

7-1.1 All materials used in construction of the helmet shall meet all requirements of this chapter. All materials used in the construction of the helmet that are designed to come in contact with the wearer's head or skin shall be known to be nonirritating to normal skin.

7-1.2 Helmets shall have a brim or peak.

7-1.3 Helmets shall be designed to consist of a shell and a means of absorbing energy. Provisions shall be made for ventilation between the head and the shell.

7-1.4 The helmet shall be generally dome shaped. The area under the peak or the front of the brim shall be permitted to be covered only with a nonconducting, nonflammable, antiglare material.

7-1.5 Head fit assemblies shall be provided and shall be removable and replaceable. Head fit assemblies shall be adjustable in at least 1/8 in. (3.2 mm) hat size increments. The size range that can be accommodated shall be marked on a product label. When the head fit assembly is adjusted to the maximum designated size, there shall be sufficient clearance between the shell and the head fit assembly to provide ventilation.

7-1.6 A sweatband shall be provided that shall cover at least the forehead portion of the head fit assembly. Sweatbands shall be either removable and replaceable, or shall be integral with the head fit assembly.

7-1.7 The helmet shall be designed so that the distance between the top of the head and the underside of the shell cannot be adjusted to less clearance than the manufacturer's requirements for that specific helmet.

7-1.8 Chin straps shall be provided that attach to the helmet shell. Nape straps shall also be permitted. Both chin and nape straps shall not be less than 0.5 in. (12.7 mm) in width.

7-1.9 Helmets shall have retroreflective markings on the exterior of the shell. A minimum of 4 sq in. (25.8 cm) of retroreflective markings shall be visible when the helmet is viewed from either the side or rear.

7-1.10 Accessories.

7-1.10.1 A face and neck shroud, where provided, shall meet the requirements specified in Section 3-3.

7-1.10.2 Winter liners shall not be required, but shall be permitted to be provided by the manufacturer.

7-1.10.3 Lamp brackets, where provided, shall be constructed of a suitable material to properly hold the lamp.

7-1.10.4 Accessories shall be permitted to be mounted through the use of openings provided along the lower edge of the helmet shell. These openings in the shell, where provided, shall be designed with an inner wall that shall extend below the electrical test line as determined in 7-4.1.4.

7-1.10.5 The openings in helmet shells provided for mounting of accessories shall be permitted to be filled by gasketing or other means, provided the helmet will continue to meet the requirements specified in Section 7-3.

7-1.10.6 The addition of helmet accessories shall not interfere with the function of the helmet or its component parts and shall not degrade the helmet's performance below the requirements of this standard.

7-2 Product Labeling Requirements.

7-2.1 Each helmet shall have a product label or labels permanently and conspicuously attached to the helmet upon which at least the following warnings and information are printed in letters at least 3/64 in. (1.2 mm) in height.

"THIS WILDLAND FIRE FIGHTING HELMET MEETS THE REQUIREMENTS OF NFPA 1977, *STANDARD ON PROTECTIVE CLOTHING AND EQUIPMENT FOR WILDLAND FIRE FIGHTING*, 1993 EDITION.

WARNING

THIS HELMET MUST BE PROPERLY ADJUSTED AND SECURED TO THE HEAD, WITH ALL COMPONENTS IN PLACE, AND USED AS SPECIFIED IN MANUFACTURER'S INSTRUCTIONS. DO NOT USE THIS HELMET ALONE FOR WILDLAND FIRE FIGHTING OPERATIONS; OTHER PROTECTIVE EQUIPMENT—PROTECTIVE GARMENTS, GLOVES, FOOTWEAR, FIRE SHELTER—IS REQUIRED FOR PROTECTION. DO NOT MODIFY OR REPLACE ANY COMPONENTS OF THIS HELMET, INCLUDING THE SHELL, ENERGY ABSORBING SYSTEM, RETENTION SYSTEM, RETROREFLECTIVE MARKINGS, OR FACE SHROUD, WITH OTHER THAN THOSE COMPONENTS OR ACCESSORIES APPROVED BY THE MANUFACTURER. ANY SUCH MODIFICATION OR REPLACEMENT VOIDS COMPLIANCE WITH NFPA 1977. FAILURE TO COMPLY WITH THESE INSTRUCTIONS MAY RESULT IN SERIOUS INJURY OR DEATH."

Manufacturer name
Model number or design
Month and year of manufacture (uncoded)
Lot number
Nominal weight of helmet
Recommended cleaning procedure
Helmet size, or size range
Authorized mark of certification organization
Date of certification

"DO NOT REMOVE THIS LABEL."

7-2.2 All portions of the required product labels shall be printed in at least English.

7-2.3 Product labels and any other identification labels or markers used on shells shall be affixed without making holes through the shell and without the use of any metal parts or metallic labels.

7-3 Performance Requirements.

7-3.1* Helmets shall be tested for electrical insulation as specified in 7-4.1, and any electrical leakage shall not exceed 3 milliamperes.

7-3.2 Helmets shall be tested for top impact resistance as specified in 7-4.2 and shall transmit an average force of not more than 850 lb (3781 N). No individual sample specimen shall transmit a force of more than 1000 lb (4450 N). Disengagement of , deformation of, or damage to the helmet shell or component parts shall not in itself constitute failure.

7-3.3 Helmets shall be tested for penetration resistance as specified in 7-4.3, and any penetration shall not pierce the helmet shell by more than $\frac{3}{8}$ in. (9.5 mm).

7-3.4 Helmets shall be tested for flammability resistance as specified in 7-4.4 and any afterflame shall not have a duration greater than 5.0 seconds.

7-3.5 Any antiglare material, where provided as permitted in 7-1.4, shall be tested for flammability resistance as specified in 7-4.5, and any afterflame shall not have a duration greater than 5.0 seconds.

7-3.6 Helmets shall be tested for heat resistance as specified in 7-4.9, and any deformation of the brim or peak shall not exceed 25 percent of its length where measured from the junction of the crown with the brim or peak.

7-3.7 Helmets shall be tested for suspension system separation as specified in 7-4.6. The minimum force required to separate any individual attachment point of the suspension assembly from the helmet shell shall be 5 lb (2.3 kg).

7-3.8 Helmet retroreflective markings shall be tested for coefficient or retroreflectivity (CPL) as specified in 7-4.7 and shall have a coefficient or retroreflectivity (CPL) of not less than 90 cp/ft-c/ft^2.

7-3.9 Each helmet chin strap and each adjusting mechanism of the suspension system assembly shall be tested for retention system separation as specified in 7-4.8, without the failure of any mechanism to function properly.

7-4 Testing Requirements.

7-4.1 Electrical Insulation Test.

7-4.1.1 The following equipment shall be provided for the test:

(a) A source of 60 Hz alternating current variable from 0 to 30,000 rms with at least a 20-milliampere capability at 20,000 volts.

(b) Wiring and terminals for application of voltage across the crown of the sample helmet.

(c) A voltmeter to measure the applied voltage within 2 percent.

(d) A milliammeter to measure the leakage current to within 2 percent.

(e) A vessel, containing fresh tap water, of sufficient size to submerge an inverted sample helmet to within 12.7 mm (0.5 in.) of the juncture of the brim with the crown.

(f) A frame for suspending the sample helmet in the water.

7-4.1.2 Where the sample helmet has a coating over the basic shell material, the exterior surface of the shell shall be abraded with a No. 60 grit garnet paper until the basic shell material is exposed.

7-4.1.3 Sample helmets shall be preconditioned at a temperature of 70°F, ±5°F (21°C, ±3°C) and at a relative humidity of 65 percent, ±5 percent, for at least 24 hours. Sample helmets shall be tested within 5 minutes after removal from preconditioning.

7-4.1.4 The inside of the sample helmet, with suspension system and permanent accessories installed, shall be filled with fresh tap water within 12.7 mm (0.5 in.) of the juncture of the crown and the peak or brim with the helmet inverted, unless the helmet has holes in the crown for mounting the suspension system, in which case it shall be filled to within 12.7 mm (0.5 in.) of these holes. No special provisions shall be made for any accessory-mounting holes above the plane of the suspension system mounting holes. The sample helmet shall then be submerged in the same type of water at the same level as the water on the inside of the helmet.

7-4.1.5 The voltmeter and milliammeter shall be attached to the circuit. Care shall be taken to keep the unsubmerged portion of the sample helmet dry so that electrical flashover will not occur when voltage is applied.

7-4.1.6 A 60 Hz alternating current voltage shall be applied and increased to 2,200 volts R.M.S. The voltage shall be maintained at 2,200 volts for 1 minute. Any current leakage or evidence of breakdown shall be recorded to determine pass/fail.

7-4.2 Top Impact Resistance Testing—Force.

7-4.2.1 Sample helmets shall be conditioned for each of the following environmental conditions prior to each impact. Impact shall take place within 15 +0/–5 seconds unless otherwise specified.

7-4.2.1.1 Sample helmets shall be conditioned for room temperature at 68°F to 82°F (20°C to 28°C) for at least 2 hours.

7-4.2.1.2 Sample helmets shall be conditioned for low temperature 0°F, ±2°F (-18°C, ±1°C) for a minimum of 2 hours.

7-4.2.1.3 Sample helmets shall be conditioned for water environment by immersing them in water at a temperature of 68°F to 82°F (20°C to 28°C) for 2 hours, +2/–0 min. The helmet shall be surface dried and shall be tested within 10 minutes after removal from the water.

7-4.2.1.4 Sample helmets shall be conditioned for radiant heat by exposing the area to be impacted/penetrated to a radiant heat source with an irradiance of 1.0 W/cm^2, ±0.1 W/cm^2 for a length of time determined by the exposure of a radiant heat transducer. The heat source shall be removed, and the helmet shall be tested.

7-4.2.1.4.1 The radiometer, radiant heat transducer, and radiant chamber/panel shall be as specified in 5-2.3 through 5-2.5 of NFPA 1972, *Standard on Helmets for Structural Fire Fighting*.

7-4.2.1.4.2 The procedure shall be as specified in 5-2.6 through 5-2.9 of NFPA 1972, *Standard on Helmets for Structural Fire Fighting*. Paragraph 5-2.8 of NFPA 1972 shall be modified to reflect a test temperature of 350°F, ±5°F, (177°C, ±3°C), and the test time shall be 1 minute, +5/–0 seconds.

7-4.2.2 An aluminum headform, size 7, commonly known as the "ISEA Standard Headform," shall be used. The headform shall have a mass of 8.0 lb, ±1.0 lb (3.6 kg, ±0.5 kg).

7-4.2.3 A steel drop mass of 7.90 lb, ±0.10 lb (3.58 kg, ±0.05 kg) shall be used. The striking face of the drop mass shall be a spherical segment with a radius of 1.9 in., ±0.3 in. (4.8 cm, ±0.8 cm) and a chord length of at least 3.0 in. (7.6 cm).

7-4.2.4 An electronic force measurement system with the following minimum specifications shall be used:

Range	1,000 lb (4450 N)
Peak force measurement accuracy	±2.5 percent
Resolution	5 lb (22 N)
Load cell rigidity	2.5×10^7 lb/in. (4.4×10^9 N/m)
Minimum mechanical resonant frequency of the headform/load cell system	5000 Hz
Load cell diameter	3.0 in. (7.6 cm)

7-4.2.4.1 The system frequency response shall comply with SAE J211 Channel Frequency Class 1000 specifications. The minimum mechanical resonant frequency shall be calculated from the formula $F = \frac{\sqrt{k/m}}{2\pi}$

where: k is the load cell rigidity (lb/ft or N/m) and m is the mass of the structure on top of the load cell (slugs or kg).

7-4.2.4.2 All surfaces in contact with the load cell shall have a surface finish of at least 32×10^{-6} in. (0.8×10^{-6}m) rms. In addition, those surfaces in contact with the load cell shall be flat to within 500×10^{-6} in. (12.7×10^{-6}m).

7-4.2.5 The load cell shall have a back-up mass of at least 1,200 lbs (540 kg). The load cell assembly shall be rigidly mounted between the headform structure and a steel plate at least 1 ft × 1 ft (0.3 m × 0.3 m) and 1 in. (2.5 cm) thick. The back-up mass shall be concrete or a rigid material of equal or greater density at least 2 ft × 2 ft (0.6 m × 0.6 m).

7-4.2.5.1 The surface of the steel plate, in the area of the load cell assembly mounting, shall be flat within ±0.005 in. (±0.15 mm) and within 1 degree of level. The steel plate shall be rigidly attached to, and in intimate contact with, the back-up mass.

7-4.2.6 The vertical centerline of the drop mass, the headform, and the load cell shall all be colinear within .125 in. (3 mm). The sensitive axis of the load cell shall be aligned within 1 degree of vertical. The guide or guides shall be vertical, or parallel in the case of a double guide system, to within 0.25 in. (6 mm) per 10 ft (3 m) of length.

7-4.2.7* The instrumentation calibration shall be verified at least before and after each test series or at the beginning and end of each day of testing, whichever is the shorter length of time. The results of each system verification shall be made part of the test results for the helmets being tested. The verification tests shall demonstrate an accuracy of 2.5 percent or better in the measured force.

7-4.2.8 The test system shall be analyzed dynamically to ensure that any mechanical resonances associated with transducer mountings do not distort the output data.

7-4.2.9 Prior to testing, the instrumentation shall be allowed to warm up until stability is achieved.

7-4.2.10 Throughout calibration, verification, and testing, the ambient temperature shall be 68°F to 82°F (20°C to 28°C), and the relative humidity shall be 30 to 70 percent.

7-4.2.11 Sample helmets shall be adjusted to size 7¼ or larger to prevent binding. Sample helmets shall be positioned on the headform, with the horizontal center plane parallel within 5 degrees of the reference plane. The front-to-back centerline of the shell shall be within 0.5 in. (12.7 mm) of the mid-sagittal plane of the headform. Helmets shall be subjected to the environmental conditions specified in 7-4.2.1 prior to each impact and within the specified time after being removed from conditioning.

7-4.2.12 The impactor shall be dropped from a height that yields an impact velocity within 2 percent of 17.9 ft/sec (5.47 m/sec). A means of verifying the impact velocity to within 2 percent for each impact shall be incorporated.

7-4.2.13 The peak force and impact velocity shall be recorded for each test, and pass/fail shall be determined.

7-4.3 Penetration Resistance Testing.

7-4.3.1 Sample helmets shall be conditioned for each of the following environmental conditions prior to each penetration.

7-4.3.1.1 Sample helmets shall be conditioned for room temperature at 68°F to 82°F (20°C to 28°C) for at least 2 hours.

7-4.3.1.2 Sample helmets shall be conditioned for low temperature at 0°F, ±2°F (-18°C, ±1°C) for a minimum of 2 hours.

7-4.3.1.3 Sample helmets shall be conditioned for water environment by immersing them in water at a temperature of 68°F to 82°F (20°C to 28°C) for 2 hours, +2/–0 min. The helmet shall be surface dried and shall be tested within 10 minutes after removal from the water.

7-4.3.1.4 Sample helmets shall be conditioned for radiant heat by exposing the area to be impacted/penetrated to a radiant heat source with an irradiance of 1.0 W/cm^2, ±0.1 W/cm^2, for a length of time determined by the exposure of a radiant heat transducer. The heat source shall be removed, and the helmet shall be tested within 15 seconds, +0/–5 seconds.

7-4.3.1.4.1 The radiometer, radiant heat transducer, and radiant chamber/panel shall be as specified in 5-2.3 through 5-2.5 of NFPA 1972, *Standard on Helmets for Structural Fire Fighting*.

7-4.3.1.4.2 The procedure shall be as specified in 5-2.6 through 5-2.9 of NFPA 1972, *Standard on Helmets for Structural Fire Fighting*. Paragraph 5-2.8 of NFPA 1972 shall be modified to reflect a test temperature of 350°F, ±5°F (177°C, ±3°C), and the test time shall be 1 minute, +5/–0 seconds.

7-4.3.2 Test apparatus shall consist of a standard headform as specified in 5-6.2 of NFPA 1972, *Standard on Helmets for Structural Fire Fighting*, and a plumb bob that weighs 1 lb (0.45 kg) and has a steel point with an included angle of 35 degrees, ±1 degree, and a maximum point radius of 0.010 in. (0.25 mm).

7-4.3.3 Sample helmets shall be mounted as specified in 7-4.2.11. Testing shall be conducted within 15 seconds after the sample helmet is removed from conditioning.

7-4.3.4 The conditioned sample helmet shall be placed on a rigidly mounted test headform. The plumb bob shall be dropped 10 ft (3.048 m) to strike the sample helmet shell within a circle whose diameter is 3.0 in. (76 mm) and whose center shall be the geometric center of the shell. The plumb bob shall not fall on any portion of the ridges or make contact with the headform.

7-4.3.5 To determine pass/fail, the perpendicular distance traveled by the plumb bob into the sample helmet, including the shell thickness, shall be the depth of penetration.

7-4.4 Flammability Testing.

7-4.4.1 The test apparatus shall consist of the following:

(a) Laboratory test stand

(b) Fume hood

(c) Bunsen burner, 0.5-in. (12.7-mm) bore

(d) Methane source of gas

(e) Gas regulator

(f) Stop watch.

7-4.4.2 The Bunsen burner shall be adjusted to produce a 2-in. (5.1-cm) blue flame with a 1-in. (2.5-cm) inner cone.

7-4.4.3 The sample helmet shall be conditioned in accordance with 7-4.3.1.1 of this section, and then shall be attached to the laboratory test stand so that it is held in an inverted horizontal position. The stand and sample helmet shall be placed in a draft-free fume hood. Any point within 4 in. (102 mm) of the apex of the helmet crown shall be chosen, and the flame of the Bunsen burner shall be applied so that the tip of the inner cone is at the helmet surface, ±0.2 in. (±5.0 mm). The barrel of the Bunsen burner shall be held at an angle of 45 degrees, ±5 degrees, to the helmet surface. The chosen point shall not be closer than 1 in. (25.4 mm) from any decals, logos, or retroreflective markings. The flame shall be applied to the test surface for 10 seconds, +1/–0 seconds. After removal of the flame, any afterflame shall be measured to determine pass/fail.

7-4.5 Antiglare Material Flammability Test.

7-4.5.1 The sample helmet shall be conditioned to 7-4.3.1.1, and then shall be attached to the laboratory test stand so that it is held in the "as worn" position. The stand and sample helmet shall be placed in a draft-free fume hood. The flame of the Bunsen burner shall be applied so that the tip of the inner cone is at the helmet surface, ±0.2 in. (±5.0 mm) at any point under the brim, and 0.5 in., ±1/8 in. (12.7 mm, ±3.2 mm) from the edge of the brim.

7-4.5.2 The flame shall be applied to the test surface for 5 seconds, +1/–0 seconds. After removal of the flame, any afterflame shall be measured to determine pass/fail.

7-4.6 Suspension System Retention Testing.

7-4.6.1 The suspension system retention test fixtures shall consist of rigid material of sufficient thickness and optional design to facilitate firm attachment to the helmet suspension and the tensile test machine.

7-4.6.2 Sample helmets shall be positioned and secured so that the helmet's reference plane is horizontal. Each attachment point of the suspension assembly to the helmet shall be tested by slowly applying a perpendicular pull force to the reference plane, at a maximum of 5 lb, +0.25/–0 lb (22 N, +1/–0 N). The cross-head speed shall be 1 in., ±0.2 in. (25.4 mm, ±5 mm) per minute. The force shall be applied through the centerline of each attachment point. If the pull force is applied at any other angle, the test results shall be unacceptable, and the test shall be repeated.

7-4.6.3 The force gauge shall be accurate to 0.25 lb (1 N).

7-4.6.4 The individual pass/fail results for each attachment point shall be recorded to determine pass/fail.

7-4.7 Retroreflectivity Testing.

7-4.7.1 Test procedure shall be in accordance with ASTM E 810, *Standard Test Method for Coefficient of Retroreflection of*

Retroreflective Sheeting, with an observation angle of 0.2 degrees and an entrance angle of -4 degrees.

7-4.8 Retention System Testing.

7-4.8.1 Each adjusting mechanism of the helmet chin strap assembly shall be secured and unsecured, as applicable, for 20 repetitions. Each mechanism shall be observed for proper functioning to determine pass/fail.

7-4.8.2 Each adjusting mechanism of the helmet suspension system assembly shall be secured and unsecured, as applicable, for 20 repetitions. Each mechanism shall be observed for proper functioning to determine pass/fail.

7-4.9 Heat Distortion Test.

7-4.9.1 The test oven shall be a horizontal flow circulating air oven with minimum internal dimensions of 18 in. × 18 in. × 18 in. (45 cm × 45 cm × 45 cm). The oven shall be heated and stabilized to a temperature of 350°F, +10°/-0°F (177°C, +5°/-0°C).

7-4.9.2 Sample helmets shall be securely mounted on a room-temperature nonmetallic headform in the "as worn" position. A liner, ear flaps, or a similar device shall be deployed to protect the suspension, if necessary.

7-4.9.3 A series of points shall be marked 3 in. (76 mm) apart on the outer edge of the peak or brim of the sample helmets, allowing at least 3 points on a peak and 8 or more points on a full brim. The vertical distance from a known horizontal base plane to the mark points on the peak or brim shall be measured and recorded.

7-4.9.4 The sample helmet mounted on the headform shall be placed in the center of the oven. If the sample helmet contains a peak only, the sample helmet shall face into the airflow. The oven door shall not remain open more than 15 seconds. The air circulation shall be shut off while the door is open and turned on when the door is closed.

7-4.9.5 After 5 minutes, +15/-0 seconds, the sample helmet mounted on the headform shall be removed and allowed to cool for a minimum of 2 minutes. The vertical distance from the marked points to the base plane shall be measured, recorded, and compared with the measurements recorded in 7-4.9.3 to determine pass/fail.

Chapter 8 Referenced Publications

8-1 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.

8-1.1 NFPA Publication. National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

NFPA 1972, *Standard on Helmets for Structural Fire Fighting*, 1992 edition.

8-1.2 AATCC Publications. 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.

AATCC 160, *Dimensional Restoration of Knitted and Woven Fabrics After Laundering*, 1987.

8-1.3 ASTM Publications. American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.

ASTM B 117, *Standard Method of Salt Spray (Fog) Testing*, 1990.

ASTM D 1424, *Standard Test Method for the Tear Resistance of Woven Fabrics by Falling Pendulum (Elmendorf) Apparatus*, 1983.

ASTM D 1518, *Standard Test Method for Thermal Transmittance of Textile Materials*, 1985.

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

ASTM D 3940, *Standard Test Method for Failure in Sewn Seams of Knit Fabric*, 1983.

ASTM D 4108, *Standard Test Method for Thermal Protective Performance of Materials for Clothing; Open Flame Method*, 1987.

ASTM D 4966, *Standard Test Method for Abrasion Resistance of Textile Fabrics*, 1989.

ASTM E 810, *Standard Test Method for Coefficient of Retroreflection of Retroreflective Sheeting*, 1991.

ASTM F 1060, *Standard Test Method for Thermal Protective Performance of Materials for Protective Clothing for Hot Surface Contact*, 1987.

ASTM F 1342, *Standard Test Method for Resistance of Protective Clothing Materials to Puncture*, 1991.

8-1.4 FIA Publications. Footwear Industries of America, 3700 Market Street, University City Science Center, Philadelphia, PA 19194.

FIA Test Method 301, *NBS Abrasion*, 1984.

FIA Test Method 308, *Ross Flex Endurance of Soling Materials, Modified ASTM Procedure*, 1984.

8-1.5 GSA Publication. U.S. Government Printing Office, Superintendent of Documents, Washington, DC 20402.

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

8-1-6 Psychological Corporation Publication. The Psychological Corporation, 555 Academic Court, San Antonio, TX 78204, (512) 299-1061.

Bennett Hand-Tool Dexterity Test, Manual 8018-111, 1981.

8-1.7 USDA Forest Service Publications. Missoula Technology and Development Center, Building 1, Fort Missoula, Missoula, MT 59801.

5100-320F *Shelter, Fire*, April 1993.

5100-322B *Case, Carrying, Fire Shelter*, April 1993.

5100-00323A *Liner, Fire Shelter, Carrying Case*, April, 1993.

8-1.8 U.S. Navy Publications. Navy Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120.

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

Military Specification MS 27980E, *Fasteners, Snaps, Style 2*, November 30, 1984.

Military Specification MIL-C-24941, *Cloth, Laminated, Aluminized (para-aramid/PBI base)*, September 30, 1988.

Military Specification MIL-F-21840G, *Fastener Tapes, Hook and Pile, Synthetic*, December 16, 1987.

Appendix A Explanatory Material

This appendix is not part of the requirements of this document, but is included for informational purposes only.

A-1-1.2 At the time the Committee was developing this document, there was insufficient data available to develop criteria for respiratory protection as a required element of wildland fire fighter protective equipment.

A limited number of studies of air samples collected on wildland fire fighters and workers involved with prescribed burning indicate potential for hazardous exposure (e.g., respirable particulate, carbon monoxide, formaldehyde, and acrolein). Studies of the respiratory effects of smoke exposure on wildland fire fighters indicate that exposure during a fire season may result in changes in lung function. The health implications of short-term exposures and the potential health effects of long-term exposures are yet to be quantified.

It is current practice to consider wildfire smoke not immediately dangerous to life and health (IDLH) even though the human health hazards have not been quantified. As a prudent practice, significant wildfire smoke exposure should be reduced when possible. Fire fighters and crew supervisors should consider the level of smoke exposure of the tasks to be performed before committing personnel to action. Mitigation efforts could include short work periods, removal of crews from areas of heavy smoke concentration, or use of respiratory protection. While self-contained breathing apparatus (SCBA) offers the most complete respiratory protection, SCBA might not be practical for use by wildland fire fighters who work for extended periods in remote locations. The weight of an SCBA, its limited use time, and breathing air cylinder recharging logistics make it impractical for use by wildland fire fighters.

No currently available air-purifying respirator provides protection for all currently known hazards of wildland smoke. A HEPA filter-equipped air-purifying respirator might be considered as an option for the filtration of respirable particles from the air to be breathed. The addition of sorbents to remove selected gases and vapors (e.g., cartridge with HEPA plus OV/AG) could also be an option when greater exposure is anticipated, as in a direct attack on a prescribed fire. Due to the potential for increased carbon monoxide exposure, the wildland fire fighters' agency should provide programs to expand training, and develop and implement procedures to monitor CO exposure when fire fighters use air-purifying respirators.

Any respirator being considered for use by wildland fire fighters must be NIOSH certified. Care should be exercised in the use of NIOSH certified respirators because they have not been tested for heat resistance and flammability of the filter medium, and have not been evaluated for their ability to provide protection from the products of combustion of wildfires.

A-1-2.1 Based on information studied by this committee, the majority of documented injuries to wildland fire fighters are related to heat stress. The goal of this standard is to provide thermal protection for the fire fighter against external heat sources with flame resistant clothing and equipment without inducing an extraordinary internal heat stress load.

The total protection package consists of protective clothing and equipment for normal exposure limits, and an emergency fire shelter for severe exposure situations where serious injury or death can result.

Objectively, the clothing should be flame resistant so that it does not contribute to burns resulting primarily from radiant heat and limited conductive heat (direct flame contact). The clothing should also have a thermal heat loss factor, which minimizes its adverse effect on the retention of body heat caused by high work output over long periods.

Wildland fire fighters face working conditions characterized by work periods as long as 36 to 48 hours, in deserts, high mountains, in temperatures from below freezing to above 120°F (49°C), and in relative humidities ranging from very dry to very humid. Their proximity to the fire can be from as close as a few feet to several miles.

The work done by the wildland fire fighter involves manual labor. Firelines are constructed with hand tools that are used to cut, dig, and scrape. Portable power equipment is carried to, and used on, the fireline. Hoselines are also carried and pulled to the fire to provide water. Mechanized equipment such as bulldozers and tractor plows are used where possible.

The fire environment that affects the fire fighter is smoke and heat. Smoke causes inefficient respiration, causing fire fighters to work their bodies harder when performing tasks and increasing stress. Accumulations of carbon monoxide in the bloodstream coupled with fatigue can create a dangerous work situation. The long-term effects of wildland smoke exposure are only now in the preliminary study stages.

Ambient air temperature is not the only source of external heat. Those working close to a fire are affected primarily by radiant heat, some convective heat, and, in extreme situations, conductive heat.

The minimum radiant protective requirements specified in this standard do not necessarily address other important factors provided in wildland fire fighter protective clothing. However, radiant heat is the primary thermal hazard requiring protection.

The RPP requirements are based on the factors listed above, which recognize that the upper torso is the main heat-producing area of the body. The lower torso is more often subject to abrasion, puncture, and tearing forces. Therefore, the potential user should consider that a heavier fabric is needed for lower torso garments.

A-1-2.2 Protective apparel and equipment that complies with this standard are designed to improve the safety of the wildland fire fighter and to mitigate adverse environmental effects to the fire fighter's body. Users are cautioned

that, as unusual conditions prevail, or if there are signs of abuse or mutilation of the equipment or any component thereof, or modifications or replacements made without permission of the manufacturer, the margin of protection can be reduced.

A-1-3.1 Accessories. Any accessories carried on the person of the fire fighter should be examined for any possibility of causing injury or contributing to an injury. Specifically, accessories such as utility belts, goggles, back packs, chain saw chaps, and the like should not be made of materials that melt, drip, or ignite at temperatures of 350°F (177°C) or less.

A-1-3.1 Approved. The National Fire Protection Association does not approve, inspect, or certify any installations, procedures, equipment, or materials nor does it approve or evaluate testing laboratories. In determining the acceptability of installations or procedures, equipment, or materials, the authority having jurisdiction may base acceptance on compliance with NFPA or other appropriate standards. In the absence of such standards, said authority may require evidence of proper installation, procedure, or use. The authority having jurisdiction may also refer to the listings or labeling practices of an organization concerned with product evaluations which is in a position to determine compliance with appropriate standards for the current production of listed items.

A-1-3.1 Authority Having Jurisdiction. The phrase "authority having jurisdiction" is used in NFPA documents in a broad manner since jurisdictions and "approval" agencies vary as do their responsibilities. Where public safety is primary, the "authority having jurisdiction" may be a federal, state, local or other regional department or individual such as a fire chief, fire marshal, chief of a fire prevention bureau, labor department, 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 government installations, the commanding officer or departmental official may be the "authority having jurisdiction."

A-1-3.1 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-1-3.1 Major "A" Seams. Examples of these seam assembly constructions include:

(a) Trousers—seat seams, outseams, inseams

(b) Shirts—side seams, sleeve seams, shoulder seams.

A-1-3.1 Major "B" Seams. Examples of these seam assembly constructions include:

(a) Trousers—belt loops, cuffs, pocketing

(b) Shirts—cuff, collar flap, hem.

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

A-2-2.3 The contractual provisions covering the 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 are not able to move quickly to protect their name, marks, or reputation. A product safety certification program is 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 major testing is undertaken.

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

A-3-1 The protective apparel ensemble comprises outer garments only, consisting of a shirt and trousers, or a 1-piece garment. These garments are worn over other clothing or directly over undergarments. Because the scope of this standard does not address various types of undergarments that can be used with this ensemble, the following advice is provided for information only.

The material type and style of undergarments worn in conjunction with the protective clothing is extremely important. Undergarments serve several functions to the wildland fire fighter, since they provide warmth and thermal protection, and assist in the absorption and transport of perspiration.

Undergarments are necessary in order to provide basic warmth to the body under various environmental conditions (e.g., cold weather and night conditions).

Undergarments can enhance the thermal protective performance of the protective clothing ensemble, because the undergarments provide an additional layer of fabric and air between the radiant heat source and the skin. The type of undergarment material and its construction also affects the thermal protective performance (TPP) of the clothing ensemble. Research has shown that knit undergarments enhance thermal protective performance where used in conjunction with protective lightweight clothing (*see "Burn Injury Potential of Navy Shipboard Work Clothing"*). Knit textiles (T-shirt fabrics) generally entrap more air than woven textiles (fabrics utilized for boxer shorts). Increasing the entrapped air volume of the fabric increases the thermal protective performance of the undergarment. T-shirt knit fabrics generally provide the wildland fire fighter with better protection from radiant heat than the woven fabrics utilized in boxer shorts. Increasing the weight of the undergarment (weight per unit area) also increases the protection from thermal radiative heat. For a given fabric, a 6 oz/yd^2 knit will provide better TPP protection than a 4 oz/yd^2 knit. Undergarments generally reduce the extent of burn injury by 15 percent. The greater the area covered