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WITHDRAWAL

August 2012

Firefighters' protective clothing for protection against heat and flame

This National Standard of Canada is hereby withdrawn due to limited use and support for its revision.

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Août 2012

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CAN/CGSB-155.1-2001

Supersedes CAN/CGSB-155.1-98

Firefighters' Protective Clothing for Protection Against Heat and Flame

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FIREFIGHTERS' PROTECTIVE CLOTHING FOR PROTECTION AGAINST HEAT AND FLAME

Prepared by the

Canadian General Standards Board 

Approved by the

Standards Council of Canada



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**FIREFIGHTERS' PROTECTIVE CLOTHING FOR PROTECTION AGAINST
HEAT AND FLAME****PREFACE**

In preparation of this standard, the CGSB committee has harmonized the requirements and tests to the extent possible with the corresponding draft international standard.

The following sections of this standard are based on ISO 11613 —Protective clothing for firefighters — Laboratory test methods and performance requirements:

Composite — general requirements (ISO par. 5.2.1)

Hardware — general requirements (ISO par. 4.2.5, 5.2.8.2 and 5.4.9)

Composite collar — height, components (ISO par. 5.2.8.4)

Thread type and melting point requirements (ISO par. 5.4.7)

Moisture barrier — water resistance (seams) and water penetration requirements (ISO par. 4.4.10, 4.4.11, 5.4.3.3 and 5.4.4)

Heat resistance and thermal shrinkage — requirements and tests (ISO par. 4.4.5, 4.4.9, 5.4.2.2 and 5.4.2.3)

Visibility trim — dimensions (in part) and retroreflective properties (ISO par. 4.2.7, 5.2.8.6, 5.2.8.7 and 5.4.8)

Corrosion resistance requirements (ISO par. 5.4.9.2) and

Seam strength requirements (machine operating rate) (ISO par. 4.2.4 and 5.4.1.2).

The source of the ISO publication is shown in the Notes section.

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FIREFIGHTERS' PROTECTIVE CLOTHING FOR PROTECTION AGAINST HEAT AND FLAME

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**FIREFIGHTERS' PROTECTIVE CLOTHING FOR PROTECTION AGAINST
HEAT AND FLAME****1. SCOPE**

- 1.1 This standard states the design and performance requirements for protective clothing worn by firefighters', for protection against heat and flame encountered during fires and related life saving activities, and specifies methods for testing the materials and material assemblies used in the protective clothing.
- 1.2 The standard does not apply to specialized protective clothing such as proximity suits, fire-entry clothing or clothing for hazardous material emergencies. Protective clothing to this standard is not intended to provide protection from chemical, radiological, electrical or biological hazards.
- 1.3 The tests specified in this standard are for evaluating materials, material assemblies or garments to ensure their compliance with the requirements of this standard and shall not be deemed to establish performance levels for all firefighting situations to which firefighting personnel may be exposed.
- 1.4 This standard does not address the issue of fit of the protective clothing on the user. Improperly fitted protective clothing worn by users may be dangerous. It is the responsibility of the users to assure themselves that they are fitted with the proper protective clothing when engaged in firefighting activities.
- 1.5 The testing and evaluation of a product against this standard may require the use of materials and/or equipment that could be hazardous. This document does not purport to address all the safety aspects associated with its use. Anyone using this standard has the responsibility to consult the appropriate authorities and to establish appropriate health and safety practices in conjunction with any applicable regulatory requirements prior to use.

2. REFERENCED PUBLICATIONS

- 2.1 The following publications are referenced in this standard:

- 2.1.1 Canadian General Standards Board (CGSB)

CAN/CGSB-4.2 — Textile Test Methods:

No. 2 — Conditioning Textile Materials for Testing

No. 9.2 — Breaking Strength of Fabrics — Grab Method — Constant-time-to-break Principle

No. 12.2 — Tearing Strength — Trapezoid Method

No. 18.3/ISO 105-B02 — Textiles — Tests for Colourfastness — Part B02: Colourfastness to Artificial Light: Xenon Arc Fading Lamp Test

No. 27.10 — Flame Resistance — Vertically Oriented Textile Fabric or Fabric Assembly Test

No. 32.2 — Breaking Strength of Seams in Woven Fabrics

No. 46/ISO 105-A02 — Textiles — Tests for Colourfastness — Part A02: Grey Scale for Assessing Change in Colour

No. 49 — Resistance of Materials to Water Vapour Diffusion

No. 58 — Colourfastness and Dimensional Change in Domestic Laundering of Textiles

CAN/CGSB-86.1 — Care Labelling of Textiles.

- 2.1.2 Industry Canada

Textile Labelling Act and Regulations.

- 2.1.3 American Society for Testing and Materials (ASTM)
- B 117 — Standard Practice for Operating Salt Spray (Fog) Apparatus
 - D 1683-90a — Standard Test Method for Failure in Sewn Seams of Woven Fabrics
 - E 808 — Standard Practice for Describing Retroreflection
 - E 809 — Standard Practice for Measuring Photometric Characteristics of Retroreflectors.
- 2.1.4 General Services Administration (U.S.)
- Federal Standards (Fed. Std.)
- No. 191A — Textile Test Methods:
- 1534 — Melting Point of Synthetic Fibers
 - 5504 — Water Resistance of Coated Cloth; Spray Absorption Method
 - 5512 — Water Resistance of Coated Cloth; High Range Hydrostatic Pressure Method
 - 5516 — Water Resistance of Cloth, Water Permeability, Hydrostatic Pressure Method
- Federal Specification
- FF-R-556D — Rivet, Solid, Small; Rivet, Split, Small; Rivet Tubular Small; Flat Washer (Burr); and Cap Rivet; General Purpose.
- 2.1.5 Military Specifications
- MIL-F-10884 — Fasteners, Snap
 - MIL-CID AA55126A — Fastener Tapes, Hook and Loop, Synthetic.
- 2.1.6 National Fire Protection Association (NFPA)
- NFPA 1971 — Standard on Protective Ensemble for Structural Fire Fighting.
- 2.2 A reference to a regulation is always to the latest issue. A dated reference is to the issue specified. An undated reference is to the latest issue unless otherwise specified by the authority applying this standard. The sources are given in the Notes section.
3. DEFINITIONS
- 3.1 The following definitions apply in this standard:
- Char** (Produit de carbonisation)
Carbonaceous residue resulting from pyrolysis or incomplete combustion.
- Component** (Composant)
A functional element of the protective garment including, but not limited to, the outer shell, moisture barrier, thermal barrier and winter liner.
- Composites** (Composite)
The layer or combination of layers of the protective ensemble or any element of the protective ensemble that provides the required protection.
- Drip** (Égoutture)
A molten drop or blob that falls from the test specimen.
- Firefighting** (Lutte contre les incendies)
The activities of rescue, fire suppression and property conservation in buildings, enclosed structures, vehicles, vessels, aircraft or like properties that are involved in a fire or emergency situation.
- Flame Resistance** (Résistance à la flamme)
The property of a material whereby flaming combustion is slowed, terminated or prevented.¹ Flame resistance can be imparted by specific treatment or can be an inherent property of the basic material.

¹ The degree of flame resistance exhibited by a material during testing may vary with test conditions.

Fluorescent Area (Aire fluorescente)

The area of fluorescent surface of the visibility trim that absorbs radiant energy at certain wavelengths and emits some of the absorbed energy at other wavelengths.

Hardware (Élément de quincaillerie)

Non-fabric items used in protective clothing, including those made of metal or plastic material.

Inherently Flame-Resistant (Essentiellement ininflammable)

As applied to textiles, having flame resistance that derives from an essential characteristic of the fibre or polymer from which the textile is made.

Interfacing (Entoilage)

A material used to provide body and substance to a garment. Almost any type of fabric may be utilized. The selection of the type of material to use depends upon fabric weight, flexibility, stiffness and other specific properties pertinent to the task at hand.

Lining Fabric (Doublure)

The inside fabric portions of a garment.

Major A Seams (Coutures principales A)

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

Major B Seams (Coutures principales B)

Moisture barrier or thermal barrier seam assemblies where rupture could reduce protection of the garment by exposing the next layer of the garment, the wearer's work/station uniform, other clothing or skin.

Melt (Fondre)

The physical process of changing from solid to liquid by the action of heat, as evidenced by flowing or dripping.

Minor Seams (Coutures secondaires)

Seam assemblies that are not classified as Major A or Major B seams.

Moisture Barrier (Écran imperméable)

The component designed to prevent the transfer of liquid water.

Outer Shell (Tissu extérieur)

The exterior fabric component of the garment.

Protective Coat (Manteau de protection)

The garment that provides protection to the firefighters' torso, neck and arms, excluding hands and head.

Positive Closure System (Système de fermeture sûr)

A positive locking fastener, such as hooks and dees or zippers, used for the front closure of the garment. In this standard, snaps and hook pile tapes are considered non-positive closure systems.

Protective Clothing (Tenue de protection)

The coat and trousers designed as a complete ensemble, or the coverall that provide protection to the firefighters' upper and lower torso, neck, arms and legs, excluding head, hands and feet.

Protective Coverall (Combinaison de protection)

The garment that provides protection to the firefighters' upper and lower torso, neck, arms and legs, excluding head, hands and feet.

Protective Garment (Vêtement de protection)

The protective coat, the protective trousers or the protective coverall.

Protective Trousers (Pantalon de protection)

The garment that provides protection to the firefighters' lower torso and legs, excluding the feet.

Reinforcement (Pièce de renfort)

Any fabric, material or manufacturing operation used to increase the mechanical strength or resistance to abrasion of any component of the ensemble.

Sewn Seams (Couture)

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

Thermal Barrier (Écran anti-chaleur)

The component designed to provide protection against heat.

Thermal Protection/Thermal Protective Performance (TPP)

((Protection contre la chaleur/capacité de protection thermique (TPP))

An indicator of the thermal energy input to a fabric specimen that is required to result in a heat transfer through the specimen sufficient to cause second-degree (partial thickness) burns in human tissue. The higher the TPP, the higher the level of protection provided.

Visibility Trim (Bande de visibilité)

Retroreflective and fluorescent materials permanently attached to the outer shell to enhance visibility.

Winter Liner (Doublure isolante)

An optional component designed to provide added insulation against cold.

4. GENERAL REQUIREMENTS**4.1 General**

- 4.1.1 The protective clothing shall consist of a composite of at least an outer shell, moisture barrier and thermal barrier. This composite may be configured as a single layer or combination of layers.
- 4.1.2 The protective garment shall have a means of securing the moisture barrier and the thermal barrier to the outer shell.
- 4.1.3 The distance from the outer shell sleeve ends to the thermal and moisture barriers shall not exceed 3.0 cm. The distance from the pant leg ends and coat hem to the thermal and moisture barriers shall not exceed 8.0 cm. At the neck, the coat moisture and thermal barriers shall extend to the neckline seam. The upper edge of the trouser moisture and thermal barriers shall extend at least to the waistline.
- 4.1.4 The garment shall have a positive front closure system to secure the garment. The front closure system shall be constructed to provide continuous moisture and thermal protection, consistent with the performance requirements of this standard.
- 4.1.5 The exterior pockets shall have a means of drainage and of fastening in the closed position. When specified (par. 10.1), at least the lowest 13.0 cm of each exterior cargo pocket shall be reinforced with a single thickness of additional material meeting the flame and heat resistance requirements of the outer shell.
- 4.1.6 An ensemble of coat and trousers shall have an overlap sufficient to provide continuous protection by all the layers, when the user is engaged in firefighting operations. To determine what should be considered a sufficient protective coat/trouser overlap, see section 8.
- 4.1.7 The pattern of visibility trim as required by this standard shall not be obscured by any garment components such as pockets, storm flaps and reinforcing patches.
- 4.2 **Wristlet** — Each sleeve shall have a permanently attached wristlet to provide protection to the wrist area.
 - 4.2.1 The wristlet assembly shall be designed to restrict the entry of water to the interior of the sleeve.
 - 4.2.2 The wristlet material shall be resilient so that the wristlet will fit snugly but not hinder donning, and not inhibit the use of hand protection.
- 4.3 **Collar** — The coat shall have a collar that is not less than 10.0 cm in height at any point, consisting of a composite that meets all the performance requirements of this standard with the exception of diffusion resistance.
 - 4.3.1 The collar shall have a closing system that, when closed, shall eliminate any gap.
 - 4.3.2 If the collar does not meet or overlap without the benefit of a throat tab, the throat tab shall meet the performance requirements of this standard with the exception of diffusion resistance.
- 4.4 **Hardware** — All hardware shall be free of rough spots, burrs or sharp edges.
 - 4.4.1 The protective trouser hardware shall not penetrate through the outer shell, moisture barrier and thermal barrier to the wearer's body when the trousers are worn with the closure system fastened, unless the hardware is located on or above the waistline, or is completely covered by external closure flaps.

- 4.5 **Reinforcement** — Except where reinforcement is made optional for exterior cargo pockets (par. 4.1.5), reinforcement shall be provided at stress points, such as but not limited to, pockets, crotch, storm flaps, pocket flaps, and where used, throat tabs.

5. DETAILED REQUIREMENTS

5.1 Requirements for a Variety of Components and Other Materials Used in Garment Construction

- 5.1.1 **Thermal Protection** — When tested in accordance with par. 6.1, the garment fabric composite, minus any optional removable winter liner (par. 10.1), shall exhibit an average TPP of not less than 35.0 for the ensemble. The wristlet shall exhibit an average TPP of not less than 20.0. If the individual results vary more than $\pm 8.0\%$ from the average result, the average result shall be discarded, and another set of specimens shall be tested.

- 5.1.2 **Flame Resistance** — The outer shell, lining fabrics (including but not limited to the moisture barrier, thermal barrier, winter liner), emblems² if placed on the outside of the garment wristlets, visibility trim, padding, reinforcement, interfacing, binding, collar and positive closure system shall be individually tested for flame resistance in accordance with par. 6.2. The average damaged length shall not be more than 100.0 mm, and the average afterflame shall not be more than 2.0 s. There shall be no molten drips. The flame resistance test shall be conducted both before and after five cycles of washing and drying in accordance with CAN/CGSB-4.2 No. 58, Procedure VII E. The temperature of the exhaust from the drum of the tumble dryer shall be set at 50 to 55°C.

- 5.1.3 **Heat Resistance** — The outer shell, moisture barrier, thermal barrier, winter liner fabric, and other materials used in construction, including wristlets, padding, reinforcement, garment labels, interfacing, binding, hangar loops and emblems, but excluding visibility trims, elastics and hook and pile fasteners when not placed in direct contact with the body, shall be individually tested for heat resistance and shall not melt, separate or ignite when tested in accordance with par. 6.3.

- 5.1.4 **Thermal Shrinkage Resistance** — The garment outer shell, moisture barrier, thermal barrier, collar lining, and winter liner fabric, and other materials used in construction, including but not limited to wristlets, padding and visibility trims shall not shrink more than 10.0% in any direction when tested in accordance with par. 6.3.

- 5.1.5 **Dimensional Stability in Laundering** — The outer shell and lining fabrics, including but not limited to the moisture barrier, thermal barrier, winter liner, collar and closure system shall be individually tested and shall not shrink more than 5.0% in either direction after five washing and drying cycles in accordance with CAN/CGSB-4.2 No. 58, Procedure VII E. The temperature of the exhaust from the drum of the tumble dryer shall be set at 50 to 55°C.

- 5.1.6 **Tearing Strength** — All tearing strength testing shall be in accordance with CAN/CGSB-4.2 No. 12.2.

- 5.1.6.1 The outer shell and the collar fabric shall have a tearing strength of at least 100.0 N before and 45.0 N after exposure in accordance with CAN/CGSB-4.2 No. 18.3/ISO 105-B02 using the low humidity and high temperature exposure conditions. The light exposure period should be such that an AATCC Blue Wool Lightfast Standard L5 shows a colour change equivalent to a Grey Scale 4 contrast in accordance with CAN/CGSB-4.2 No. 46/ISO 105-A02.

- 5.1.6.2 Each separable liner layer (moisture barrier, thermal barrier or single layer combining both functions) and the winter liner shall have a tearing strength of at least 25.0 N.

5.2 Thread Requirements

- 5.2.1 **Thread Type** — All thread used in the construction of the protective garment shall be inherently flame-resistant.

- 5.2.2 **Melting Resistance** — All thread used shall be tested for melting resistance and shall not melt below 260°C when tested in accordance with Fed. Std. 191A-1534.

5.3 Moisture Barrier — Additional Requirements

- 5.3.1 **Resistance to Water Penetration** — The moisture barrier fabric shall have a minimum water penetration resistance of 170 kPa when tested in accordance with Fed. Std. 191A-5512. The water penetration resistance testing shall be

² Emblems include but are not limited to any badge, insignia or lettering permanently attached to the outside of the garment during the manufacturing process.

conducted after five cycles of washing and drying in accordance with CAN/CGSB-4.2 No. 58, Procedure VII E. The temperature of the exhaust from the drum of the tumble dryer shall be set at 50 to 55°C.

- 5.3.2 **Water Resistance (Seams)** — The moisture barrier seams shall have a total resistance to water penetration when tested in accordance with Fed. Std. 191A-5516 for 5 min using a 700 mm hydrostatic head of water. The water resistance testing shall be conducted after five cycles of washing and drying in accordance with CAN/CGSB-4.2 No. 58, Procedure VII E. The temperature of the exhaust from the drum of the tumble dryer shall be set at 50 to 55°C.
- 5.3.3 **Diffusion Resistance** — The layer of the composite garment that serves as the moisture barrier, excluding reinforcing material and/or facings used in collar, throat tab, storm flap, sleeve well, waistband, knees and elbows shall have an average diffusion resistance not greater than the equivalent of 30.0 mm of still air when tested in accordance with CAN/CGSB-4.2 No. 49, (option 2).
- 5.4 **Outer Shell Fabric — Additional Requirement**
- 5.4.1 **Water Absorption** — The outer shell fabric shall have a water absorption of not more than 15.0% when tested in accordance with Fed. Std. 191A-5504. The water absorption resistance testing shall be conducted after five cycles of washing and drying in accordance with CAN/CGSB-4.2 No. 58, Procedure VII E. The temperature of the exhaust from the drum of the tumble dryer shall be set at 50 to 55°C.
- 5.5 **Visibility Trim — Additional Requirements**
- 5.5.1 **Dimensions and Area** — The trim shall not be less than 5 cm wide and shall have both retroreflective and fluorescent surfaces. The retroreflective surface of trim shall be not less than 1.6 cm wide. The fluorescent and retroreflective areas of trim shall appear to be continuous for the length of the trim, with gaps between areas of retroreflectivity of not more than 3.2 mm. The trim used to meet the minimum trim pattern requirements shall have a minimum fluorescent surface in accordance with par. 4-1.12.1 of NFPA 1971.
- 5.5.2 **Placement** — The trim configuration for the coat shall be in accordance with Figure 4-1.14.5 of NFPA 1971 front view (option 1) and back view (option 1) or back view only (option 3) as specified (par. 10.1). The minimum trim pattern for the coat shall be in accordance with par. 4-1.14.5 of NFPA 1971 except for the sleeve trim configuration. The sleeve trim configuration shall consist of one circumferential band around each arm between the wrist and the elbow area.
- 5.5.2.1 The trim configuration for the trousers shall be in accordance with Figure 4-1.15.3 of NFPA 1971. The minimum trim pattern for the trousers shall be in accordance with par. 4-1.15.3 of NFPA 1971.
- 5.5.2.2 Where a staggered pattern is used, the lower edge of the upper trim piece shall not be higher than the upper edge of the lower trim piece.
- 5.5.2.3 The trim used in excess of the minimum trim configuration and pattern of the garment is acceptable.
- 5.5.3 **Retroreflective Properties**
- 5.5.3.1 The visibility trim shall have a coefficient of retroreflection (R_A) of not less than 100.0 cd/lux/m² for the total ensemble when tested in accordance with ASTM E 809 and using the conditions specified in section 6.2 of ASTM E 808.
- 5.5.3.2 The specimens shall be tested for coefficient of retroreflection (R_A) in accordance with ASTM E 809, as modified herein, with a test distance of 15.2 m, an observation angle of 0.2°, an entrance angle of -4.0° and a photoreceptor angular aperture and source angular aperture of 0.1°. The projector exit aperture shall be circular with a diameter of 2.54 cm. The retroreflector reference angle shall be 90°. The datum mark shall be placed as specified by the trim manufacturer.
- 5.5.3.3 The coefficient of retroreflection (R_A) shall be calculated by the following equation:
- $$R_A = R_I/A_r$$
- where:
- R_I = the coefficient of luminous intensity, measured in accordance with par. 11 of ASTM E 809
- A_r = the retroreflective surface area

5.5.3.4 A_r shall be calculated by the following equation:

$$A_r = T_s - N_s$$

where:

T_s = the test specimen total surface area 0.092 m²

N_s = the non-retroreflective surface area

5.6 Hardware — Additional Requirements

5.6.1 **Heat Resistance** — All exterior hardware and closure systems shall be tested for heat resistance. When tested in accordance with par. 6.3.2, the hardware shall not ignite or melt and shall remain functional after testing. Hardware shall not be directly exposed on the inside of the garment and shall not come in direct contact with the body.

5.6.2 **Corrosion Resistance** — All metal hardware and hardware that includes metal parts shall not show more than light surface-type corrosion or oxidation for metals that are inherently resistant to corrosion (stainless steel, brass, aluminum and zinc). Ferrous metals shall show no corrosion of the base metal when tested in accordance with ASTM B 117 for 20 h.

5.6.3 **Rivets** — Rivets shall meet the requirements of FF-R-556D, except that the inside of the rivet shank may be chamfered.

5.6.4 **Snaps** — Snaps shall meet the requirements of MIL-F-10884.

5.6.5 **Hook and Dee Closures** — Hook and dee closures shall be non-ferrous and shall conform to the design in Figure 1.

5.7 **Hook and Pile Closures** — Hook and pile closures shall meet the requirements of MIL-CID AA55126A.

5.8 Ensemble — Requirements

5.8.1 **Seam Strength** — All seam assemblies shall be tested for breaking strength and shall demonstrate a sewn seam strength³ equal to or greater than 675.0 N force for Major A seams, 337.5 N force for Major B seams, and 180.0 N for all Minor seams when tested in accordance with either CAN/CGSB-4.2 No. 32.2 or ASTM D 1683.⁴ The test machine shall be operated at a rate of 305 ± 10 mm/min.

6. TEST METHODS

6.1 **Thermal Protection Test** — Condition all specimens in accordance with CAN/CGSB-4.2 No. 2. Testing shall be in accordance with Appendix A of this standard and shall be carried out no more than 5 min after the removal of the specimens from conditioning.

6.2 Flame Resistance Test

6.2.1 **Specimens** — Test six specimens with three specimens cut from each of the two major directions. Where the two surfaces of the fabric are different, cut another set of specimens and test both surfaces. Positive closure systems should be centered between two supporting pieces of outershell material. Overall size of fabric configuration to meet specimen size requirements. The trim and tape are to be attached to a specimen of outershell of the size required (Figure 2).

6.2.2 **Edge Ignition Procedure** — The outer shell, lining fabrics (including but not limited to the moisture barrier, thermal barrier and winter liner), visibility trim, padding, reinforcement, interfacing, binding, collar and positive closure system shall be individually tested in accordance with CAN/CGSB-4.2 No. 27.10, edge ignition procedure.

³ The seam breaking strength (including but not limited to wristlets) shall be considered acceptable when the fabric breaking strength determined in accordance with CAN/CGSB-4.2 No. 9.2 (with the speed of the clamp adjusted to 300 ± 10 mm/min) is less than the required seam strength specified in par. 5.8.1 of this standard, providing the fabric fails without the failure of the seam below the applicable forces specified in par. 5.8.1. The type of failure shall be reported.

⁴ In the event of a dispute, CAN/CGSB-4.2 No. 32.2 shall be the referee method.

6.2.3 **Surface Ignition Procedure** — The wristlet shall be individually tested in accordance with CAN/CGSB-4.2 No. 27.10, surface ignition procedure.

6.3 Heat Resistance and Thermal Shrinkage Resistance Tests

6.3.1 Fabric

6.3.1.1 **Specimens** — Cut three 180 × 180 mm specimens (± 10 mm in each direction) representative of the fabric lot to be used in the construction of the garment. On each specimen, mark three separate, accurately-measured (± 1.0 mm) distances of at least 150 mm in each of the principle directions of the fabric.

6.3.1.2 **Procedure** — Suspend each specimen from its top corners from two metal hooks separated by at least 170 mm in a forced-air circulating oven at $260 \pm 3^\circ\text{C}$. Each specimen shall be placed so that no part of it is less than 50 mm from any oven surface or from any other specimen; the direction of the airflow shall be parallel to the plane of the specimen. The oven shall be capable of regaining test temperature in a maximum of 30 s after insertion of the specimen(s). Expose the specimen(s) for a minimum of 5.0 min and a maximum of 5.25 min, beginning when the oven has recovered to a temperature of $260 \pm 3^\circ\text{C}$.

a. **Heat Resistance Results** — Remove the specimen(s) and immediately examine for evidence of ignition, melting or separation.

b. **Thermal Shrinkage Results** — Shake and smooth out on a flat surface, the specimen(s) from par. 6.3.1.2 a. Knit fabric shall be pulled to its original dimensions. Allow to relax for 1 min. Remeasure the marked distances and calculate the shrinkage in each of the two principle directions of the fabric. Average the shrinkage for each direction.

6.3.2 **Hardware** — Test three specimens. Support or freely suspend the hardware specimen near the centre of the oven so that it is at least 50.0 cm from any oven surface and is exposed to the circulating air. The specimen shall be maintained at $260 \pm 3^\circ\text{C}$ for a minimum of 5 min and a maximum of 5.25 min, beginning when the oven has recovered to an air temperature of $260 \pm 3^\circ\text{C}$. Note any melting, or ignition of specimens and ensure functionality.

7. LABELLING

7.1 All garments shall have affixed a label with warnings and information in French and English as shown on the following page.

7.2 All labels shall be clearly legible before and after five cycles of washing and drying in accordance with CAN/CGSB-4.2 No. 58, Procedure VII E. The temperature of the exhaust from the drum of the tumble dryer shall be set at 50 to 55°C .

THIS GARMENT MEETS THE REQUIREMENTS OF CAN/CGSB-155.1.

WARNING

DO NOT USE FOR PROXIMITY OR FIRE-ENTRY APPLICATIONS OR FOR PROTECTION FROM CHEMICAL, RADIOLOGICAL, ELECTRICAL OR BIOLOGICAL HAZARDS. KEEP CLEAN — SOILING WILL REDUCE PROTECTIVE QUALITIES.

OUTER SHELL, MOISTURE BARRIER AND THERMAL BARRIER, MEETING ALL REQUIREMENTS OF CAN/CGSB-155.1 MUST BE USED AND ALL GARMENT CLOSURES MUST BE FASTENED WHEN IN USE.

Manufacturers name and mailing address or CA number

Date of manufacture

Size

Cleaning and drying instructions (in accordance with CAN/CGSB-86.1)

Fibre content (in accordance with the Textile Labelling Act)

“DO NOT REMOVE THIS LABEL”

CE VÊTEMENT EST CONFORME AUX EXIGENCES DE LA NORME CAN/CGSB-155.1.

AVERTISSEMENT

NE PAS UTILISER COMME VÊTEMENT D'APPROCHE NI DE PÉNÉTRATION DANS LES FLAMMES NI COMME PROTECTION CONTRE LES DANGERS CHIMIQUES, RADIOLOGIQUES, ÉLECTRIQUES OU BIOLOGIQUES. GARDER PROPRE — LES SOUILLURES RÉDUISENT LA PROTECTION.

UN TISSU EXTÉRIEUR, UN ÉCRAN IMPERMÉABLE ET UN ÉCRAN ANTI-CHALEUR CONFORMES AUX EXIGENCES DE LA NORME CAN/CGSB-155.1 DOIVENT ÊTRE UTILISÉS ET TOUS LES SYSTÈMES DE FERMETURE DU VÊTEMENT DOIVENT ÊTRE ADÉQUATEMENT FERMÉS LORSQUE LE VÊTEMENT EST PORTÉ.

Nom et adresse postale ou numéro CA du fabricant

Date de fabrication

Taille

Instructions de lavage et de séchage (conformément à la norme CAN/CGSB-86.1)

Teneur en fibre (conformément à la Loi sur l'étiquetage des textiles)

“ NE PAS ENLEVER CETTE ÉTIQUETTE ”

8. INSTRUCTIONS FOR USE/INFORMATION SHEET

- 8.1 In addition to the instructions affixed to each garment, each garment offered for sale shall be accompanied by a sheet or booklet, readily accessible to the purchaser, which contains the following information in French and English.

PROTECTIVE COAT AND TROUSERS OVERLAP

AN ENSEMBLE OF COAT AND TROUSERS MAY BE UNSAFE IF THE OVERLAP OF ALL PROTECTIVE LAYERS (LINERS) IS NOT SUFFICIENT TO PREVENT GAPS FORMING DURING FIREFIGHTING OPERATIONS.

IT IS THE RESPONSIBILITY OF THE USER OF THIS SUIT TO VERIFY THAT THE OVERLAP OF THE PROTECTIVE LAYERS IS A MINIMUM OF 5 CM WHILE (A) REACHING HIGH OVERHEAD AND (B) BENDING OVER FORWARDS.

CHEVAUCHEMENT DU MANTEAU ET DU PANTALON DE PROTECTION

UN ENSEMBLE CONSTITUÉ D'UN MANTEAU ET D'UN PANTALON PEUT ÊTRE NON SÉCURITAIRE SI LE CHEVAUCHEMENT DE TOUTES LES ÉPAISSEURS DE PROTECTION (DOUBLURES) N'EST PAS SUFFISANT POUR EMPÊCHER LA FORMATION DE ZONE NON PROTÉGÉE PENDANT LES ACTIVITÉS DE LUTTE CONTRE LES INCENDIES.

IL INCOMBE À L'UTILISATEUR DE L'ENSEMBLE DE VÉRIFIER SI LE CHEVAUCHEMENT DES ÉPAISSEURS DE PROTECTION EST D'AU MOINS 5 CM (A) LORSQU'IL LÈVE LES BRAS AU-DESSUS DE LA TÊTE ET (B) LORSQU'IL SE PENCHE VERS L'AVANT.

9. PREPARATION FOR DELIVERY

- 9.1 The manufacturer shall provide to the purchaser upon request, the latest version (in both official languages) of the guidelines with respect to garment inspection and criteria, and care and maintenance.

10. NOTES

- 10.1 **Options** — The following options must be specified in the application of this standard:

- a. Reinforcement for exterior cargo pockets, if required (par. 4.1.5)
- b. Winter liner, if required (par. 5.1.1)
- c. Coat back visibility trim, option 1 or option 3 (par. 5.5.2).

10.2 Related Publication

- 10.2.1 International Organization for Standardization (ISO)

ISO 11613 — Protective clothing for firefighters — Laboratory test methods and performance requirements.

10.3 Sources of Referenced Publications

- 10.3.1 The publications referred to in par. 2.1.1 may be obtained from the Canadian General Standards Board, Sales Centre, Ottawa, Canada K1A 1G6. Telephone (819) 956-0425 or 1-800-665-CGSB (Canada only). Fax (819) 956-5644.
- 10.3.2 The publication referred to in par. 2.1.2 may be obtained from the Canada Communication Group Inc., Publishing, Ottawa, Canada K1A 0S9. Telephone (819) 956-4802. Fax (819) 994-1498.
- 10.3.3 The publications referred to in par. 2.1.3 may be obtained from the American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959, U.S.A., telephone (610) 832-9585, or from IHS Canada (see par. 10.3.6).

- 10.3.4 The publications referred to in par. 2.1.4 and 2.1.5 may be obtained from the Department of the Navy, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120-5099, U.S.A. or from IHS Canada (see par. 10.3.6).
- 10.3.5 The publication referred to in par. 2.1.6 may be obtained from the National Fire Protection Association, One Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101 or from the Canadian Association of Fire Chiefs, 2425 Don Reid Drive, Unit 1, Ottawa, Ontario K1H 1A4, telephone (613) 736-0576.
- 10.3.6 The publication referred to in par. 10.2.1 may be obtained from IHS Canada, 240 Catherine Street, Suite 305, Ottawa, Ontario K2P 2G8. Telephone (613) 237-4250 or 1-800-567-1914. Fax (613) 237-4251.

Withdrawn/Retirée

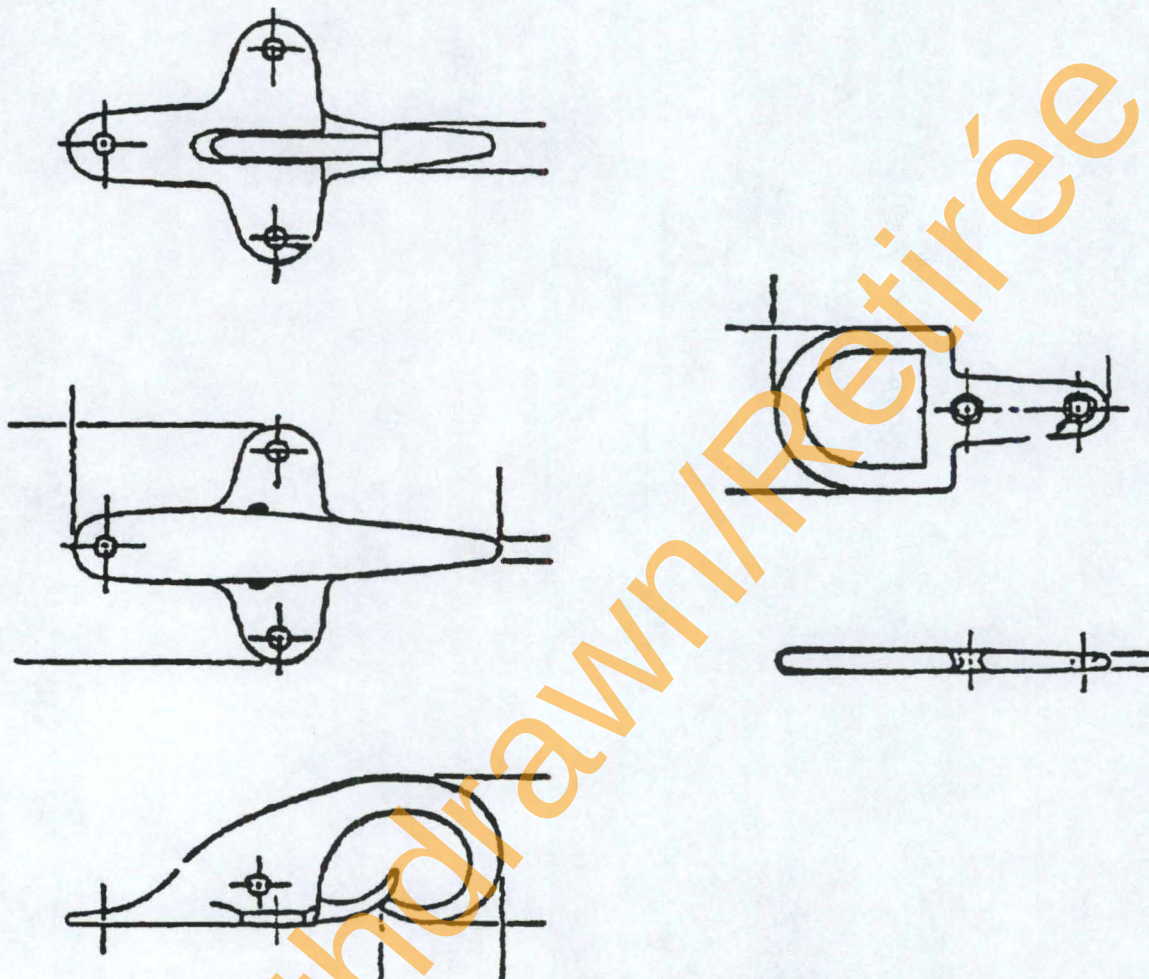


FIGURE 1
Hook and Dee Ring (Inward Facing)
(Not to Scale)

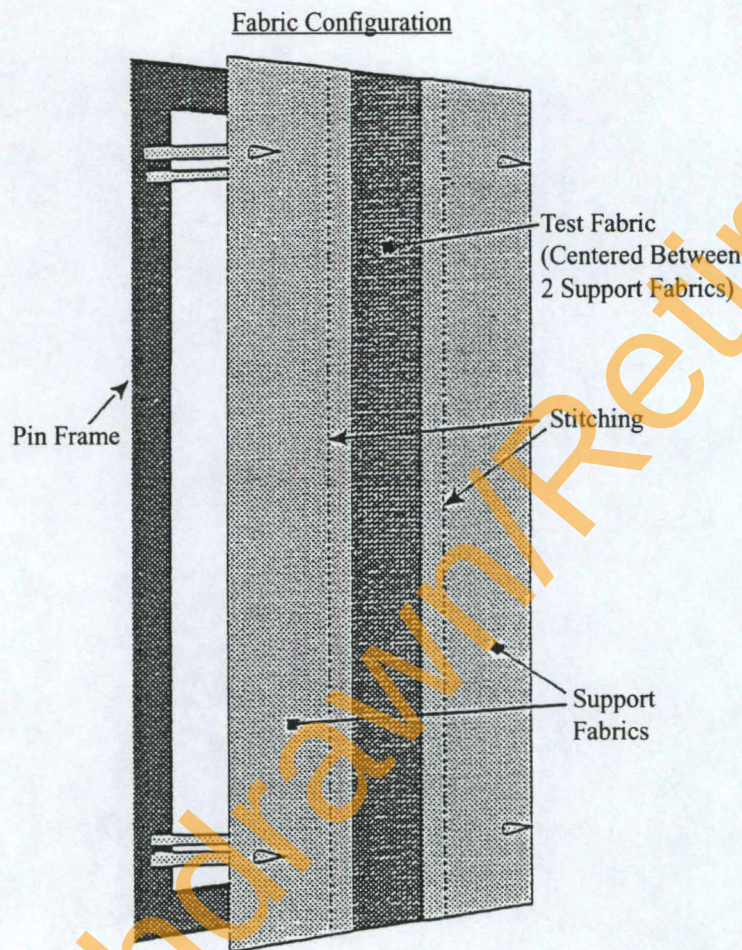


FIGURE 2
Flame Resistance Testing of Narrow Components

(This appendix forms a mandatory part of the standard.)

THERMAL PROTECTIVE PERFORMANCE TEST

A1. PRINCIPLE

- A1.1 Horizontally-oriented specimens of the component assembly are exposed to a 50/50 combined convective and radiant heat source at $83 \pm 4 \text{ kW/m}^2$ produced by a bank of nine quartz radiant tubes and two Meker burners angled under the specimen. A copper calorimeter is used to measure the heat flux through the specimen. The curve of heat flux versus time is used to determine the estimated time to second degree burn using human skin heat tolerance data.

A2. APPARATUS

- A2.1 **Overall Configuration** — The test apparatus shall consist of a specimen holder assembly, a specimen holder assembly support, a thermal flux source, a protective shutter, a sensor assembly, and a recorder. The apparatus shall also have a gas supply, a gas rotameter, burners and a sensor.
- A2.1.1 **Specimen Holder Assembly** — The specimen holder assembly shall consist of upper and lower mounting plates. The specimen holder maintaining plates shall be $203 \pm 1.6 \text{ mm} \times 203 \pm 1.6 \text{ mm} \times 6.4 \pm 0.8 \text{ mm}$. The lower specimen mounting plate shall have a centered hole of $102 \pm 1.6 \text{ mm} \times 102 \pm 1.6 \text{ mm}$. The upper specimen mounting plate shall have a centered hole of $130 \pm 1.6 \text{ mm} \times 130 \pm 1.6 \text{ mm}$. The lower specimen mounting plate shall have a $25 \pm 1.6 \text{ mm}$ high $\times 3.2 \pm 0.8 \text{ mm}$ thick steel post welded to each corner $6.4 \pm 1.6 \text{ mm}$ from each side and perpendicular to the plane of the plate, or some other method for aligning the specimen shall be provided. 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. Specifications for the specimen holder assembly are provided in Figure A1.
- A2.1.2 **Specimen Holder Assembly Support** — The specimen holder assembly support shall consist of a steel frame that rigidly holds and positions, in a reproducible manner, the specimen holder assembly and a specimen relative to the thermal flux.
- A2.1.3 **Thermal Flux Source** — The thermal flux source shall consist of a convective thermal flux source and a radiant thermal flux source. The convective thermal flux source shall consist of two Meker burners affixed beneath the specimen holder assembly opening, and subtended at a nominal 45° angle from the vertical so that the flames converge at a point immediately beneath the specimen. The radiant thermal flux source shall consist of nine quartz T-150 infrared tubes affixed beneath and centered between the burners as shown in Figure A2. The burners shall be Meker burners with a 38 mm diameter top and with an orifice size of 1.2 mm for propane, or 2.4 mm for methane or natural gas.
- A2.1.4 **Protective Shutter** — The protective shutter shall be placed between the thermal flux source and the specimen. The protective shutter shall be capable of completely dissipating the thermal load from the thermal flux source for the time periods before and after specimen exposure.
- A2.1.5 **Sensor Assembly** — The sensor assembly shall be a copper calorimeter mounted in an insulating block. The calorimeter shall conform to the specifications provided in Figure A3. The sensor shall be coated with a thin layer of flat black paint, with an emissivity of at least 0.95. The sensor assembly shall consist of a $133 \times 133 \times 13 \text{ mm}$ heat-resistant block that fits without binding into the hole of the upper specimen mounting plate. The sensor assembly shall be uniformly weighted so that the complete sensor assembly, including copper calorimeters, weighs $1000 \pm 10 \text{ g}$. The sensor assembly shall be fitted into the opening in the top plate of the specimen holder and be in contact with the surface of the thermal barrier normally facing the wearer.^{A1}
- A2.1.6 **Recorder** — The recorder shall be a strip chart recorder with full scale deflection of at least 150°C or 10 mV and sufficient sensitivity and scale divisions to read exposure time to $\pm 0.1 \text{ s}$. Alternatively, an equivalent automated data

^{A1} A suitable paint is Medtherm flat black paint having an absorptivity of 0.95 and temperature rating of 182°C available from Medtherm Corporation. P. O. Box 412, Huntsville, AL 35804, U.S.A. Telephone 1-256-837-2000.

acquisition system meeting or exceeding the sensitivity and accuracy requirements of the strip chart recorder shall be permitted to be used instead of a strip chart recorder.

- A2.1.7 **Gas Supply** — The gas supply shall be propane, methane or natural gas with appropriate reducer and valving arrangements to control the gas supply pressure at 55 ± 1 kPa and capable of providing flow equivalent to 2 L/min air at standard conditions.
- A2.1.8 **Gas Rotameter** — The gas rotameter shall have a range of performance to give flow equivalent to 2 L air at standard conditions.
- A2.1.9 **Radiometer** — The radiometer shall be a Gardon type radiation transducer with a diameter of 25 mm, a minimum 150° view angle, and a heat flux operating range from 0 to 60 kW/m². If the radiometer is water cooled, the cooling water temperature shall be above the ambient dew point temperature.^{A2}

A3. SPECIMENS

- A3.1 Thermal protective performance testing shall be conducted on three specimens. Specimens shall measure 150 ± 6.4 mm $\times$ 150 ± 6.4 mm and shall consist of all layers representative of the clothing item to be tested. Specimens shall not include seams. Specimens may be bar-tacked in one corner only, to facilitate the handling of the samples during the test.

A4. PROCEDURES

- A4.1 **General Procedures** — All testing and calibration shall be performed in a hood or ventilated area to carry away combustion products, smoke, or fumes. If air currents disturb the flame, the apparatus shall be shielded. Procedures for testing and calibration shall be performed using the same hood and ventilation conditions.

- A4.1.1 Care shall be exercised in handling the burner with open flame. Adequate separation shall be maintained between flame and combustible materials. Since the specimen holder and sensor assembly become heated during prolonged testing, protective gloves shall be used when handling these hot objects. Since some test specimens become hazardous when exposed to direct flame, care shall be used when the specimen ignites or releases combustible gases. If specimens ignite, the gas supply at the cylinder shall be shut off and the flame shall be allowed to burn the gas.

A4.2 Calibration Procedures

A4.2.1 Copper Calorimeter Calibration

- A4.2.1.1 Calibration of the copper calorimeter is based on the following equation:

$$I = \left(\frac{mc}{A\epsilon} \right) \times \left(\frac{dT}{dt} \right)$$

where:

I = the incident heat flux, kW/m²

dT/dt = the rate of temperature rise for the calorimeter indicated by °C/s

- A4.2.1.2 $(mc/A\epsilon)$ represents the calorimeter's physical constant, which includes the following material properties.

m = the finished mass (kg) of the calorimeter which includes the copper disk and flat black paint mass on the sensing surface minus the thermocouple mass

c = the heat capacity of pure copper, which is 0.385 kJ/kg°C

A = the surface area (0.001257 m²) for the calorimeter's front surface which is exposed to the test heat flux

ϵ = the emissivity (or absorptivity) of the black paint used on the calorimeter's front surface, usually a value not less than 0.95

^{A2} A combination total calorimeter/radiometer Model 64P-5-24 from Medtherm Corporation, P.O. Box 412, Huntsville, AL 35804, U.S.A, telephone 1-256-837-2000, has been found satisfactory for this purpose.

The physical constant used in calibration calculations with these sensors is sensitive to changes in mass and/or emissivity values. For the copper disk calorimeter used in the TPP test, the punched out and drilled copper slug mass must be 18.0 ± 0.1 g. The calorimeter's physical constant can be calculated based on the above discussion. Check the repaired calorimeter's performance by substituting it with the calibration calorimeter. After proving equivalence, the test calorimeter may be placed back into service.

- A4.2.2 Specimens shall be exposed to a thermal flux of 83 ± 4 kW/m² as measured with the copper calorimeter. The copper calorimeter shall be the only heat sensor used in setting the total 83 kW/m² exposure condition. The total heat flux shall be calculated directly and only from the output of the thermocouples, using the measured temperature rise of the testing copper calorimeter, the area and mass of the calorimeter, and the heat capacity of copper to calibrate the heat flux. Other heat sensing devices shall not be used to reference or adjust the total heat flux read by the copper calorimeter.
- A4.2.3 The total heat flux and the 50%/50% $\pm 5\%$ radiant/convective balance of the energy sources shall be set in accordance with these procedures. The level of the radiant heat flux shall be determined using a radiometer, and the level of the total heat flux shall be determined by using a calibration copper calorimeter designated and used only to set the total exposure level.
- A4.2.4 Once an initial setting of 12 ± 4 kW/m² has been made to the array of new quartz lamps, the operating voltage shall be recorded and permanently retained for testing purposes. During all future calibration procedures, the voltage setting of the quartz lamps shall be compared to the current voltage setting of the new quartz lamps, and if the voltage increase is 5 V or greater from the initial setting, the lamps shall be replaced.
- A4.2.5 The two Meker burners shall be initially adjusted so that the flame converge upon each other just below the center of the radiometer, before adjusting the voltage supply to the nine quartz tubes to a total radiant heat flux of 42 ± 4 kW/m².
- A4.2.6 The radiant thermal flux source of nine quartz infrared tubes alone shall be set to an incoming radiant heat flux of 12 ± 4 kW/m² using a commercial radiometer meeting the specifications of par. A2.1.9. The radiometer window shall be positioned at the geometric center of the sample holder and at the same plane as a test specimen. The radiometer shall be mounted in a holder of the same overall size, shape, and material as the one used for the copper calorimeter to assure similar heat and flame patterns across the faces of the radiometer and calorimeters. The radiant quartz tubes shall be turned on and "run" for a minimum of 2 min prior to measuring the radiant heat flux.
- A4.2.7 The total radiant thermal flux shall be set at 42 ± 4 kW/m² by using a radiometer specified in par. A2.1.9 to measure the radiant heat flux from both the nine quartz tubes and the two Meker or Fisher burners by adjusting only the voltage supplies to the nine quartz tubes.
- A4.2.8 The total heat flux shall be set at 83 ± 4 kW/m² using the calibration copper calorimeter by adjusting only the gas supply to the Meker burners. Without a mounted specimen, the calibration copper calorimeter shall be placed on top of the specimen holder with the blackened copper calorimeter facing down, and then exposed directly to the flame of the burner. The response of the calorimeter shall be recorded for at least 10 s. The lowest temperature point on the curve where the response is linear shall be chosen, and the increase in sensor temperature for 10 s of heating shall also be determined. The initial reading from the 10 s reading shall be subtracted to obtain the increase. The required temperature rise in 10 s can be calculated using the equation in par. A4.2.1.1. For example, for a sensor with a mass of 18.0 g and an emissivity of 0.98, the response shall be $148 \pm 7.1^\circ\text{C}$ for an exposure heat flux of 83 ± 4 kW/m².
- A4.2.9 Procedures in par. A4.2.7 and A4.2.8 shall be repeated until both the radiant thermal heat flux and the total heat flux are within the ± 4 kW/m² of the levels specified.

A4.3 Test Procedure

- A4.3.1 After the total thermal heat flux has been set at 83 ± 4 kW/m² using the calibration procedure in par. A4.2.5 to A4.2.9, the testing copper calorimeter shall be used to measure the total heat flux. Prior to testing, the testing copper calorimeter shall be used to measure the total heat flux by placing the calorimeter facing down, and then exposing it directly to the total heat source. The response of the calorimeter shall be recorded for at least 10 s. The lowest temperature point on the curve where the response is linear shall be chosen, and the increase in sensor temperature for 10 s of heating shall be determined. The initial reading from the 10 s reading shall be subtracted to obtain the increase.

- A4.3.2 If the measurement from the testing copper calorimeter is within $\pm 4 \text{ kW/m}^2$ then testing shall be done. If the measurement from the testing copper calorimeter does not agree within $\pm 4 \text{ kW/m}^2$ of the measurement of the calibration calorimeter, the testing copper calorimeter shall be repaired, reconditioned, or replaced to achieve agreement.^{A3}
- A4.3.3 Specimens shall be mounted by placing the surface of the material to be used as the outside of the garment face down on the mounting plate. The subsequent layers shall be placed on top in the order used in the garment, with the surface to be worn toward the skin facing up. With the protective shutter engaged, the specimens shall be placed on the specimen holder.
- A4.3.4 The testing copper calorimeter shall be placed directly on the specimen in contact with the surface to be worn toward the skin.
- A4.3.5 The protective shutter shall be retracted and chart paper movement on the recorder shall be started using a chart speed consistent with the preparation of the overlay described in par. A4.4.1. The start time of the exposure shall be indicated. The exposure shall be continued for 30 s. The protective shutter shall be engaged (closed), the recorder shall be stopped, the calorimeter shall be removed and cooled, and then the specimen holder and exposed specimen shall be removed.
- A4.3.6 After each exposure, the calorimeter shall be cooled to $33 \pm 1^\circ\text{C}$ before the next heat flux determination. The sensor shall be cooled after exposure with a jet of air or by contact with a cold surface.
- A4.3.7 The sensor face shall be wiped immediately after each run, while hot, to remove any decomposition products which 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 acetone or petroleum solvent, making certain there is no ignition source nearby.
- A4.3.7.1 If copper is showing on the testing copper calorimeter, the surface shall be completely repainted with a thin layer of flat black paint, with an emissivity of at least 0.95. At least one calibration run shall be performed comparing the testing copper calorimeter with the calibration copper calorimeter. If the testing calorimeter is in error by more than $\pm 4 \text{ kW/m}^2$, all electrical connections and points where thermocouples are secured to the testing calorimeter shall be checked. Two more calibration runs shall be conducted by comparing the testing copper calorimeter with the calibration grade copper calorimeter. The average error shall be calculated. If the average error of the testing calorimeter is more than $\pm 4 \text{ kW/m}^2$, then the testing calorimeter shall be repaired and recalibrated or the testing calorimeter shall be replaced.

A4.4 Preparation of Human Tissue Burn Tolerance

- A4.4.1 **Tolerance Overlay** — The thermal end point shall be determined with a plot energy versus the estimated time to cause a second-degree burn in human tissue as shown in Table A1. The calorimeter equivalent from Table A1 which corresponds to the recorder scale shall be plotted on recorder chart paper. $\Delta T^\circ\text{C}$ (Column 4) or ΔmV (Column 5) shall be plotted on the vertical axis and the corresponding time (column 1) shall be plotted on the horizontal axis. Chart units based on the recorder full scale deflection and the chart speed for a graph directly comparable to the recorder sensor trace shall be used. If the pen deflection is from left to right and the paper movement down, plot from right to left with the origin at lower right. If the recorder trace differs, the graph shall be adjusted accordingly.

^{A3} *Copper Calorimeter Repair Procedures: The copper disk may be removed from its support board and checked to ensure that all thermocouple to disk connections are securely made. Any loose connections should be repaired. To repair loose connections, the thermocouple data transfer wire should be removed, while leaving the short thermocouple wires extending from the sensor's back side. The sensing surface should be smoothed, cleaned and repainted with a quality flat black paint of known emissivity, with a value of no less than 0.95. It may take two or three light coats to completely and evenly cover the surface. After the paint has thoroughly dried, the finished calorimeter should be carefully weighed, and its total mass recorded to an accuracy of 0.01 g. The total mass should include the copper disk mass with the short thermocouple wires attached, and also includes the mass of flat black paint applied to the calorimeter's surface. The calorimeter's finished mass should be determined by subtracting the sensor's thermocouple wire mass from the sensor's total mass. This is accomplished by measuring the sensor's thermocouple wire lengths from their ends down to the calorimeter's back surface. Then the total wire mass should be calculated based on the number of wires and their lengths. This value should then be subtracted from the total mass of the calorimeter assembly to obtain the finished mass. After the finished mass is determined, the data transfer wires should be securely reconnected, and the sensor repositioned in its support board.*

An exact transparent duplicate shall be made for the overlay. The overlay shall be compared with the original to ensure change in the overlay size.

TABLE A1
Human Tissue* — Tolerance to Second-Degree Burn

Exposure Time	Heat Flux	Total Energy	Calorimeter** Equivalent	
			$\Delta T^{\circ}\text{C}$	ΔmV
s	kW/m ²	kJ/m ²		
1	50	50	8.9	0.46
2	31	61	10.8	0.57
3	23	69	12.2	0.63
4	19	75	13.3	0.69
5	16	80	14.1	0.72
6	14	85	15.1	0.78
7	13	88	15.5	0.8
8	11.5	92	16.2	0.83
9	10.6	95	16.8	0.86
10	9.8	98	17.3	0.89
11	9.2	101	17.8	0.92
12	8.6	103	18.2	0.94
13	8.1	106	18.7	0.97
14	7.7	108	19.1	0.99
15	7.4	111	19.7	1.02
16	7.0	113	19.8	1.03
17	6.7	114	20.2	1.04
18	6.4	116	20.6	1.06
19	6.2	118	20.8	1.08
20	6.0	120	21.2	1.1
25	5.1	128	22.6	1.17
30	4.5	134	23.8	1.23

*Stoll, A.M. and Chianta, M.A., "Method and Rating System for Evaluation of Thermal Protection, Aerospace Medicine," Vol. 40, 1969, pp. 1232-1238.

Stoll, A.M. and Chianta, M.A., "Heat Transfer Through Fabrics as Related to Thermal Injury, Transactions—New York Academy of Sciences, 33 (7) Nov. 1971, pp. 649-670.

**Iron-constantan thermocouple.

A4.4.2 Computer Processing of the Data — The information provided in Table A1 may be used as the criteria of performance in the software of a computer program. In this case, the sensor response shall be compared with the estimated time to second degree burn in human tissue to determine the thermal end points.

A4.5 Determination of Test Results — The time-to-second degree burn shall be graphically determined from the recorder chart of the sensor response and criterion overlay prepared in Table A1. The overlay shall be positioned on

the recorder chart, matching the zero of the overlay with the exposure start time resulting from heat transfer. The horizontal axis (time) shall be placed in line with the initial trace of the pen, keeping the overlay square with the recorder chart. The time-to-second degree burn shall be read to the nearest 0.1 s from the overlay chart at the point when the sensor response curve and the tissue tolerance curve cross. If the sensor response curve and the tissue tolerance curves do not cross, no burn shall be recorded as the test result.

- A4.5.1 If a computer software program is used, the sensor response should be compared with the data describing the human tissue heat tolerance to determine like values. The time from the start of the exposure to the time when these values are the same is taken as the exposure time.

A5. REPORT

The individual TPP rating of each specimen shall be reported. The average TPP rating shall be calculated as specified below.

$$\text{TPP rating} = F \times T$$

where:

F = exposure energy heat flux ($\text{cal}/\text{cm}^2/\text{s}$) = exposure energy heat flux (kW/m^2) $\div 41.9$

T = estimated time to second degree burn determined in the test (s)

If a TPP rating is greater than 60, then the TPP rating shall be reported as ">60." Pass or fail determinations shall be based on the average reported TPP rating of all specimens tested. If an individual result from any test set varies more than $\pm 8\%$ from the average result, the results from the test set shall be discarded and another set of specimens shall be tested.

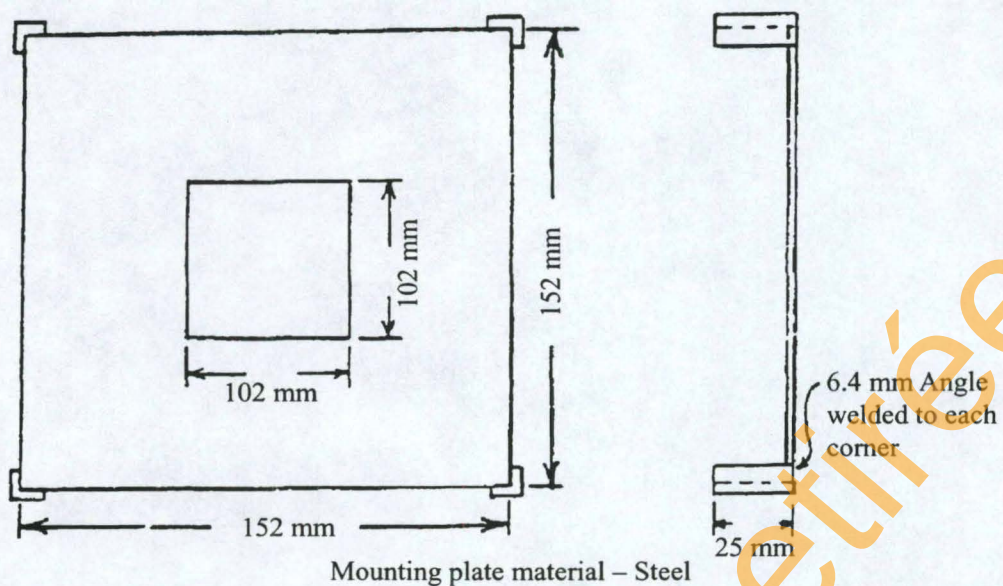


FIGURE A1

Specifications for Specimen Holder Assembly

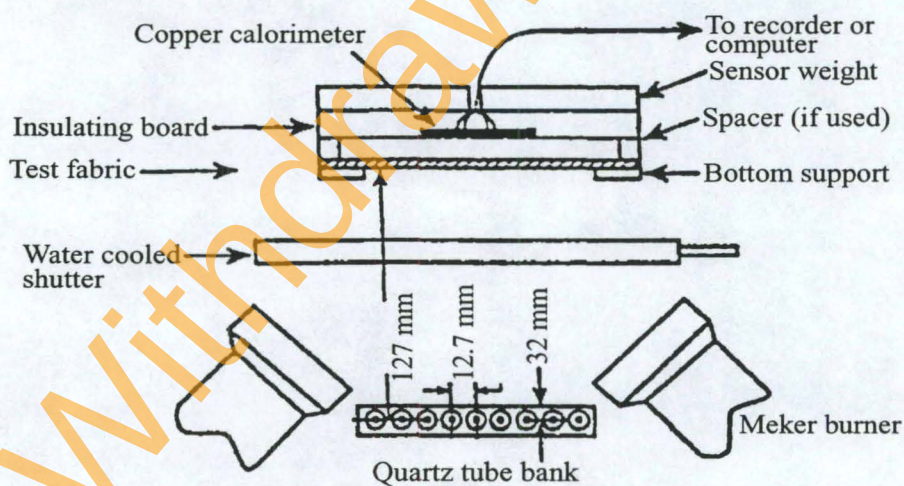
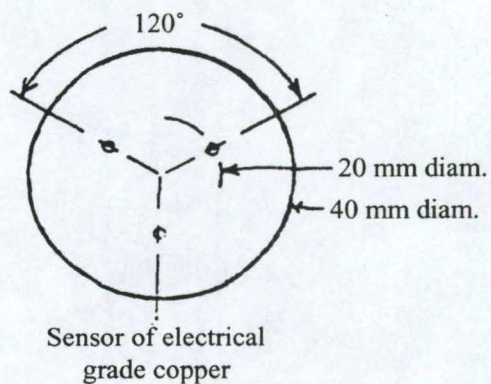
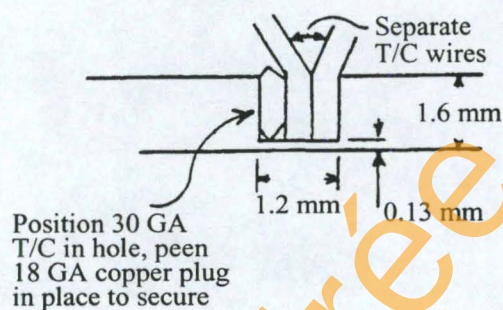


FIGURE A2

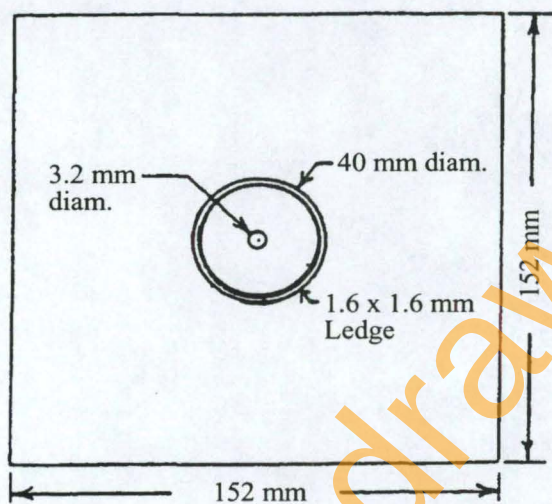
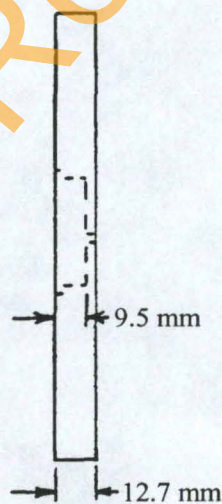
Specifications for TPP Tester Thermal Flux Source



Hole detail and method of securing thermocouple



Details of Calorimeter Construction



Sensor Support of Soft Insulation Board

Connect 4 T/C in parallel, silver solder connections. Bring common lead out of centre hole of support. Secure sensor into support with 3 or 4 sewing pins cut to 9.5 mm long.

Note: Calorimeters should be painted with flat black paint.

FIGURE A3

Specifications for Sensor Assembly



Withdrawn/Retirée