Change the title of section 7.1 from:

"7.1 Fabric Requirements."

to:

"7.1 Garment and Fabric Requirements."

Submitter Information Verification

Submitter Full Name: Eric Nette
Organization: [ Not Specified ]
Street Address: 
City: 
State:
Zip: 
Submittal Date: Wed Nov 05 14:21:47 CST 2014

Committee Statement

Committee Statement: This establishes performance requirements for the additional items.
Response Message:
First Revision No. 40-NFPA 2112-2014 [ Global Input ]

Change title to:
“Standard on Flame-Resistant Clothing for Protection of Industrial Personnel Against Short-Duration Thermal Exposures from Fire”

Submitter Information Verification

Submitter Full Name: Eric Nette
Organization: [ Not Specified ]
Street Address: 
City: 
State: 
Zip: 
Submittal Date: Wed Nov 05 14:52:11 CST 2014

Committee Statement

Committee Statement: The title was changed to maintain consistency with NFPA 2113 and to address the clothing items that were added to the scope of the document. This document represents minimum specifications of clothing for egress of workers with the intent of not contributing to the burn injury of the wearer, providing a degree of protection to the wearer, and reducing the severity of burn injuries resulting from short-duration thermal exposures or accidental exposure to flash fires.

Response Message:
Public Input No. 34-NFPA 2112-2014 [Global Input]
Public Input No. 26-NFPA 2112-2014 [Global Input]
Change the title of Section 8.4.8 from:
"8.4.8 Specific Requirements for Testing Flame-Resistant Garment Textile Materials."
to:
"8.4.8 Specific Requirements for Testing Flame-Resistant Garment, Shroud/Hood/Balaclava, Glove and Rainwear Textile Materials."

Submitter Information Verification

Submitter Full Name: Eric Nette
Organization: [ Not Specified ]
Street Address:
City:
State:
Zip:
Submittal Date: Thu Nov 06 06:14:55 CST 2014

Committee Statement

Committee Statement: Additional clothing items were added to the scope of the document. The committee would like to solicit Public Comments on the test method. Data and refinements to the methods will be submitted and considered.

Response Message:
First Revision No. 57-NFPA 2112-2014 [Global Input]

Change the title of Section 8.4.9 from:

"8.4.9 Specific Requirements for Testing Other Flame-Resistant Garment Materials (Including Reflective Striping)."

to:

"8.4.9 Specific Requirements for Testing Other Flame-Resistant Garment, Shroud/Hood/Balaclava, Glove, and Rainwear Materials (Including Reflective Striping)."

Submitter Information Verification

Submitter Full Name: Eric Nette
Organization: [Not Specified]
Street Address:
City:
State:
Zip:
Submittal Date: Thu Nov 06 06:17:35 CST 2014

Committee Statement

Committee Statement: Additional clothing items were added to the scope of the document. The committee would like to solicit Public Comments on the test method. Data and refinements to the methods will be submitted and considered.

Response Message:
Chapter 1

1.1 Scope.
The standard shall specify the minimum design, performance, testing, and certification requirements and test methods for flame-resistant fabrics and components and the design and certification requirements for garments for garments, shrouds/hoods/balaclavas, gloves, and rainwear for use in areas at risk from flash fires short-duration thermal exposure from fire.

1.2 Purpose.

1.2.1 This standard shall provide minimum requirements for the design, construction, evaluation, and certification of flame-resistant garments, shrouds/hoods/balaclavas, gloves, and rainwear for use by industrial personnel, with the intent of not contributing to the burn injury of the wearer, providing a degree of protection to the wearer, and reducing the severity of burn injuries resulting during egress, from or accidental exposure to short-duration thermal exposures or accidental exposure to flash fires exposure from fire.

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

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

1.3 Application.

1.3.1 This standard shall apply to the design, manufacturing, and certification of new flame-resistant garments, shrouds/hoods/balaclavas, gloves, and rainwear.

1.3.2 This standard shall not apply to protective clothing for wildland fire-fighting, technical rescue, structural fire-fighting, proximity fire-fighting, or any other fire-fighting operations or hazardous materials emergencies. This standard shall not apply to single-use or limited-use garments. This standard shall not apply to protection from electrical flashes, radiological agents, biological agents, or hazardous materials.

1.3.3 Certification of flame-resistant garments to the requirements of this standard shall not preclude certification to additional appropriate standards where the garment, shrouds/hoods/balaclavas, gloves, or rainwear meets all the applicable requirements of each standard.

1.3.4 The requirements of this standard shall not apply to accessories that might be attached to flame-resistant garments, shrouds/hoods/balaclavas, gloves, or rainwear unless specifically addressed herein.

1.3.5 The minimum requirements identified in this standard are not intended to meet all the protection needs of a user in areas at risk from flash fires short-duration thermal exposure from fire. Users shall refer to NFPA 2113, Standard on Selection, Care, Use, and Maintenance of Flame-Resistant Garments for Protection of Industrial Personnel Against Flash Fire, for conducting the appropriate hazard assessment to identify the in-use area’s minimum protection requirements.

1.4 Retroactivity.
This standard shall only apply only to garments, shrouds/hoods/balaclavas, gloves, or rainwear manufactured on or after the effective date of the standard.

1.5 Equivalency.
Nothing herein shall restrict any jurisdiction or manufacturer from exceeding these minimum requirements.
1.6 Units.
In this standard, values for measurement are followed by an equivalent in parentheses, but only the first stated value shall be regarded as the requirement. Equivalent values in parentheses shall not be considered as the requirement, as these values might be approximate.

Supplemental Information

<table>
<thead>
<tr>
<th>File Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>FR-30_Annex_A.docx</td>
<td></td>
</tr>
</tbody>
</table>

Submitter Information Verification

Submitter Full Name: Eric Nette
Organization: [ Not Specified ]
Street Address:
City:
State:
Zip:
Submittal Date: Wed Nov 05 08:48:01 CST 2014

Committee Statement

Committee Statement: The scope of the standard is limited to garments and does not address other items of clothing that equally can ignite and cause injuries to industrial personnel. Industry claims for flame resistance should be standardized for these other items of clothing.

The standard was changed to maintain consistency with NFPA 2113 and to address the clothing items that were added to the scope of the document. This document represents minimum specifications of clothing for egress of workers with the intent of not contributing to the burn injury of the wearer, providing a degree of protection to the wearer, and reducing the severity of burn injuries resulting from short-duration thermal exposures or accidental exposure to flash fires.

Response Message:
Public Input No. 29-NFPA 2112-2014 [Chapter 1]
Public Input No. 46-NFPA 2112-2014 [Section No. A.1.2.2]
Public Input No. 47-NFPA 2112-2014 [Section No. A.1.2.3]
Public Input No. 45-NFPA 2112-2014 [Section No. A.1.2.1]
FR-30 Annex A changes:

A.1.2.1
Users are cautioned that flammable, non-flame resistant clothing can contribute to the severity of burn injuries through its ignition and continued burning after exposure to flash fire.

Short-duration thermal exposures can arise from other multiple fire types in industrial environments. These include, but are not limited to vapor cloud fires, jet flames, liquid fires (pool fires or running liquid fires), solids fires (fires of solid materials or dust fires), or warehouse fires, and fires associated with oxygen.

A.1.2.2
The testing requirements in Chapter 8 of this standard are not intended to establish the limitations of the working environment for personnel involved in situations that might be exposed to chemical flash fires, but are intended to establish material performance.

Users should be advised that if unusual conditions prevail, or if there are signs of abuse or mutilation of the protective garment, or if modifications or replacements are made or accessories are added without authorization of the protective garment manufacturer, the margin of protection might be reduced.

Users should be advised that the protective properties in new protective garments, as required by this standard, can change as the product is worn and ages.

A.1.2.3
This standard is not designed to be utilized as a purchase specification. It is prepared, as far as practical, with regard to required performance, avoiding restriction of design wherever possible. Purchasers should specify departmental requirements for such items as color, markings, closures, pockets, and trim patterns. Tests specified in this standard should not be deemed as defining or establishing performance levels for protection from all flash-fire environments.
Chapter 2  Referenced Publications

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

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

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

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

2.3.3 GSA Publications.
U.S. General Services Administration, 1800 F Street, N.W., Washington, DC 20405.

2.3.3 ISO Publications.
International Organization for Standardization, 1, rue de Varembé, Case postale 56, CH-1211 Geneve 20, Switzerland.

2.3.4 Other Publications.
2.4 References for Extracts in Mandatory Sections.


### Submitter Information Verification

<table>
<thead>
<tr>
<th>Submitter Full Name:</th>
<th>Eric Nette</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organization:</td>
<td>[ Not Specified ]</td>
</tr>
<tr>
<td>Street Address:</td>
<td></td>
</tr>
<tr>
<td>City:</td>
<td></td>
</tr>
<tr>
<td>State:</td>
<td></td>
</tr>
<tr>
<td>Zip:</td>
<td></td>
</tr>
<tr>
<td>Submittal Date:</td>
<td>Tue Nov 04 09:49:52 CST 2014</td>
</tr>
</tbody>
</table>

### Committee Statement

<table>
<thead>
<tr>
<th>Committee Statement:</th>
<th>Referenced current editions and titles. Draft standards will not be referenced at this time. AATC 158 will be addressed as a committee input in section 8.1.4.1 and Annex Table B.1.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Response Message:</td>
<td>Public Input No. 27-NFPA 2112-2014 [Chapter 2]</td>
</tr>
</tbody>
</table>
3.3.6* Cold Weather Insulation Material.

A fabric that consists of one or more nonseparable layers that is used for protection in a low-temperature environment.

Supplemental Information

File Name | Description
---|---
A.3.3.6_FR-2.docx |

Submitter Information Verification

Submitter Full Name: Eric Nette
Organization: [Not Specified]
Street Address:
City:
State:
Zip:
Submittal Date: Tue Nov 04 09:26:26 CST 2014

Committee Statement

Committee Statement: The current criteria in NFPA 2112-2012 are not workable to support the inclusion of cold weather insulation materials that provide safe and effective protection of flame resistant garments used for protection of workers against accident flash fires. Changes were made to the 2012 edition of NFPA 2112 without the benefit of a full validation effort. An effort intended to meet this purpose has now been completed by a task group under the direction of the Technical Committee where several prospective cold weather insulation materials were evaluated using existing and proposed test methods that included both current and modified flame resistance and heat/thermal shrinkage resistance testing. Additional evaluations were carried out using full scale manikin testing with garments incorporating the selected cold weather insulation materials in jackets of a simple design to assess effects of simulated flash fires on the clothing and insulation materials.

This effort produced the following two primary findings:

1. One of the cold weather insulation materials included in the investigation exhibited average afterflame times in excess of the 2-second requirement using the current flame resistance test procedures. When tested according to the proposed modified flame resistance test procedures, afterflame times were compliant or near compliant. In addition, the manikin-based testing for the same fabric exhibiting extended afterflame times, showed no unusual burning behavior during manikin testing of full garments where the liner consisted of the cold weather insulation material or showed shrinkage that differed radically from garments using materials that qualify to current NFPA 2112 performance criteria. Based on these findings, the modified flame resistance testing can be utilized for the evaluation of cold weather insulation materials.

It was observed that after flame times were observed to be generally shorter when a 50 mm folded edge was used as compared to a 25 mm folded edge. It was also rationalized that more consistent results would be provided with the 50 mm folded edge for the modified flame test because the specimen is positioned 19 mm into a 38 mm high flame leaving only a 6 mm space between the top of the flame and the beginning of the unprotected (by the folded edge) batting. It was therefore reasoned and consistent with the observed test results that the modified flame resistance test should use a 50 mm folded edge.
Specific changes to NFPA 2112 have been proposed in proposed modifications shown in Section 8.3.

2. Certain cold weather insulation materials exhibited significant distortion in heat/thermal shrinkage resistance testing and thermal shrinkage. Yet, these same materials when employed in the form of a liner in a flame resistant jacket utilizing a lightweight shell material did not show significant differences in their shrinkage (of the liner) with materials that would otherwise pass the NFPA 2112-2013 thermal shrinkage resistance criteria. This further included testing with the jacket samples inverted (turned inside out) representing a “worst case” exposure and wearing configuration where no adverse safety issues were observed. From these results, the exemption of cold weather insulation materials from the thermal shrinkage resistance requirement can be justified. Specific changes to NFPA 2112 implementing these modifications are provided as in paragraphs 7.1.3, 7.1.3.1 (deletion), 7.1.4, and Section 8.4.

It is important to point out that the cold weather insulation material is required to meet a heat resistance requirement and is always covered by an outer (shell) material (paragraph 7.1.4). If it is not, it would not qualify as a cold weather insulation material. It is also important to point out that while these changes were based on testing that did not show any safety of the protective garment to be compromised when presented to a simulated flash fire, conditions may exist for which cold weather insulation materials (and other garment materials) will fail to provide intended levels of protection.

The following substantiations are proposed for the additional changes in this amendment to address cold weather insulation material definitions, labeling, design criteria, performance criteria, and test methods:

• A clarification was added to the definition of cold weather insulation material to indicate that the material is not an interlining. Additional language was also added to distinguish an interlining that is not tested for heat resistance or thermal shrinkage resistance from a cold weather insulation material, which is tested for heat resistance but not thermal shrinkage resistance (paragraphs 3.3.6, 3.3.20, A.3.3.6, and A.3.3.20).

• Additional labeling language was added to require the identification of the cold weather insulation material fiber content, the inclusion of a warning that garments with cold weather insulation materials must be properly secured and that a separate label must be provided on the liner if detachable, that indicates that the liner must not be worn by itself. These changes are covered in paragraph 5.1.2, 5.1.9, 5.1.12, and 5.1.13).

• Design criteria were added to permit garment with sewn-in or detachable liners that utilize cold weather insulation materials but that manufacturers must design removable liners so that the liner cannot be worn without the outer layer (paragraphs 6.4 and A.6.4).

• Changes were made in the performance criteria to clarify to which requirements cold weather insulation materials are tested (paragraphs 7.1.2, 7.1.3, and 7.1.4).

• A clarification was provided to specify that the cold weather insulation material is not tested for thermal protective performance (paragraphs 7.1.1.1 and 7.1.1.2).

• Specific procedures were added to address the modified testing of the cold weather insulation material as specified in U.S. Air Force purchase description NCTRF PD N2-01-3A, Batting, Quilted, Aramid, involving the removal of 50 mm of batting and folding of the face cloth over the remaining batting, as supported by the test information provided above (paragraph 8.3.1.7 and Section 8.3.13). Additional instructions were provided for preparing samples for conditioning by sewing a layer of flame resistant fabric to the cold weather insulation material prior to laundering with its removal following laundering or dry cleaning (paragraphs 8.3.13.1 and 8.3.13.2).

• Modifications for the heat and thermal shrinkage resistance test method were made to clarify that the cold weather insulation materials are not evaluated for thermal shrinkage resistance as supported by the test information above (paragraphs 8.4.1.1 through 8.4.1.5, paragraph 8.4.2.1, and section 8.4.11). Additional instructions were provided for preparing samples for conditioning by sewing a layer of flame resistant fabric to the cold weather insulation material prior to laundering with its removal following laundering or dry cleaning (paragraphs 8.4.3.1 through 8.4.3.3).
Emergency Nature: The proposed TIA intends to correct a circumstance in which the revised NFPA Standard has resulted in an adverse impact on a product or method that was inadvertently overlooked in the total revision process or was without adequate technical (safety) justification for the action. As currently written, NFPA 2112 includes criteria that create a bias against cold weather insulation materials that is inconsistent with their use and in consistent with demonstrated levels of safety.

The OSHA interpretation of March 2010 encouraging employers to provide their employees with garments certified to a consensus standard like NFPA 2112 has created a need and demand for outerwear garments for cold weather protection that are certified to the NFPA 2112 standard. The current edition of the NFPA 2112 standard does not provide clear methods to properly test and certify garments that incorporate insulation for additional protection from cold weather.

Response Message:

Public Input No. 5-NFPA 2112-2013 [Section No. 3.3.6]
Public Input No. 7-NFPA 2112-2013 [Section No. A.3.3.6]
A.3.3.6 Cold Weather Insulation Material.
Examples of insulation materials are include textile batting(s) alone or batting(s) that are attached to a face cloth. For example, an insulation material consisting of two layers are considered nonseparable by the attachment that combines the two layers. The insulation material might or might not have a face cloth. Cold weather insulation materials generally are provided within the garment such that their area of coverage coincides with the majority of garment area covering the wearer’s body.

Cold weather insulation material as defined in this standard does not preclude the use of intermediate layers for additional protection against thermal hazards.
3.3.13* 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. [1971, 2013] (See 3.3.13.1, Inherent Flame Resistance.)

3.3.13.1 Inherent Flame Resistance.
Flame resistance that is derived from the essential characteristic of the fiber or polymer. [1971, 2013]

Submitter Information Verification
Submitter Full Name: Eric Nette
Organization: [Not Specified]
Street Address:
City:
State:
Zip:
Submittal Date: Tue Nov 04 16:17:40 CST 2014

Committee Statement
Committee Statement: The current definition for the term "flame resistance" is not the complete NFPA definition for this term, there is more wording that was omitted in the body of the standard. The omitted wording was "Flame resistance can be an inherent property of a material or it can be imparted by specific treatment"

Annex: the definition was altered to no longer necessitate the inclusion of this explanatory material in the annex, delete associated annex material.

Response Message:
Public Input No. 57-NFPA 2112-2014 [Section No. 3.3.12]
3.3.12 Fire
A rapid oxidation process, which is a chemical reaction resulting in the evolution of light and heat in varying intensities. [921, 2014]
Fire. Fire is the result of combustion, or the chemical process of rapid oxidation (burning) that requires an ignition source, a flammable substance or fuel, and oxygen (usually from air). In an industrial environment, different types of fires may result from a variety of different events. “Jet” fires typically arise from line breaks or ruptures of pressurized flammable materials. These fires can create directed “jets” or “flares”, which may project flames in any direction for considerable distances, depending on the characteristics of the source, and burn until the fuel is exhausted or the break is isolated. A pool, or running pool fire, arises from the ignition of spills and leaks of flammable liquids. The size and intensity is dependent on the amount of material involved and typically extends upward from the surface of the pool. These fires also continue until the fuel is exhausted and the source of the leak isolated. A flash, or vapor cloud fire arises from the release or presence of a flammable gas or combustible finely divided particles (e.g., coal dust or grain) that contains a concentration above the lower explosive limit of the chemical. Flash fire characteristics depend on the size of the gas or vapor cloud and local conditions. When ignited, the flame front may expand outward in the form of a fireball or be driven by external convection (wind). The resulting effect of the fireball or flame front’s energy with respect to radiant heat significantly enlarges the hazard areas around the gas released.
3.3.14 Flash Fire. A type of short-duration fire that spreads by means of a flame front rapidly through a diffuse fuel, such as dust, gas, or the vapors of an ignitible liquid, without the production of damaging pressure. [921, 2011]

Submitter Information Verification

Submitter Full Name: Eric Nette
Organization: [Not Specified]
Street Address:
City:
State:
Zip:
Submittal Date: Thu Nov 06 09:33:25 CST 2014

Committee Statement

Committee Statement: In response to PI-40, which proposed to delete the definition of flash fire, the committee modified the definition of flash fire.

Annex: Further explanatory material is no longer necessary due to FR-48 adding explanatory text in the annex. Delete associated annex material.

Response Message:

Public Input No. 40-NFPA 2112-2014 [Section No. 3.3.13]
Public Input No. 48-NFPA 2112-2014 [Section No. A.3.3.13]
Clothing including, but not limited to, coveralls, trousers, shirts, and outerwear, and rainwear.

Submitter Information Verification

Submitter Full Name: Eric Nette
Organization: [ Not Specified ]
Street Address:
City:
State:
Zip:
Submittal Date: Wed Nov 05 10:23:45 CST 2014

Committee Statement

Committee Statement: Rainwear was defined elsewhere in the standard.
Response Message:
3.3.16  Functional.
The ability of an item to continue to be utilized for its intended purpose.

Submitter Information Verification

Submitter Full Name: Eric Nette
Organization: National Fire Protection Assoc
Street Address:
City:
State:
Zip:
Submittal Date: Tue Jan 13 09:00:15 EST 2015

Committee Statement

Committee Statement: The proposed definitions are needed to address new elements of protective clothing.
Response Message:
3.3.18  **Glove.**
An item designed to provide protection to the wearer's hand and wrist.

**Submitter Information Verification**

**Submitter Full Name:** Eric Nette  
**Organization:** National Fire Protection Assoc  
**Street Address:**  
**City:**  
**State:**  
**Zip:**  
**Submittal Date:** Tue Jan 13 09:01:20 EST 2015

**Committee Statement**

**Committee Statement:** The proposed definitions are needed to address new elements of protective clothing.

**Response Message:**
3.3.22  Industrial Personnel.

Workers who might be exposed to flash at risk of burn injuries resulting during egress from or accidental exposure to short-duration thermal exposure from fire.

Submitter Information Verification

Submitter Full Name: Eric Nette
Organization: [ Not Specified ]
Street Address: 
City: 
State: 
Zip: 
Submittal Date: Wed Nov 05 17:06:45 CST 2014

Committee Statement

Committee Statement: The standard was changed to maintain consistency with NFPA 2113. This document represents minimum specifications of clothing for egress of workers with the intent of not contributing to the burn injury of the wearer, providing a degree of protection to the wearer, and reducing the severity of burn injuries resulting from short-duration thermal exposures or accidental exposure to flash fires.

Response Message: 
3.3.23* Interlining.
Any textile that is incorporated into any garment as a layer between outer and inner layers that covers only a small portion of the overall garment. [1975, 2009]

Supplemental Information

<table>
<thead>
<tr>
<th>File Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.3.3.20_FR-3.docx</td>
<td></td>
</tr>
</tbody>
</table>

Submitter Information Verification

Submitter Full Name: Eric Nette
Organization: [Not Specified]
Street Address: 
City: 
State: 
Zip: 
Submittal Date: Tue Nov 04 09:26:43 CST 2014

Committee Statement

Committee Statement: The current criteria in NFPA 2112-2012 are not workable to support the inclusion of cold weather insulation materials that provide safe and effective protection of flame resistant garments used for protection of workers against accident flash fires. Changes were made to the 2012 edition of NFPA 2112 without the benefit of a full validation effort. An effort intended to meet this purpose has now been completed by a task group under the direction of the Technical Committee where several prospective cold weather insulation materials were evaluated using existing and proposed test methods that included both current and modified flame resistance and heat/thermal shrinkage resistance testing. Additional evaluations were carried out using full scale manikin testing with garments incorporating the selected cold weather insulation materials in jackets of a simple design to assess effects of simulated flash fires on the clothing and insulation materials.

This effort produced the following two primary findings:

1. One of the cold weather insulation materials included in the investigation exhibited average afterflame times in excess of the 2-second requirement using the current flame resistance test procedures. When tested according to the proposed modified flame resistance test procedures, afterflame times were compliant or near compliant. In addition, the manikin-based testing for the same fabric exhibiting extended afterflame times, showed no unusual burning behavior during manikin testing of full garments where the liner consisted of the cold weather insulation material or showed shrinkage that differed radically from garments using materials that qualify to current NFPA 2112 performance criteria. Based on these findings, the modified flame resistance test can be utilized for the evaluation of cold weather insulation materials.

It was observed that after flame times were observed to be generally shorter when a 50 mm folded edge was used as compared to a 25 mm folded edge. It was also rationalized that more consistent results would be provided with the 50 mm folded edge for the modified flame test because the specimen is positioned 19 mm into a 38 mm high flame leaving only a 6 mm space between the top of the flame and the beginning of the unprotected (by the folded edge) batting. It was therefore reasoned and consistent with the observed test results that the modified flame resistance test should use a 50 mm folded edge.
Specific changes to NFPA 2112 have been proposed in proposed modifications shown in Section 8.3.

2. Certain cold weather insulation materials exhibited significant distortion in heat/thermal shrinkage resistance testing and thermal shrinkage. Yet, these same materials when employed in the form of a liner in a flame resistant jacket utilizing a lightweight shell material did not show significant differences in their shrinkage (of the liner) with materials that would otherwise pass the NFPA 2112-2013 thermal shrinkage resistance criteria. This further included testing with the jacket samples inverted (turned inside out) representing a “worst case” exposure and wearing configuration where no adverse safety issues were observed. From these results, the exemption of cold weather insulation materials from the thermal shrinkage resistance requirement can be justified. Specific changes to NFPA 2112 implementing these modifications are provided as in paragraphs 7.1.3, 7.1.3.1 (deletion), 7.1.4, and Section 8.4.

It is important to point out that the cold weather insulation material is required to meet a heat resistance requirement and is always covered by an outer (shell) material (paragraph 7.1.4). If it is not, it would not qualify as a cold weather insulation material. It is also important to point out that while these changes were based on testing that did not show any safety of the protective garment to be compromised when presented to a simulated flash fire, conditions may exist for which cold weather insulation materials (and other garment materials) will fail to provide intended levels of protection.

The following substantiations are proposed for the additional changes in this amendment to address cold weather insulation material definitions, labeling, design criteria, performance criteria, and test methods:

• A clarification was added to the definition of cold weather insulation material to indicate that the material is not an interlining. Additional language was also added to distinguish an interlining that is not tested for heat resistance or thermal shrinkage resistance from a cold weather insulation material, which is tested for heat resistance but not thermal shrinkage resistance (paragraphs 3.3.6, 3.3.20, A.3.3.6, and A.3.3.20).

• Additional labeling language was added to require the identification of the cold weather insulation material fiber content, the inclusion of a warning that garments with cold weather insulation materials must be properly secured and that a separate label must be provided on the liner if detachable, that indicates that the liner must not be worn by itself. These changes are covered in paragraph 5.1.2, 5.1.9, 5.1.12, and 5.1.13).

• Design criteria were added to permit garment with sewn-in or detachable liners that utilize cold weather insulation materials but that manufacturers must design removable liners so that the liner cannot be worn without the outer layer (paragraphs 6.4 and A.6.4).

• Changes were made in the performance criteria to clarify to which requirements cold weather insulation materials are tested (paragraphs 7.1.2, 7.1.3, and 7.1.4).

• A clarification was provided to specify that the cold weather insulation material is not tested for thermal protective performance (paragraphs 7.1.1.1 and 7.1.1.2).

• Specific procedures were added to address the modified testing of the cold weather insulation material as specified in U.S. Air Force purchase description NCTRF PD N2-01-3A, Batting, Quilted, Aramid, involving the removal of 50 mm of batting and folding of the face cloth over the remaining batting, as supported by the test information provided above (paragraph 8.3.1.7 and Section 8.3.13). Additional instructions were provided for preparing samples for conditioning by sewing a layer of flame resistant fabric to the cold weather insulation material prior to laundering with its removal following laundering or dry cleaning (paragraphs 8.3.13.1 and 8.3.13.2).

• Modifications for the heat and thermal shrinkage resistance test method were made to clarify that the cold weather insulation materials are not evaluated for thermal shrinkage resistance as supported by the test information above (paragraphs 8.4.1.1 through 8.4.1.5, paragraph 8.4.2.1, and section 8.4.11). Additional instructions were provided for preparing samples for conditioning by sewing a layer of flame resistant fabric to the cold weather insulation material prior to laundering with its removal following laundering or dry cleaning (paragraphs 8.4.3.1 through 8.4.3.3).
For supporting documentation see the doc info pages at www.nfpa.org/2112.

Emergency Nature: The proposed TIA intends to correct a circumstance in which the revised NFPA Standard has resulted in an adverse impact on a product or method that was inadvertently overlooked in the total revision process or was without adequate technical (safety) justification for the action. As currently written, NFPA 2112 includes criteria that create a bias against cold weather insulation materials that is inconsistent with their use and in consistent with demonstrated levels of safety.

The OSHA interpretation of March 2010 encouraging employers to provide their employees with garments certified to a consensus standard like NFPA 2112 has created a need and demand for outerwear garments for cold weather protection that are certified to the NFPA 2112 standard. The current edition of the NFPA 2112 standard does not provide clear methods to properly test and certify garments that incorporate insulation for additional protection from cold weather.

Response
Message:

Public Input No. 6-NFPA 2112-2013 [Section No. 3.3.20]
Public Input No. 8-NFPA 2112-2013 [New Section after A.3.3.15.2]
A.3.3.20 Interlining.

The outer and inner layers are compliant to the fabric requirements of this standard. Examples of an interlining are a fabric layer used to stiffen the waist band in a pair of pants or a facing fabric used inside the closure flap of a coverall. Interlining materials do not come in contact with the wearer’s skin or underclothing.
3.3.29 Rainwear.
An item worn primarily to provide protection from precipitation, including but not limited to, coveralls, trousers, jackets, and ponchos.

Submitter Information Verification

Submitter Full Name: Eric Nette
Organization: National Fire Protection Assoc
Street Address:
City:
State:
Zip:
Submittal Date: Tue Jan 13 09:01:58 EST 2015

Committee Statement

Committee Statement: The proposed definitions are needed to address new elements of protective clothing.
Response Message:
### Inherent Flame Resistance

Flame resistance that is derived from the essential characteristic of the fiber or polymer. [1971, 2013]

---

### Submitter Information Verification

**Submitter Full Name:** Eric Nette  
**Organization:** [Not Specified]  
**Street Address:**  
**City:**  
**State:**  
**Zip:**  
**Submittal Date:** Tue Nov 04 16:26:15 CST 2014

---

### Committee Statement

**Committee Statement:** This definition was added to accompany FR-27.

**Response Message:**
3.3.35* Short-Duration Thermal Exposure from Fire.
A period of egress from or accidental exposure to thermal events, including but not limited to, vapor cloud fires, jet flames, liquid fires (pool fires or running liquid fires), solids fires (fires of solid materials or dust fires), or warehouse fires.

Supplemental Information

<table>
<thead>
<tr>
<th>File Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A3.3.x_Short-Duration_Thermal_Exposure_from_Fire.docx</td>
<td></td>
</tr>
</tbody>
</table>

Submitter Information Verification

Submitter Full Name: Eric Nette
Organization: [ Not Specified ]
Street Address:
City:
State:
Zip:
Submittal Date: Thu Nov 06 08:27:27 CST 2014

Committee Statement

Committee Statement: The standard was changed to maintain consistency with NFPA 2113. This document represents minimum specifications of clothing for egress of workers with the intent of not contributing to the burn injury of the wearer, providing a degree of protection to the wearer, and reducing the severity of burn injuries resulting from short-duration thermal exposures or accidental exposure to flash fires.

Response Message:
A3.3.x Short-Duration Thermal Exposure from Fire.
This standard establishes minimum requirements for clothing that provides limited protection from short-duration thermal exposure from fire with the aim of limiting potential injury to persons egressing from or encountering accidental hazardous exposures to fire. See the requirements established in NFPA 2113 for selection, care and maintenance of these clothing items.
3.3.36 Shroud/Balaclava/Hood.
An item designed to provide protection to the wearer's head or neck or both less the face opening.

Submitter Information Verification

Submitter Full Name: Eric Nette
Organization: National Fire Protection Assoc
Street Address:
City:
State:
Zip:
Submittal Date: Tue Jan 13 09:02:25 EST 2015

Committee Statement

Committee Statement: The proposed definitions are needed to address new elements of protective clothing.
Response Message:
Chapter 4 Certification

4.1 General.

4.1.1 All flame-resistant garments, shrouds/hoods/balaclavas, gloves, and rainwear that are labeled as being compliant with this standard shall meet or exceed all applicable requirements specified in this standard and shall be certified.

4.1.2 All test data used to determine compliance of flame-resistant garments, shrouds/hoods/balaclavas, gloves, and rainwear with this standard shall be provided by an accredited testing laboratory.

4.1.3 All flame-resistant garments, shrouds/hoods/balaclavas, gloves, and rainwear shall be labeled and listed.

4.1.4 All flame-resistant garments, shrouds/hoods/balaclavas, gloves, and rainwear shall have a product label, which shall meet the requirements of Section 5.1.

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

4.1.6 Manufacturers shall not claim compliance with a portion(s) or segment(s) of the requirements of this standard and shall not use the name or identification of this standard in any statements about their respective product(s) unless the product(s) is certified as compliant to this standard.

4.1.7 The certification organization shall not certify any flame-resistant garments, shrouds/hoods/balaclavas, gloves, and rainwear to the 2007 edition of this standard on or after August 1, 2012.

4.1.8 The certification organization shall not permit any manufacturer to label any flame-resistant garments, shrouds/hoods/balaclavas, gloves, and rainwear as compliant with the 2007 edition of this standard on or after August 1, 2012.

4.2 Certification Program.

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

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

4.2.3 The certification organization shall be accredited for personal protective equipment in accordance with ISO/IEC Guide 65: General Requirements for Bodies Operating Product Certification Systems and ISO/IEC 17065: Conformity Assessment — Requirements for Bodies Certifying Products, Processes, and Services.

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

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

4.2.5.1 There shall be no conditional, temporary, or partial certifications.

4.2.5.2 Manufacturers shall not be authorized to use any label or reference to the certification organization on products that are not manufactured in compliance with all applicable requirements of this standard.
4.2.6
The certification organization shall have a program to accredit laboratories to perform the tests required by this standard.

4.2.6.1
The accredited laboratory shall conduct the required tests and maintain documentation of test results.

4.2.6.2
The accredited laboratory shall have laboratory facilities and equipment available for conducting required tests.

4.2.7
A program for calibration of all instruments shall be in place and operating, and procedures shall be in use to ensure proper control of all testing.

4.2.8
In the absence of an accredited laboratory, the certification organization shall be permitted to have its own laboratory facilities and equipment available for conducting required tests.

4.2.9*
The certification organization shall require the manufacturer to establish and maintain a program of production inspection and testing that meets the requirements of Section 4.4.

4.2.9.1
The certification organization shall ensure that the audit assurance program provides continued product compliance with this standard.

4.2.9.2
The certification organization shall permit the manufacturer to be registered to ISO 9001, *Quality Management Systems — Requirements*, in lieu of meeting the requirements of Section 4.4.

4.2.10
The certification organization and the manufacturer shall evaluate any changes affecting the form, fit, or function of the certified product to determine its continued certification to this standard.

4.2.11*
The certification organization shall have a follow-up inspection program of the manufacturing facilities of the certified product, with a minimum of one visit per 12-month period.

4.2.12
As part of the follow-up inspection program, the certification organization shall review the manufacturer's records and sample product to ensure the following:

1. Garments, shrouds/hoods/balaclavas, gloves, and rainwear conform with the requirements of this standard.

2. The manufacturer has documentation that the fabric and components used in the garment, shroud/hood/balaclava, glove, and rainwear were tested by an accredited laboratory and comply with this standard.

3. A manufacturing quality assurance plan meeting the requirements of this standard is in place.

4.2.13
The certification organization shall also have a follow-up inspection program of the accredited testing laboratory(ies).

4.2.13.1
The certification organization shall conduct a minimum of one visit per 12-month period.

4.2.13.2
The certification organization shall review the accredited laboratory's records and facilities to ensure required documentation is maintained and to ensure conformance with testing requirements.

4.2.14
The certification organization shall have a program for investigating field reports alleging malperformance or failure of listed products.

4.2.15*
The certification organization shall require the manufacturer to have a product recall system as part of the manufacturer's quality assurance program.
4.2.16
The certification organization's operating procedures shall provide a mechanism for the manufacturer to appeal decisions, which shall include the presentation of information from both sides of a controversy to a designated appeals panel.

4.2.17
The certification organization shall be in a position to use legal means to protect the integrity of its name and label, which shall be registered and legally defended.

4.3 Inspection and Testing.

4.3.1
For the certification of flame-resistant garments, shrouds/hoods/balaclavas, gloves, and rainwear, the certification organization shall conduct inspections of the manufacturing facility and the accredited laboratory, as specified in 4.3.2 through 4.3.9.

4.3.2
All inspections, evaluations, conditioning, and testing for certification or for recertification shall be conducted by the certification organization or a facility accredited for inspections, evaluations, conditioning, and testing in accordance with all requirements pertaining to testing laboratories in ISO 17025, General Requirements for the Competence of Testing and Calibration Laboratories.

4.3.3
All inspections, evaluations, conditioning, or testing conducted by a product manufacturer shall not be used in the certification or recertification process unless the facility for inspections, evaluations, conditioning, or testing has been accredited in accordance with all requirements pertaining to testing laboratories in ISO 17025, General Requirements for the Competence of Testing and Calibration Laboratories.

4.3.4
Inspection by the certification organization shall include a review of all product labels to ensure that all required label attachment, compliance statements, certification statements, and other product information are as specified for the specific item in Section 5.1.

4.3.5
Inspection by the certification organization shall include a review of any graphic representations used on product labels, as permitted in 5.1.6 to ensure that the systems are consistent with the worded statements, are readily understood, and clearly communicate the intended message.

4.3.6
Inspection by the certification organization shall include a review of the user information required by Section 5.2 to ensure that the information has been developed and is available.

4.3.7
Inspection by the certification organization for determining compliance with the design requirements specified in Chapter 6 shall be performed on whole or complete products.

4.3.8
Testing conducted by the accredited laboratory in accordance with the testing requirements of Chapter 8, for determining product compliance with the applicable requirements specified in Chapter 7, shall be performed on samples representative of materials and components used in the actual construction of the flame-resistant garment, shroud/hood/balaclava, glove, and rainwear, or sample materials cut from a representative product.

4.3.9 Recertification.

4.3.9.1
Any change in the design, construction, or material of a compliant product shall require new inspection and testing to verify compliance with all applicable requirements of this standard that the certification organization determines can be affected by such change.

4.3.9.2
Recertification shall be conducted before labeling the modified products as being compliant with this standard.

4.3.10 Product Modifications.

4.3.10.1
The certification organization shall not permit any modifications, pretreatment, conditioning, or other such special processes of the product or any product component prior to the product's submission for evaluation and testing by the accredited laboratory.
4.3.10.2
The accredited laboratory shall accept, from the manufacturer for evaluation and testing for certification, only product or product components that are the same in every respect to the actual final product or product component.

4.3.10.3
The accredited laboratory shall not permit the substitution, repair, or modification, other than as specifically permitted herein, of any product or any product component during testing.

4.4 Manufacturer's Quality Assurance Program.

4.4.1 General.

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

4.4.1.2 The manufacturer shall have an inspection system to substantiate conformance to this standard.

4.4.1.3* The manufacturer shall be permitted to be registered to ISO 9001, Quality Management Systems — Requirements, in lieu of meeting the requirements of 4.4.2 through 4.4.8.

4.4.2 Instructions.

4.4.2.1 The manufacturer shall maintain written inspection and testing instructions.

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

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

4.4.3 Records.

4.4.3.1 The manufacturer shall maintain records of all “pass” and “fail” tests.

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

4.4.4 Inspection System.

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

4.4.5 Calibration Program.

4.4.5.1 The manufacturer shall maintain, as part of the quality assurance program, a calibration program of all instruments used to ensure proper control of testing.

4.4.5.2 The calibration program shall be documented as to the date of calibration and performance verification.

4.4.6 Inspection Status.

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

4.4.7 Nonconforming Materials.

4.4.7.1 The manufacturer shall establish and maintain a system for controlling nonconforming material, including procedures for the identification, segregation, and disposition of rejected material.

4.4.7.2 All nonconforming materials or products shall be identified to prevent use, shipment, and intermingling with conforming materials or products.

4.4.8 Third-Party Audit.

4.4.8.1 The manufacturer's quality assurance program shall be audited by the third-party certification organization to determine that the program ensures continued product compliance with this standard.

Supplemental Information
## Committee Statement

**Committee Statement:** Changes in certification section to address the addition of other items.

**Response Message:**

Public Input No. 69-NFPA 2112-2014 (Chapter 4)
Chapter 4 Certification

4.1 General.

4.1.1 -
All flame-resistant garments, shrouds/hoods/balaclavas, gloves, and rainwear that are labeled as being compliant with this standard shall meet or exceed all applicable requirements specified in this standard and shall be certified.

4.1.2 -
All test data used to determine compliance of flame-resistant garments, shrouds/hoods/balaclavas, gloves, and rainwear with this standard shall be provided by an accredited testing laboratory.

4.1.3 -
All flame-resistant garments, shrouds/hoods/balaclavas, gloves, and rainwear shall be labeled and listed.

4.1.4 -
All flame-resistant garments, shrouds/hoods/balaclavas, gloves, and rainwear shall have a product label, which shall meet the requirements of Section 5.1.

4.1.5* -
The certification organization's label, symbol, or identifying mark shall be attached to the product label, be part of the product label, or be immediately adjacent to the product label.

4.1.6 -
Manufacturers shall not claim compliance with a portion(s) or segment(s) of the requirements of this standard and shall not use the name or identification of this standard in any statements about their respective product(s) unless the product(s) is certified as compliant to this standard.

4.1.7 -
The certification organization shall not certify any flame-resistant garments, shrouds/hoods/balaclavas, gloves, and rainwear to the 20022012 edition of this standard on or after August 1, 2012May 13, 2016.
The certification organization shall not permit any manufacturer to label any flame-resistant garments, shrouds/hoods/balaclavas, gloves, and rainwear as compliant with the 2007 - 2012 edition of this standard on or after August 1, 2012 - May 13, 2016.

4.2 Certification Program.

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

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

4.2.3 -
- The certification organization shall be accredited for personal protective equipment in accordance with ISO/IEC Guide 65, General Requirements for Bodies Operating Product Certification Systems.

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

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

4.2.5.1 -
- There shall be no conditional, temporary, or partial certifications.

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

4.2.6 -
The certification organization shall have a program to accredit laboratories to perform the tests required by this standard.

4.2.6.1 - The accredited laboratory shall conduct the required tests and maintain documentation of test results.

4.2.6.2 - The accredited laboratory shall have laboratory facilities and equipment available for conducting required tests.

4.2.7 - A program for calibration of all instruments shall be in place and operating, and procedures shall be in use to ensure proper control of all testing.

4.2.8 - In the absence of an accredited laboratory, the certification organization shall be permitted to have its own laboratory facilities and equipment available for conducting required tests.

4.2.9* - The certification organization shall require the manufacturer to establish and maintain a program of production inspection and testing that meets the requirements of Section 4.4.

4.2.9.1 - The certification organization shall ensure that the audit assurance program provides continued product compliance with this standard.

4.2.9.2 - The certification organization shall permit the manufacturer to be registered to ISO 9001, *Quality Management Systems — Requirements*, in lieu of meeting the requirements of Section 4.4.

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

4.2.11* -
The certification organization shall have a follow-up inspection program of the manufacturing facilities of the certified product, with a minimum of one visit per 12-month period.

4.2.12 -

As part of the follow-up inspection program, the certification organization shall review the manufacturer's records and sample product to ensure the following:

1. Garments, shrouds/hoods/balaclavas, gloves, and rainwear conform with the requirements of this standard.
2. The manufacturer has documentation that the fabric and components used in the garment, shroud/hood/balaclava, glove, and rainwear were tested by an accredited laboratory and comply with this standard.
3. A manufacturing quality assurance plan meeting the requirements of this standard is in place.

4.2.13 -

The certification organization shall also have a follow-up inspection program of the accredited testing laboratory(ies).

4.2.13.1--

The certification organization shall conduct a minimum of one visit per 12-month period.

4.2.13.2 -

The certification organization shall review the accredited laboratory's records and facilities to ensure required documentation is maintained and to ensure conformance with testing requirements.

4.2.14 -

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

4.2.15*--

The certification organization shall require the manufacturer to have a product recall system as part of the manufacturer's quality assurance program.

4.2.16--

The certification organization's operating procedures shall provide a mechanism for the manufacturer to appeal decisions, which shall include the presentation of information from both sides of a controversy to a designated appeals panel.
4.2.17 - The certification organization shall be in a position to use legal means to protect the integrity of its name and label, which shall be registered and legally defended.

4.3 Inspection and Testing.

4.3.1 - For the certification of flame-resistant garments, shrouds/hoods/balaclavas, gloves, and rainwear, the certification organization shall conduct inspections of the manufacturing facility and the accredited laboratory, as specified in 4.3.2 through 4.3.9.

4.3.2 - All inspections, evaluations, conditioning, and testing for certification or for recertification shall be conducted by the certification organization or a facility accredited for inspections, evaluations, conditioning, and testing in accordance with all requirements pertaining to testing laboratories in ISO 17025, *General Requirements for the Competence of Testing and Calibration Laboratories*.

4.3.3 - All inspections, evaluations, conditioning, or testing conducted by a product manufacturer shall not be used in the certification or recertification process unless the facility for inspections, evaluations, conditioning, or testing has been accredited in accordance with all requirements pertaining to testing laboratories in ISO 17025, *General Requirements for the Competence of Testing and Calibration Laboratories*.

4.3.4 - Inspection by the certification organization shall include a review of all product labels to ensure that all required label attachment, compliance statements, certification statements, and other product information are as specified for the specific item in Section 5.1.

4.3.5 - Inspection by the certification organization shall include a review of any graphic representations used on product labels, as permitted in 5.1.6 to ensure that the systems are consistent with the worded statements, are readily understood, and clearly communicate the intended message.

4.3.6 - Inspection by the certification organization shall include a review of the user information required by Section 5.2 to ensure that the information has been developed and is available.
4.3.7 Inspection by the certification organization for determining compliance with the design requirements specified in Chapter 6 shall be performed on whole or complete products.

4.3.8 Testing conducted by the accredited laboratory in accordance with the testing requirements of Chapter 8, for determining product compliance with the applicable requirements specified in Chapter 7, shall be performed on samples representative of materials and components used in the actual construction of the flame-resistant garment, shroud/hood/balaclava, glove, and rainwear, or sample materials cut from a representative product.

4.3.9 Recertification.

4.3.9.1 Any change in the design, construction, or material of a compliant product shall require new inspection and testing to verify compliance with all applicable requirements of this standard that the certification organization determines can be affected by such change.

4.3.9.2 Recertification shall be conducted before labeling the modified products as being compliant with this standard.

4.3.10 Product Modifications.

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

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

4.3.10.3 The accredited laboratory shall not permit the substitution, repair, or modification, other than as specifically permitted herein, of any product or any product component during testing.

4.4 Manufacturer's Quality Assurance Program.
4.4.1 General.

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

4.4.1.2 The manufacturer shall have an inspection system to substantiate conformance to this standard.

4.4.1.3* The manufacturer shall be permitted to be registered to ISO 9001, *Quality Management Systems—Requirements*, in lieu of meeting the requirements of 4.4.2 through 4.4.8.

4.4.2 Instructions.

4.4.2.1 The manufacturer shall maintain written inspection and testing instructions.

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

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

4.4.3 Records.

4.4.3.1 The manufacturer shall maintain records of all “pass” and “fail” tests.

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

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

4.4.5 Calibration Program.

4.4.5.1 - The manufacturer shall maintain, as part of the quality assurance program, a calibration program of all instruments used to ensure proper control of testing.

4.4.5.2 - The calibration program shall be documented as to the date of calibration and performance verification.

4.4.6 Inspection Status.

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

4.4.7 Nonconforming Materials.

4.4.7.1 - The manufacturer shall establish and maintain a system for controlling nonconforming material, including procedures for the identification, segregation, and disposition of rejected material.

4.4.7.2 - All nonconforming materials or products shall be identified to prevent use, shipment, and intermingling with conforming materials or products.

4.4.8 Third-Party Audit.

The manufacturer's quality assurance program shall be audited by the third-party certification organization to determine that the program ensures continued product compliance with this standard.
5.1.1*
All flame-resistant garments shall have a product label or labels permanently and conspicuously attached to each flame-resistant garment, shroud/hood/balaclava, glove, and rainwear.
5.1.2
At least one product label shall be conspicuously located inside each flame-resistant garment, when the item is properly assembled with all layers and components in place shroud/hood/balaclava, glove, and rainwear.

Submitter Information Verification

Submitter Full Name: Eric Nette
Organization: [ Not Specified ]
Street Address: 
City: 
State: 
Zip: 
Submittal Date: Tue Nov 04 09:27:26 CST 2014

Committee Statement

Committee Statement: Additional clothing items were added to the scope of the document.

The current criteria in NFPA 2112-2012 are not workable to support the inclusion of cold weather insulation materials that provide safe and effective protection of flame resistant garments used for protection of workers against accident flash fires. Changes were made to the 2012 edition of NFPA 2112 without the benefit of a full validation effort. An effort intended to meet this purpose has now been completed by a task group under the direction of the Technical Committee where several prospective cold weather insulation materials were evaluated using existing and proposed test methods that included both current and modified flame resistance and heat/thermal shrinkage resistance testing. Additional evaluations were carried out using full scale manikin testing with garments incorporating the selected cold weather insulation materials in jackets of a simple design to assess effects of simulated flash fires on the clothing and insulation materials.

This effort produced the following two primary findings:

1. One of the cold weather insulation materials included in the investigation exhibited average afterflame times in excess of the 2-second requirement using the current flame resistance test procedures. When tested according to the proposed modified flame resistance test procedures, afterflame times were compliant or near compliant. In addition, the manikin-based testing for the same fabric exhibiting extended afterflame times, showed no unusual burning behavior during manikin testing of full garments where the liner consisted of the cold weather insulation material or showed shrinkage that differed radically from garments using materials that qualify to current NFPA 2112 performance criteria. Based on these findings, the modified flame resistance testing can be utilized for the evaluation of cold weather insulation materials.

Specific changes to NFPA 2112 have been proposed in proposed modifications shown in Section 8.3.
2. Certain cold weather insulation materials exhibited significant distortion in heat/thermal shrinkage resistance testing and thermal shrinkage. Yet, these same materials when employed in the form of a liner in a flame resistant jacket utilizing a lightweight shell material did not show significant differences in their shrinkage (of the liner) with materials that would otherwise pass the NFPA 2112-2013 thermal shrinkage resistance criteria. This further included testing with the jacket samples inverted (turned inside out) representing a “worst case” exposure and wearing configuration where no adverse safety issues were observed. From these results, the exemption of cold weather insulation materials from the thermal shrinkage resistance requirement can be justified. Specific changes to NFPA 2112 implementing these modifications are provided as in paragraphs 7.1.3, 7.1.3.1 (deletion), 7.1.4, and Section 8.4.

It is important to point out that the cold weather insulation material is required to meet a heat resistance requirement and is always covered by an outer (shell) material (paragraph 7.1.4). If it is not, it would not qualify as a cold weather insulation material. It is also important to point out that while these changes were based on testing that did not show any safety of the protective garment to be compromised when presented to a simulated flash fire, conditions may exist for which cold weather insulation materials (and other garment materials) will fail to provide intended levels of protection.

The following substantiations are proposed for the additional changes in this amendment to address cold weather insulation material definitions, labeling, design criteria, performance criteria, and test methods:

• A clarification was added to the definition of cold weather insulation material to indicate that the material is not an interlining. Additional language was also added to distinguish an interlining that is not tested for heat resistance or thermal shrinkage resistance from a cold weather insulation material, which is tested for heat resistance but not thermal shrinkage resistance (paragraphs 3.3.6, 3.3.20, A.3.3.6, and A.3.3.20).

• Additional labeling language was added to require the identification of the cold weather insulation material fiber content, the inclusion of a warning that garments with cold weather insulation materials must be properly secured and that a separate label must be provided on the liner if detachable, that indicates that the liner must not be worn by itself. These changes are covered in paragraph 5.1.2, 5.1.9, 5.1.12, and 5.1.13).

• Design criteria were added to permit garment with sewn-in or detachable liners that utilize cold weather insulation materials but that manufacturers must design removable liners so that the liner cannot be worn without the outer layer (paragraphs 6.4 and A.6.4).

• Changes were made in the performance criteria to clarify to which requirements cold weather insulation materials are tested (paragraphs 7.1.2, 7.1.3, and 7.1.4).

• A clarification was provided to specify that the cold weather insulation material is not tested for thermal protective performance (paragraphs 7.1.1.1 and 7.1.1.2).

• Specific procedures were added to address the modified testing of the cold weather insulation material as specified in U.S. Air Force purchase description NCTRF PD N2-01-3A, Batting, Quilted, Aramid, involving the removal of 50 mm of batting and folding of the face cloth over the remaining batting, as supported by the test information provided above (paragraph 8.3.1.7 and Section 8.3.13). Additional instructions were provided for preparing samples for conditioning by sewing a layer of flame resistant fabric to the cold weather insulation material prior to laundering with its removal following laundering or dry cleaning (paragraphs 8.3.13.1 and 8.3.13.2).

• Modifications for the heat and thermal shrinkage resistance test method were made to clarify that the cold weather insulation materials are not evaluated for thermal shrinkage resistance as supported by the test information above (paragraphs 8.4.1.1 through 8.4.1.5, paragraph 8.4.2.1, and section 8.4.11). Additional instructions were provided for preparing samples for conditioning by sewing a layer of flame resistant fabric to the cold weather insulation material prior to laundering with its removal following laundering or dry cleaning (paragraphs 8.4.3.1 through 8.4.3.3).

For supporting documentation see the doc info pages at www.nfpa.org/2112.
Emergency Nature: The proposed TIA intends to correct a circumstance in which the revised NFPA Standard has resulted in an adverse impact on a product or method that was inadvertently overlooked in the total revision process or was without adequate technical (safety) justification for the action. As currently written, NFPA 2112 includes criteria that create a bias against cold weather insulation materials that is inconsistent with their use and in consistent with demonstrated levels of safety.

The OSHA interpretation of March 2010 encouraging employers to provide their employees with garments certified to a consensus standard like NFPA 2112 has created a need and demand for outerwear garments for cold weather protection that are certified to the NFPA 2112 standard. The current edition of the NFPA 2112 standard does not provide clear methods to properly test and certify garments that incorporate insulation for additional protection from cold weather.

Response Message:
Public Input No. 9-NFPA 2112-2013 [Section No. 5.1.2]
First Revision No. 42-NFPA 2112-2014 [ Section No. 5.1.8 ]

5.1.8
The following statement shall be printed legibly on the product label in letters at least 2.5 mm (0.10 in.) high:

THIS GARMENT CLOTHING ITEM MEETS THE REQUIREMENTS OF NFPA 2112, STANDARD ON
FLAME-RESISTANT GARMENTS FOR PROTECTION OF INDUSTRIAL PERSONNEL AGAINST
FLASH FIRE, 2012 EDITION -2016. NFPA 2113 REQUIRES UPPER AND LOWER BODY
COVERAGE.

Submitter Information Verification

Submitter Full Name: Eric Nette
Organization: [ Not Specified ]
Street Address:
City:
State:
Zip:
Submittal Date: Wed Nov 05 15:39:41 CST 2014

Committee Statement

Committee Statement: Additional clothing items were added to the scope of the document.
Response Message:
NFPA 2112-2014

Section 5.1.9

The following information shall also be printed legibly on the product label in letters at least 1.6 mm (0.063 in.) high:

1. Model name, number, or design
2. Manufacturer’s name, identification, or designation
3. Manufacturer’s address
4. Country of manufacture
5. Manufacturer’s garment identification number, lot number, or serial number
6. Size
7. Fiber content for each primary fabric layer including cold weather insulation materials but excluding interlinings and labels
8. “DO NOT REMOVE”

Supplemental Information

File Name: 5.1.9_Changes_EN_12.1.14.docx

Submitter Information Verification

Submitter Full Name: Eric Nette
Organization: [ Not Specified ]
Street Address: 
City: 
State: 
Zip: 
Submittal Date: Tue Nov 04 09:27:40 CST 2014

Committee Statement

Committee Statement: The current criteria in NFPA 2112-2012 are not workable to support the inclusion of cold weather insulation materials that provide safe and effective protection of flame resistant garments used for protection of workers against accident flash fires. Changes were made to the 2012 edition of NFPA 2112 without the benefit of a full validation effort. An effort intended to meet this purpose has now been completed by a task group under the direction of the Technical Committee where several prospective cold weather insulation materials were evaluated using existing and proposed test methods that included both current and modified flame resistance and heat/thermal shrinkage resistance testing. Additional evaluations were carried out using full scale manikin testing with garments incorporating the selected cold weather insulation materials in jackets of a simple design to assess effects of simulated flash fires on the clothing and insulation materials.

This effort produced the following two primary findings:

1. One of the cold weather insulation materials included in the investigation exhibited average afterflame times in excess of the 2-second requirement using the current flame resistance test procedures. When tested according to the proposed modified flame resistance test procedures, afterflame times were compliant or near compliant. In addition, the manikin-based testing for the
same fabric exhibiting extended afterflame times, showed no unusual burning behavior during manikin testing of full garments where the liner consisted of the cold weather insulation material or showed shrinkage that differed radically from garments using materials that qualify to current NFPA 2112 performance criteria. Based on these findings, the modified flame resistance testing can be utilized for the evaluation of cold weather insulation materials.

It was observed that after flame times were observed to be generally shorter when a 50 mm folded edge was used as compared to a 25 mm folded edge. It was also rationalized that more consistent results would be provided with the 50 mm folded edge for the modified flame test because the specimen is positioned 19 mm into a 38 mm high flame leaving only a 6 mm space between the top of the flame and the beginning of the unprotected (by the folded edge) batting. It was therefore reasoned and consistent with the observed test results that the modified flame resistance test should use a 50 mm folded edge.

Specific changes to NFPA 2112 have been proposed in proposed modifications shown in Section 8.3.

2. Certain cold weather insulation materials exhibited significant distortion in heat/thermal shrinkage resistance testing and thermal shrinkage. Yet, these same materials when employed in the form of a liner in a flame resistant jacket utilizing a lightweight shell material did not show significant differences in their shrinkage (of the liner) with materials that would otherwise pass the NFPA 2112-2013 thermal shrinkage resistance criteria. This further included testing with the jacket samples inverted (turned inside out) representing a “worst case” exposure and wearing configuration where no adverse safety issues were observed. From these results, the exemption of cold weather insulation materials from the thermal shrinkage resistance requirement can be justified. Specific changes to NFPA 2112 implementing these modifications are provided as in paragraphs 7.1.3, 7.1.3.1 (deletion), 7.1.4, and Section 8.4.

It is important to point out that the cold weather insulation material is required to meet a heat resistance requirement and is always covered by an outer (shell) material (paragraph 7.1.4). If it is not, it would not qualify as a cold weather insulation material. It is also important to point out that while these changes were based on testing that did not show any safety of the protective garment to be compromised when presented to a simulated flash fire, conditions may exist for which cold weather insulation materials (and other garment materials) will fail to provide intended levels of protection.

The following substantiations are proposed for the additional changes in this amendment to address cold weather insulation material definitions, labeling, design criteria, performance criteria, and test methods:

• A clarification was added to the definition of cold weather insulation material to indicate that the material is not an interlining. Additional language was also added to distinguish an interlining that is not tested for heat resistance or thermal shrinkage resistance from a cold weather insulation material, which is tested for heat resistance but not thermal shrinkage resistance (paragraphs 3.3.6, 3.3.20, A.3.3.6, and A.3.3.20).

• Additional labeling language was added to require the identification of the cold weather insulation material fiber content, the inclusion of a warning that garments with cold weather insulation materials must be properly secured and that a separate label must be provided on the liner if detachable, that indicates that the liner must not be worn by itself. These changes are covered in paragraph 5.1.2, 5.1.9, 5.1.12, and 5.1.13).

• Design criteria were added to permit garment with sewn-in or detachable liners that utilize cold weather insulation materials but that manufacturers must design removable liners so that the liner cannot be worn without the outer layer (paragraphs 6.4 and A.6.4).

• Changes were made in the performance criteria to clarify to which requirements cold weather insulation materials are tested (paragraphs 7.1.2, 7.1.3, and 7.1.4).

• A clarification was provided to specify that the cold weather insulation material is not tested for thermal protective performance (paragraphs 7.1.1.1 and 7.1.1.2).
Specific procedures were added to address the modified testing of the cold weather insulation material as specified in U.S. Air Force purchase description NCTRF PD N2-01-3A, Batting, Quilted, Aramid, involving the removal of 50 mm of batting and folding of the face cloth over the remaining batting, as supported by the test information provided above (paragraph 8.3.1.7 and Section 8.3.13). Additional instructions were provided for preparing samples for conditioning by sewing a layer of flame resistant fabric to the cold weather insulation material prior to laundering with its removal following laundering or dry cleaning (paragraphs 8.3.13.1 and 8.3.13.2).

Modifications for the heat and thermal shrinkage resistance test method were made to clarify that the cold weather insulation materials are not evaluated for thermal shrinkage resistance as supported by the test information above (paragraphs 8.4.1.1 through 8.4.1.5, paragraph 8.4.2.1, and section 8.4.11). Additional instructions were provided for preparing samples for conditioning by sewing a layer of flame resistant fabric to the cold weather insulation material prior to laundering with its removal following laundering or dry cleaning (paragraphs 8.4.3.1 through 8.4.3.3).

For supporting documentation see the doc info pages at www.nfpa.org/2112.

Emergency Nature: The proposed TIA intends to correct a circumstance in which the revised NFPA Standard has resulted in an adverse impact on a product or method that was inadvertently overlooked in the total revision process or was without adequate technical (safety) justification for the action. As currently written, NFPA 2112 includes criteria that create a bias against cold weather insulation materials that is inconsistent with their use and in consistent with demonstrated levels of safety.

The OSHA interpretation of March 2010 encouraging employers to provide their employees with garments certified to a consensus standard like NFPA 2112 has created a need and demand for outerwear garments for cold weather protection that are certified to the NFPA 2112 standard. The current edition of the NFPA 2112 standard does not provide clear methods to properly test and certify garments that incorporate insulation for additional protection from cold weather.

Response Message: Public Input No. 10-NFPA 2112-2013 [Section No. 5.1.9]
5.1.9
The following information shall also be printed legibly on the product label in letters at least 1.6 mm (0.063 in.) high:

1. Model name, number, or design
2. Manufacturer's name, identification, or designation
3. Manufacturer's address
4. Country of manufacture
5. Manufacturer's garment identification number, lot number, or serial number
6. Size
7. Fiber content for each primary fabric layer including cold weather insulation materials, but excluding interlinings and labels
8. “DO NOT REMOVE”
5.1.12 Garments, shrouds/hoods/balaclavas, gloves, or rainwear with multiple layers, including an outer layer and removable cold weather insulation material layer, shall specify the certified wearable configurations on the label configuration and include a warning on the label stating that all layers must be properly secured and worn in accordance with the manufacturer’s instructions.

5.1.13 For garments, shrouds/hoods/balaclavas, gloves, or rainwear with multiple layers that include an outer layer and a removable cold weather insulation layer, a label shall be conspicuously attached to the removable insulation layer that states “DO NOT WEAR THIS LINER BY ITSELF. FOR COMPLIANCE WITH THE REQUIREMENTS OF NFPA 2112, THE COMPLETE CLOTHING ITEM MUST BE WORN. FOR COMPLIANCE INFORMATION, SEE THE PRODUCT LABEL ON THE OUTER CLOTHING ITEM.”

Supplemental Information

<table>
<thead>
<tr>
<th>File Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.1.12_Changes_EN_12.1.14.docx</td>
<td></td>
</tr>
</tbody>
</table>

Submitter Information Verification

Submitter Full Name: Eric Nette
Organization: [ Not Specified ]
Street Address: [ Not Specified ]
City: [ Not Specified ]
State: [ Not Specified ]
Zip: [ Not Specified ]
Submittal Date: Wed Nov 05 16:15:04 CST 2014

Committee Statement

Committee Statement: Additional clothing items were added to the scope of the document.

The current criteria in NFPA 2112-2012 are not workable to support the inclusion of cold weather insulation materials that provide safe and effective protection of flame resistant garments used for protection of workers against accident flash fires. Changes were made to the 2012 edition of NFPA 2112 without the benefit of a full validation effort. An effort intended to meet this purpose has now been completed by a task group under the direction of the Technical Committee where several prospective cold weather insulation materials were evaluated using existing and proposed test methods that included both current and modified flame resistance and heat/thermal shrinkage resistance testing. Additional evaluations were carried out using full scale manikin testing with garments incorporating the selected cold weather insulation materials in jackets of a simple design to assess effects of simulated flash fires on the clothing and insulation materials.

This effort produced the following two primary findings:

1. One of the cold weather insulation materials included in the investigation exhibited average afterflame times in excess of the 2-second requirement using the current flame resistance test procedures. When tested according to the proposed modified flame resistance test procedures, afterflame times were compliant or near compliant. In addition, the manikin-based testing for the same fabric exhibiting extended afterflame times, showed no unusual burning behavior during manikin testing of full garments where the liner consisted of the cold weather insulation material or...
showed shrinkage that differed radically from garments using materials that qualify to current NFPA 2112 performance criteria. Based on these findings, the modified flame resistance testing can be utilized for the evaluation of cold weather insulation materials.

It was observed that after flame times were observed to be generally shorter when a 50 mm folded edge was used as compared to a 25 mm folded edge. It was also rationalized that more consistent results would be provided with the 50 mm folded edge for the modified flame test because the specimen is positioned 19 mm into a 38 mm high flame leaving only a 6 mm space between the top of the flame and the beginning of the unprotected (by the folded edge) batting. It was therefore reasoned and consistent with the observed test results that the modified flame resistance test should use a 50 mm folded edge.

Specific changes to NFPA 2112 have been proposed in proposed modifications shown in Section 8.3.2. Certain cold weather insulation materials exhibited significant distortion in heat/thermal shrinkage resistance testing and thermal shrinkage. Yet, these same materials when employed in the form of a liner in a flame resistant jacket utilizing a lightweight shell material did not show significant differences in their shrinkage (of the liner) with materials that would otherwise pass the NFPA 2112-2013 thermal shrinkage resistance criteria. This further included testing with the jacket samples inverted (turned inside out) representing a “worst case” exposure and wearing configuration where no adverse safety issues were observed. From these results, the exemption of cold weather insulation materials from the thermal shrinkage resistance requirement can be justified. Specific changes to NFPA 2112 implementing these modifications are provided as in paragraphs 7.1.3, 7.1.3.1 (deletion), 7.1.4, and Section 8.4.

It is important to point out that the cold weather insulation material is required to meet a heat resistance requirement and is always covered by an outer (shell) material (paragraph 7.1.4). If it is not, it would not qualify as a cold weather insulation material. It is also important to point out that while these changes were based on testing that did not show any safety of the protective garment to be compromised when presented to a simulated flash fire, conditions may exist for which cold weather insulation materials (and other garment materials) will fail to provide intended levels of protection.

The following substantiations are proposed for the additional changes in this amendment to address cold weather insulation material definitions, labeling, design criteria, performance criteria, and test methods:

• A clarification was added to the definition of cold weather insulation material to indicate that the material is not an interlining. Additional language was also added to distinguish an interlining that is not tested for heat resistance or thermal shrinkage resistance from a cold weather insulation material, which is tested for heat resistance but not thermal shrinkage resistance (paragraphs 3.3.6, 3.3.20, A.3.3.6, and A.3.3.20).

• Additional labeling language was added to require the identification of the cold weather insulation material fiber content, the inclusion of a warning that garments with cold weather insulation materials must be properly secured and that a separate label must be provided on the liner if detachable, that indicates that the liner must not be worn by itself. These changes are covered in paragraph 5.1.2, 5.1.9, 5.1.12, and 5.1.13).

• Design criteria were added to permit garment with sewn-in or detachable liners that utilize cold weather insulation materials but that manufacturers must design removable liners so that the liner cannot be worn without the outer layer (paragraphs 6.4 and A.6.4).

• Changes were made in the performance criteria to clarify to which requirements cold weather insulation materials are tested (paragraphs 7.1.2, 7.1.3, and 7.1.4).

• A clarification was provided to specify that the cold weather insulation material is not tested for thermal protective performance (paragraphs 7.1.1.1 and 7.1.1.2).

• Specific procedures were added to address the modified testing of the cold weather insulation material as specified in U.S. Air Force purchase description NCTRIF PD N2-01-3A, Batting, Quilted, ...
Aramid, involving the removal of 50 mm of batting and folding of the face cloth over the remaining batting, as supported by the test information provided above (paragraph 8.3.1.7 and Section 8.3.13). Additional instructions were provided for preparing samples for conditioning by sewing a layer of flame resistant fabric to the cold weather insulation material prior to laundering with its removal following laundering or dry cleaning (paragraphs 8.3.13.1 and 8.3.13.2).

- Modifications for the heat and thermal shrinkage resistance test method were made to clarify that the cold weather insulation materials are not evaluated for thermal shrinkage resistance as supported by the test information above (paragraphs 8.4.1.1 through 8.4.1.5, paragraph 8.4.2.1, and section 8.4.11). Additional instructions were provided for preparing samples for conditioning by sewing a layer of flame resistant fabric to the cold weather insulation material prior to laundering with its removal following laundering or dry cleaning (paragraphs 8.4.3.1 through 8.4.3.3).

For supporting documentation see the doc info pages at www.nfpa.org/2112.

Emergency Nature: The proposed TIA intends to correct a circumstance in which the revised NFPA Standard has resulted in an adverse impact on a product or method that was inadvertently overlooked in the total revision process or was without adequate technical (safety) justification for the action. As currently written, NFPA 2112 includes criteria that create a bias against cold weather insulation materials that is inconsistent with their use and in consistent with demonstrated levels of safety.

The OSHA interpretation of March 2010 encouraging employers to provide their employees with garments certified to a consensus standard like NFPA 2112 has created a need and demand for outerwear garments for cold weather protection that are certified to the NFPA 2112 standard. The current edition of the NFPA 2112 standard does not provide clear methods to properly test and certify garments that incorporate insulation for additional protection from cold weather.

Response
Message:
Public Input No. 11-NFPA 2112-2013 [Section No. 5.1.12]
5.1.12 - Garments, shrouds/hoods/balaclavas, gloves or rainwear with multiple layers, including an outer layer and removable cold weather insulation material layer, shall specify the certified wearable configurations on the label configuration and include a warning on the label stating that all layers must be properly secured and worn in accordance with the manufacturer’s instructions.

5.1.13 For garments, shrouds/hoods/balaclavas, gloves or rainwear with multiple layers that include an outer layer and a removable cold weather insulation layer, a label shall be conspicuously attached to the removable insulation layer that states “DO NOT WEAR THIS LINER BY ITSELF. FOR COMPLIANCE WITH THE REQUIREMENTS OF NFPA 2112, THE COMPLETE CLOTHING ITEM MUST BE WORN. FOR COMPLIANCE INFORMATION, SEE THE PRODUCT LABEL ON THE OUTER CLOTHING ITEM.”
5.2.1*
The flame-resistant garment manufacturer shall provide information including, but not limited to, warnings, information, and instructions with each flame-resistant garment, with each clothing item, at a minimum, the following instructions and information:

(1) Pre-use information
   (a) Safety considerations
   (b) Limitations of use
   (c) Marking recommendations and restrictions
   (d) Warranty information

(2) Preparation for use
   (a) Sizing/adjustment
   (b) Recommended storage practices

(3) Inspection frequency and details

(4) Donning and doffing procedures

(5) Proper use consistent with NFPA 2113

(6) Maintenance and cleaning
   (a) Cleaning instructions and precautions
   (b) Maintenance criteria and methods of repair where applicable

(7) Retirement and disposal criteria

Submitter Information Verification

Submitter Full Name: Eric Nette
Organization: [ Not Specified ]
Street Address:
City:
State:
Zip:
Submittal Date: Wed Nov 05 15:43:34 CST 2014

Committee Statement

Committee Statement: Additional clothing items were added to the scope of the document. A5.2.1 was moved out of the annex and made mandatory because the previous 5.2.1 was not specific on the information that should be provided. New explanatory annex item replaces the old annex item in FR-47.
5.2.2* Manufacturers shall provide a sizing chart that indicates the range of key wearer measurements that are accommodated by each specific size of garment, shroud/hood/balaclava, glove, or rainwear offered.

Supplemental Information

<table>
<thead>
<tr>
<th>File Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.2.2_Changes_EN_12.1.14.docx</td>
<td></td>
</tr>
</tbody>
</table>

Submitter Information Verification

<table>
<thead>
<tr>
<th>Submitter Full Name:</th>
<th>Eric Nette</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organization:</td>
<td>[ Not Specified ]</td>
</tr>
<tr>
<td>Street Address:</td>
<td></td>
</tr>
<tr>
<td>City:</td>
<td></td>
</tr>
<tr>
<td>State:</td>
<td></td>
</tr>
<tr>
<td>Zip:</td>
<td></td>
</tr>
<tr>
<td>Submittal Date:</td>
<td>Wed Nov 05 15:44:24 CST 2014</td>
</tr>
</tbody>
</table>

Committee Statement

<table>
<thead>
<tr>
<th>Committee Statement:</th>
<th>Additional clothing items were added to the scope of the document.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Response Message:</td>
<td></td>
</tr>
</tbody>
</table>
Manufacturers shall provide a sizing chart that indicates the range of key wearer measurements that are accommodated by each specific size of garment, shroud/hood/balaclava, glove, or rainwear, offered.
First Revision No. 79-NFPA 2112-2014 [Sections 6.1, 6.2, 6.3]

6.1 Garments, Shrouds/Hoods/Balaclavas, Gloves, and Rainwear.
6.1.1 Hardware Finishes.
All flame-resistant hardware finishes shall be free of rough spots, burrs, or sharp edges.
6.1.2 Metal Components.
Any metallic closure systems or metal components of the flame-resistant garments shall not come in direct contact with the body.
6.1.3 Slide Fastener Tape Requirements.
All slide fastener tape utilized in the construction of flame-resistant garments shall be made of an inherently flame-resistant fiber.

Submitter Information Verification

Submitter Full Name: Sonia Barbosa
Organization: [Not Specified]
Street Address: 
City: 
State: 
Zip: 
Submittal Date: Fri Dec 05 16:07:21 EST 2014

Committee Statement

Committee Statement: The proposed design requirements address base requirements for proposed clothing elements.

Response Message:
Public Input No. 71-NFPA 2112-2014 [Chapter 6]
6.2 Garment Design.
Shirts and coveralls shall have long sleeves.

Submitter Information Verification

Submitter Full Name: Sonia Barbosa
Organization: [ Not Specified ]
Street Address: 
City: 
State: 
Zip: 
Submittal Date: Fri Dec 05 16:05:24 EST 2014

Committee Statement

Committee Statement: This FR was made in response to PI-66. This is an attempt to reconcile 2112 requirements with language that already exists in NFPA 2113 which states: 4.3.2 Garments shall be selected that cover both the upper and lower body and flammable layers as completely as possible.

Response Message: 

Committee Statement: 

Response Message: 

Submitter Information Verification

Submitter Full Name: Sonia Barbosa
Organization: [ Not Specified ]
Street Address: 
City: 
State: 
Zip: 
Submittal Date: Fri Dec 05 16:05:24 EST 2014

Committee Statement

Committee Statement: This FR was made in response to PI-66. This is an attempt to reconcile 2112 requirements with language that already exists in NFPA 2113 which states: 4.3.2 Garments shall be selected that cover both the upper and lower body and flammable layers as completely as possible.

Response Message: 

Committee Statement: 

Response Message:
First Revision No. 8-NFPA 2112-2014 [ New Section after 6.3 ]

### 6.3 Use of a Liner for Cold Weather Insulation.
Garments shall be permitted to include liners in their construction including cold weather insulation materials where the liner is either integral to the garment or removable.

#### 6.3.1
Where garments incorporate a cold weather insulation material as part of a removable lining system, the garment shall be designed such that the removable liner consisting of the cold weather insulation material cannot be independently worn.

---

**Supplemental Information**

<table>
<thead>
<tr>
<th>File Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.6.3.1_FR-8.docx</td>
<td></td>
</tr>
</tbody>
</table>

**Submitter Information Verification**

- **Submitter Full Name:** Eric Nette
- **Organization:** [ Not Specified ]
- **Street Address:** [ Not Specified ]
- **City:** [ Not Specified ]
- **State:** [ Not Specified ]
- **Zip:** [ Not Specified ]
- **Submittal Date:** Tue Nov 04 09:27:54 CST 2014

**Committee Statement**

- **Committee Statement:** The current criteria in NFPA 2112-2012 are not workable to support the inclusion of cold weather insulation materials that provide safe and effective protection of flame resistant garments used for protection of workers against accident flash fires. Changes were made to the 2012 edition of NFPA 2112 without the benefit of a full validation effort. An effort intended to meet this purpose has now been completed by a task group under the direction of the Technical Committee where several prospective cold weather insulation materials were evaluated using existing and proposed test methods that included both current and modified flame resistance and heat/thermal shrinkage resistance testing. Additional evaluations were carried out using full scale manikin testing with garments incorporating the selected cold weather insulation materials in jackets of a simple design to assess effects of simulated flash fires on the clothing and insulation materials.

This effort produced the following two primary findings:

1. One of the cold weather insulation materials included in the investigation exhibited average afterflame times in excess of the 2-second requirement using the current flame resistance test procedures. When tested according to the proposed modified flame resistance test procedures, afterflame times were compliant or near compliant. In addition, the manikin-based testing for the same fabric exhibiting extended afterflame times, showed no unusual burning behavior during manikin testing of full garments where the liner consisted of the cold weather insulation material or showed shrinkage that differed radically from garments using materials that qualify to current NFPA 2112 performance criteria. Based on these findings, the modified flame resistance testing can be utilized for the evaluation of cold weather insulation materials.

It was observed that after flame times were observed to be generally shorter when a 50 mm folded edge was used as compared to a 25 mm folded edge. It was also rationalized that more consistent results would be provided with the 50 mm folded edge for the modified flame test because the...
specimen is positioned 19 mm into a 38 mm high flame leaving only a 6 mm space between the top of the flame and the beginning of the unprotected (by the folded edge) batting. It was therefore reasoned and consistent with the observed test results that the modified flame resistance test should use a 50 mm folded edge.

Specific changes to NFPA 2112 have been proposed in proposed modifications shown in Section 8.3.

2. Certain cold weather insulation materials exhibited significant distortion in heat/thermal shrinkage resistance testing and thermal shrinkage. Yet, these same materials when employed in the form of a liner in a flame resistant jacket utilizing a lightweight shell material did not show significant differences in their shrinkage (of the liner) with materials that would otherwise pass the NFPA 2112-2013 thermal shrinkage resistance criteria. This further included testing with the jacket samples inverted (turned inside out) representing a “worst case” exposure and wearing configuration where no adverse safety issues were observed. From these results, the exemption of cold weather insulation materials from the thermal shrinkage resistance requirement can be justified. Specific changes to NFPA 2112 implementing these modifications are provided as in paragraphs 7.1.3, 7.1.3.1 (deletion), 7.1.4, and Section 8.4.

It is important to point out that the cold weather insulation material is required to meet a heat resistance requirement and is always covered by an outer (shell) material (paragraph 7.1.4). If it is not, it would not qualify as a cold weather insulation material. It is also important to point out that while these changes were based on testing that did not show any safety of the protective garment to be compromised when presented to a simulated flash fire, conditions may exist for which cold weather insulation materials (and other garment materials) will fail to provide intended levels of protection.

The following substantiations are proposed for the additional changes in this amendment to address cold weather insulation material definitions, labeling, design criteria, performance criteria, and test methods:

• A clarification was added to the definition of cold weather insulation material to indicate that the material is not an interlining. Additional language was also added to distinguish an interlining that is not tested for heat resistance or thermal shrinkage resistance from a cold weather insulation material, which is tested for heat resistance but not thermal shrinkage resistance (paragraphs 3.3.6, 3.3.20, A.3.3.6, and A.3.3.20).

• Additional labeling language was added to require the identification of the cold weather insulation material fiber content, the inclusion of a warning that garments with cold weather insulation materials must be properly secured and that a separate label must be provided on the liner if detachable, that indicates that the liner must not be worn by itself. These changes are covered in paragraph 5.1.2, 5.1.9, 5.1.12, and 5.1.13).

• Design criteria were added to permit garment with sewn-in or detachable liners that utilize cold weather insulation materials but that manufacturers must design removable liners so that the liner cannot be worn without the outer layer (paragraphs 6.4 and A.6.4).

• Changes were made in the performance criteria to clarify to which requirements cold weather insulation materials are tested (paragraphs 7.1.2, 7.1.3, and 7.1.4).

• A clarification was provided to specify that the cold weather insulation material is not tested for thermal protective performance (paragraphs 7.1.1.1 and 7.1.1.2).

• Specific procedures were added to address the modified testing of the cold weather insulation material as specified in U.S. Air Force purchase description NCTRF PD N2-01-3A, Batting, Quilted, Aramid, involving the removal of 50 mm of batting and folding of the face cloth over the remaining batting, as supported by the test information provided above (paragraph 8.3.1.7 and Section 8.3.13). Additional instructions were provided for preparing samples for conditioning by sewing a layer of flame resistant fabric to the cold weather insulation material prior to laundering with its removal following laundering or dry cleaning (paragraphs 8.3.13.1 and 8.3.13.2).

• Modifications for the heat and thermal shrinkage resistance test method were made to clarify that
the cold weather insulation materials are not evaluated for thermal shrinkage resistance as supported by the test information above (paragraphs 8.4.1.1 through 8.4.1.5, paragraph 8.4.2.1, and section 8.4.11). Additional instructions were provided for preparing samples for conditioning by sewing a layer of flame resistant fabric to the cold weather insulation material prior to laundering with its removal following laundering or dry cleaning (paragraphs 8.4.3.1 through 8.4.3.3).

For supporting documentation see the doc info pages at www.nfpa.org/2112.

Emergency Nature: The proposed TIA intends to correct a circumstance in which the revised NFPA Standard has resulted in an adverse impact on a product or method that was inadvertently overlooked in the total revision process or was without adequate technical (safety) justification for the action. As currently written, NFPA 2112 includes criteria that create a bias against cold weather insulation materials that is inconsistent with their use and in consistent with demonstrated levels of safety.

The OSHA interpretation of March 2010 encouraging employers to provide their employees with garments certified to a consensus standard like NFPA 2112 has created a need and demand for outerwear garments for cold weather protection that are certified to the NFPA 2112 standard. The current edition of the NFPA 2112 standard does not provide clear methods to properly test and certify garments that incorporate insulation for additional protection from cold weather.

Response Message:
Public Input No. 12-NFPA 2112-2013 [New Section after 6.3]
Public Input No. 13-NFPA 2112-2013 [New Section after A.5.2.2]
A.6.4.1

Removable liners are permitted to be worn separately if the liner material(s) independently meets the appropriate fabric requirements in Chapter 7 including 7.1.1 for heat transfer performance and 7.1.5 for overall flash fire performance. If the liner contains cold weather insulation materials that are not evaluated to 7.1.1 and 7.1.5 and do not pass the thermal shrinkage resistance requirement in 7.1.3, then the manufacturer must label the liner as specified in 5.1.13 and provide a design that does not allow separate wearing of the liner without the outer layer. This may be demonstrated by the absence of a means of closure for the closure area of shirts, pants, and coveralls.
First Revision No. 10-NFPA 2112-2014 [ New Section after 7.1.1 ]

7.1.1.1 Where the flame-resistant garment consists of multiple and separable layers intended to be worn separately, the outer layer and the inner layer or layers shall be separately tested.

7.1.1.2 Where the flame-resistant garment consists of multiple layers intended only to be worn together, only the outer layer shall be tested.

Submitter Information Verification

Submitter Full Name: Eric Nette
Organization: [ Not Specified ]
Street Address:
City:
State:
Zip:
Submittal Date: Tue Nov 04 09:28:25 CST 2014

Committee Statement

Committee Statement: The current criteria in NFPA 2112-2012 are not workable to support the inclusion of cold weather insulation materials that provide safe and effective protection of flame resistant garments used for protection of workers against accidental flash fires. Changes were made to the 2012 edition of NFPA 2112 without the benefit of a full validation effort. An effort intended to meet this purpose has now been completed by a task group under the direction of the Technical Committee where several prospective cold weather insulation materials were evaluated using existing and proposed test methods that included both current and modified flame resistance and heat/thermal shrinkage resistance testing. Additional evaluations were carried out using full scale manikin testing with garments incorporating the selected cold weather insulation materials in jackets of a simple design to assess effects of simulated flash fires on the clothing and insulation materials.

This effort produced the following two primary findings:

1. One of the cold weather insulation materials included in the investigation exhibited average afterflame times in excess of the 2-second requirement using the current flame resistance test procedures. When tested according to the proposed modified flame resistance test procedures, afterflame times were compliant or near compliant. In addition, the manikin-based testing for the same fabric exhibiting extended afterflame times, showed no unusual burning behavior during manikin testing of full garments where the liner consisted of the cold weather insulation material or showed shrinkage that differed radically from garments using materials that qualify to current NFPA 2112 performance criteria. Based on these findings, the modified flame resistance testing can be utilized for the evaluation of cold weather insulation materials.

It was observed that after flame times were observed to be generally shorter when a 50 mm folded edge was used as compared to a 25 mm folded edge. It was also rationalized that more consistent results would be provided with the 50 mm folded edge for the modified flame test because the specimen is positioned 19 mm into a 38 mm high flame leaving only a 6 mm space between the top of the flame and the beginning of the unprotected (by the folded edge) batting. It was therefore reasoned and consistent with the observed test results that the modified flame resistance test should use a 50 mm folded edge.

Specific changes to NFPA 2112 have been proposed in proposed modifications shown in Section 8.3.
2. Certain cold weather insulation materials exhibited significant distortion in heat/thermal shrinkage resistance testing and thermal shrinkage. Yet, these same materials when employed in the form of a liner in a flame resistant jacket utilizing a lightweight shell material did not show significant differences in their shrinkage (of the liner) with materials that would otherwise pass the NFPA 2112-2013 thermal shrinkage resistance criteria. This further included testing with the jacket samples inverted (turned inside out) representing a “worst case” exposure and wearing configuration where no adverse safety issues were observed. From these results, the exemption of cold weather insulation materials from the thermal shrinkage resistance requirement can be justified. Specific changes to NFPA 2112 implementing these modifications are provided as in paragraphs 7.1.3, 7.1.3.1 (deletion), 7.1.4, and Section 8.4.

It is important to point out that the cold weather insulation material is required to meet a heat resistance requirement and is always covered by an outer (shell) material (paragraph 7.1.4). If it is not, it would not qualify as a cold weather insulation material. It is also important to point out that while these changes were based on testing that did not show any safety of the protective garment to be compromised when presented to a simulated flash fire, conditions may exist for which cold weather insulation materials (and other garment materials) will fail to provide intended levels of protection.

The following substantiations are proposed for the additional changes in this amendment to address cold weather insulation material definitions, labeling, design criteria, performance criteria, and test methods:

• A clarification was added to the definition of cold weather insulation material to indicate that the material is not an interlining. Additional language was also added to distinguish an interlining that is not tested for heat resistance or thermal shrinkage resistance from a cold weather insulation material, which is tested for heat resistance but not thermal shrinkage resistance (paragraphs 3.3.6, 3.3.20, A.3.3.6, and A.3.3.20).

• Additional labeling language was added to require the identification of the cold weather insulation material fiber content, the inclusion of a warning that garments with cold weather insulation materials must be properly secured and that a separate label must be provided on the liner if detachable, that indicates that the liner must not be worn by itself. These changes are covered in paragraph 5.1.2, 5.1.9, 5.1.12, and 5.1.13).

• Design criteria were added to permit garment with sewn-in or detachable liners that utilize cold weather insulation materials but that manufacturers must design removable liners so that the liner cannot be worn without the outer layer (paragraphs 6.4 and A.6.4).

• Changes were made in the performance criteria to clarify to which requirements cold weather insulation materials are tested (paragraphs 7.1.2, 7.1.3, and 7.1.4).

• A clarification was provided to specify that the cold weather insulation material is not tested for thermal protective performance (paragraphs 7.1.1.1 and 7.1.1.2).

• Specific procedures were added to address the modified testing of the cold weather insulation material as specified in U.S. Air Force purchase description NCTRF PD N2-01-3A, Batting, Quilted, Aramid, involving the removal of 50 mm of batting and folding of the face cloth over the remaining batting, as supported by the test information provided above (paragraph 8.3.1.7 and Section 8.3.13). Additional instructions were provided for preparing samples for conditioning by sewing a layer of flame resistant fabric to the cold weather insulation material prior to laundering with its removal following laundering or dry cleaning (paragraphs 8.3.13.1 and 8.3.13.2).

• Modifications for the heat and thermal shrinkage resistance test method were made to clarify that the cold weather insulation materials are not evaluated for thermal shrinkage resistance as supported by the test information above (paragraphs 8.4.1.1 through 8.4.1.5, paragraph 8.4.2.1, and section 8.4.11). Additional instructions were provided for preparing samples for conditioning by sewing a layer of flame resistant fabric to the cold weather insulation material prior to laundering with its removal following laundering or dry cleaning (paragraphs 8.4.3.1 through 8.4.3.3).

For supporting documentation see the doc info pages at www.nfpa.org/2112.
Emergency Nature: The proposed TIA intends to correct a circumstance in which the revised NFPA Standard has resulted in an adverse impact on a product or method that was inadvertently overlooked in the total revision process or was without adequate technical (safety) justification for the action. As currently written, NFPA 2112 includes criteria that create a bias against cold weather insulation materials that is inconsistent with their use and in consistent with demonstrated levels of safety.

The OSHA interpretation of March 2010 encouraging employers to provide their employees with garments certified to a consensus standard like NFPA 2112 has created a need and demand for outerwear garments for cold weather protection that are certified to the NFPA 2112 standard. The current edition of the NFPA 2112 standard does not provide clear methods to properly test and certify garments that incorporate insulation for additional protection from cold weather.

Response
Message:
Public Input No. 14-NFPA 2112-2013 [New Section after 7.1.1]
First Revision No. 11-NFPA 2112-2014 [Sections 7.1.2, 7.1.3]

7.1.2
Fabric, cold weather insulation material, and reflective striping utilized in the construction of flame-resistant garments shall be tested for flame resistance as specified in Section 8.3, and shall have a char length of not more than 100 mm (4 in.) and an after-flame of not more than 2 seconds, and shall not melt and drip.

7.1.3
Fabric utilized in the construction of flame-resistant garments, excluding manufacturers' labels, interlinings, and cold weather insulation materials, shall be individually tested for thermal shrinkage resistance as specified in Section 8.4, and shall not shrink more than 10 percent in any direction.

7.1.3.1
Cold weather insulation materials utilized in the construction of flame-resistant garments shall be tested in accordance with Section 8.4, and shall not shrink more than 20 percent in any direction.

Submitter Information Verification

Submitter Full Name: Eric Nette
Organization: [Not Specified]
Street Address: [Not Specified]
City: [Not Specified]
State: [Not Specified]
Zip: [Not Specified]
Submittal Date: Tue Nov 04 09:28:39 CST 2014

Committee Statement

Committee Statement: The current criteria in NFPA 2112-2012 are not workable to support the inclusion of cold weather insulation materials that provide safe and effective protection of flame resistant garments used for protection of workers against accident flash fires. Changes were made to the 2012 edition of NFPA 2112 without the benefit of a full validation effort. An effort intended to meet this purpose has now been completed by a task group under the direction of the Technical Committee where several prospective cold weather insulation materials were evaluated using existing and proposed test methods that included both current and modified flame resistance and heat/thermal shrinkage resistance testing. Additional evaluations were carried out using full scale manikin testing with garments incorporating the selected cold weather insulation materials in jackets of a simple design to assess effects of simulated flash fires on the clothing and insulation materials.

This effort produced the following two primary findings:

1. One of the cold weather insulation materials included in the investigation exhibited average afterflame times in excess of the 2-second requirement using the current flame resistance test procedures. When tested according to the proposed modified flame resistance test procedures, afterflame times were compliant or near compliant. In addition, the manikin-based testing for the same fabric exhibiting extended afterflame times, showed no unusual burning behavior during manikin testing of full garments where the liner consisted of the cold weather insulation material or showed shrinkage that differed radically from garments using materials that qualify to current NFPA 2112 performance criteria. Based on these findings, the modified flame resistance testing can be utilized for the evaluation of cold weather insulation materials.

It was observed that after flame times were observed to be generally shorter when a 50 mm folded edge was used as compared to a 25 mm folded edge. It was also rationalized that more consistent results would be provided with the 50 mm folded edge for the modified flame test because the
specimen is positioned 19 mm into a 38 mm high flame leaving only a 6 mm space between the top of the flame and the beginning of the unprotected (by the folded edge) batting. It was therefore reasoned and consistent with the observed test results that the modified flame resistance test should use a 50 mm folded edge.

Specific changes to NFPA 2112 have been proposed in proposed modifications shown in Section 8.3.

2. Certain cold weather insulation materials exhibited significant distortion in heat/thermal shrinkage resistance testing and thermal shrinkage. Yet, these same materials when employed in the form of a liner in a flame resistant jacket utilizing a lightweight shell material did not show significant differences in their shrinkage (of the liner) with materials that would otherwise pass the NFPA 2112-2013 thermal shrinkage resistance criteria. This further included testing with the jacket samples inverted (turned inside out) representing a “worst case” exposure and wearing configuration where no adverse safety issues were observed. From these results, the exemption of cold weather insulation materials from the thermal shrinkage resistance requirement can be justified. Specific changes to NFPA 2112 implementing these modifications are provided as in paragraphs 7.1.3, 7.1.3.1 (deletion), 7.1.4, and Section 8.4.

It is important to point out that the cold weather insulation material is required to meet a heat resistance requirement and is always covered by an outer (shell) material (paragraph 7.1.4). If it is not, it would not qualify as a cold weather insulation material. It is also important to point out that while these changes were based on testing that did not show any safety of the protective garment to be compromised when presented to a simulated flash fire, conditions may exist for which cold weather insulation materials (and other garment materials) will fail to provide intended levels of protection.

The following substantiations are proposed for the additional changes in this amendment to address cold weather insulation material definitions, labeling, design criteria, performance criteria, and test methods:

• A clarification was added to the definition of cold weather insulation material to indicate that the material is not an interlining. Additional language was also added to distinguish an interlining that is not tested for heat resistance or thermal shrinkage resistance from a cold weather insulation material, which is tested for heat resistance but not thermal shrinkage resistance (paragraphs 3.3.6, 3.3.20, A.3.3.6, and A.3.3.20).

• Additional labeling language was added to require the identification of the cold weather insulation material fiber content, the inclusion of a warning that garments with cold weather insulation materials must be properly secured and that a separate label must be provided on the liner if detachable, that indicates that the liner must not be worn by itself. These changes are covered in paragraph 5.1.2, 5.1.9, 5.1.12, and 5.1.13).

• Design criteria were added to permit garment with sewn-in or detachable liners that utilize cold weather insulation materials but that manufacturers must design removable liners so that the liner cannot be worn without the outer layer (paragraphs 6.4 and A.6.4).

• Changes were made in the performance criteria to clarify to which requirements cold weather insulation materials are tested (paragraphs 7.1.2, 7.1.3, and 7.1.4).

• A clarification was provided to specify that the cold weather insulation material is not tested for thermal protective performance (paragraphs 7.1.1.1 and 7.1.1.2).

• Specific procedures were added to address the modified testing of the cold weather insulation material as specified in U.S. Air Force purchase description NCTRF PD N2-01-3A, Batting, Quilted, Aramid, involving the removal of 50 mm of batting and folding of the face cloth over the remaining batting, as supported by the test information provided above (paragraph 8.3.1.7 and Section 8.3.13). Additional instructions were provided for preparing samples for conditioning by sewing a layer of flame resistant fabric to the cold weather insulation material prior to laundering with its removal following laundering or dry cleaning (paragraphs 8.3.13.1 and 8.3.13.2).

• Modifications for the heat and thermal shrinkage resistance test method were made to clarify that
the cold weather insulation materials are not evaluated for thermal shrinkage resistance as supported by the test information above (paragraphs 8.4.1.1 through 8.4.1.5, paragraph 8.4.2.1, and section 8.4.11). Additional instructions were provided for preparing samples for conditioning by sewing a layer of flame resistant fabric to the cold weather insulation material prior to laundering with its removal following laundering or dry cleaning (paragraphs 8.4.3.1 through 8.4.3.3).

For supporting documentation see the doc info pages at www.nfpa.org/2112.

Emergency Nature: The proposed TIA intends to correct a circumstance in which the revised NFPA Standard has resulted in an adverse impact on a product or method that was inadvertently overlooked in the total revision process or was without adequate technical (safety) justification for the action. As currently written, NFPA 2112 includes criteria that create a bias against cold weather insulation materials that is inconsistent with their use and in consistent with demonstrated levels of safety.

The OSHA interpretation of March 2010 encouraging employers to provide their employees with garments certified to a consensus standard like NFPA 2112 has created a need and demand for outerwear garments for cold weather protection that are certified to the NFPA 2112 standard. The current edition of the NFPA 2112 standard does not provide clear methods to properly test and certify garments that incorporate insulation for additional protection from cold weather.

Response Message:
Public Input No. 15-NFPA 2112-2013 [Sections 7.1.2, 7.1.3]
Fabric, cold weather insulation materials, other textile materials, and reflective striping, other than those items described in 7.1.4.1 and 7.1.4.2, used in the construction of flame-resistant garments shall be individually tested for heat resistance in their original form as specified in Section 8.4, and shall not melt and drip, separate, or ignite.

Submitter Information Verification

Submitter Full Name: Eric Nette
Organization: [ Not Specified ]
Street Address:
City:
State:
Zip:
Submittal Date: Tue Nov 04 09:28:56 CST 2014

Committee Statement

Committee Statement: The current criteria in NFPA 2112-2012 are not workable to support the inclusion of cold weather insulation materials that provide safe and effective protection of flame resistant garments used for protection of workers against accident flash fires. Changes were made to the 2012 edition of NFPA 2112 without the benefit of a full validation effort. An effort intended to meet this purpose has now been completed by a task group under the direction of the Technical Committee where several prospective cold weather insulation materials were evaluated using existing and proposed test methods that included both current and modified flame resistance and heat/thermal shrinkage resistance testing. Additional evaluations were carried out using full scale manikin testing with garments incorporating the selected cold weather insulation materials in jackets of a simple design to assess effects of simulated flash fires on the clothing and insulation materials.

This effort produced the following two primary findings:

1. One of the cold weather insulation materials included in the investigation exhibited average afterflame times in excess of the 2-second requirement using the current flame resistance test procedures. When tested according to the proposed modified flame resistance test procedures, afterflame times were compliant or near compliant. In addition, the manikin-based testing for the same fabric exhibiting extended afterflame times, showed no unusual burning behavior during manikin testing of full garments where the liner consisted of the cold weather insulation material or showed shrinkage that differed radically from garments using materials that qualify to current NFPA 2112 performance criteria. Based on these findings, the modified flame resistance testing can be utilized for the evaluation of cold weather insulation materials.

It was observed that after flame times were observed to be generally shorter when a 50 mm folded edge was used as compared to a 25 mm folded edge. It was also rationalized that more consistent results would be provided with the 50 mm folded edge for the modified flame test because the specimen is positioned 19 mm into a 38 mm high flame leaving only a 6 mm space between the top of the flame and the beginning of the unprotected (by the folded edge) batting. It was therefore reasoned and consistent with the observed test results that the modified flame resistance test should use a 50 mm folded edge.

Specific changes to NFPA 2112 have been proposed in proposed modifications shown in Section 8.3.

2. Certain cold weather insulation materials exhibited significant distortion in heat/thermal shrinkage...
resistance testing and thermal shrinkage. Yet, these same materials when employed in the form of a liner in a flame resistant jacket utilizing a lightweight shell material did not show significant differences in their shrinkage (of the liner) with materials that would otherwise pass the NFPA 2112-2013 thermal shrinkage resistance criteria. This further included testing with the jacket samples inverted (turned inside out) representing a “worst case” exposure and wearing configuration where no adverse safety issues were observed. From these results, the exemption of cold weather insulation materials from the thermal shrinkage resistance requirement can be justified. Specific changes to NFPA 2112 implementing these modifications are provided as in paragraphs 7.1.3, 7.1.3.1 (deletion), 7.1.4, and Section 8.4.

It is important to point out that the cold weather insulation material is required to meet a heat resistance requirement and is always covered by an outer (shell) material (paragraph 7.1.4). If it is not, it would not qualify as a cold weather insulation material. It is also important to point out that while these changes were based on testing that did not show any safety of the protective garment to be compromised when presented to a simulated flash fire, conditions may exist for which cold weather insulation materials (and other garment materials) will fail to provide intended levels of protection.

The following substantiations are proposed for the additional changes in this amendment to address cold weather insulation material definitions, labeling, design criteria, performance criteria, and test methods:

• A clarification was added to the definition of cold weather insulation material to indicate that the material is not an interlining. Additional language was also added to distinguish an interlining that is not tested for heat resistance or thermal shrinkage resistance from a cold weather insulation material, which is tested for heat resistance but not thermal shrinkage resistance (paragraphs 3.3.6, 3.3.20, A.3.3.6, and A.3.3.20).

• Additional labeling language was added to require the identification of the cold weather insulation material fiber content, the inclusion of a warning that garments with cold weather insulation materials must be properly secured and that a separate label must be provided on the liner if detachable, that indicates that the liner must not be worn by itself. These changes are covered in paragraph 5.1.2, 5.1.9, 5.1.12, and 5.1.13).

• Design criteria were added to permit garment with sewn-in or detachable liners that utilize cold weather insulation materials but that manufacturers must design removable liners so that the liner cannot be worn without the outer layer (paragraphs 6.4 and A.6.4).

• Changes were made in the performance criteria to clarify to which requirements cold weather insulation materials are tested (paragraphs 7.1.2, 7.1.3, and 7.1.4).

• A clarification was provided to specify that the cold weather insulation material is not tested for thermal protective performance (paragraphs 7.1.1.1 and 7.1.1.2).

• Specific procedures were added to address the modified testing of the cold weather insulation material as specified in U.S. Air Force purchase description NCTRFD N2-01-3A, Batting, Quilted, Aramid, involving the removal of 50 mm of batting and folding of the face cloth over the remaining batting, as supported by the test information provided above (paragraph 8.3.1.7 and Section 8.3.13). Additional instructions were provided for preparing samples for conditioning by sewing a layer of flame resistant fabric to the cold weather insulation material prior to laundering with its removal following laundering or dry cleaning (paragraphs 8.3.13.1 and 8.3.13.2).

• Modifications for the heat and thermal shrinkage resistance test method were made to clarify that the cold weather insulation materials are not evaluated for thermal shrinkage resistance as supported by the test information above (paragraphs 8.4.1.1 through 8.4.1.5, paragraph 8.4.2.1, and section 8.4.11). Additional instructions were provided for preparing samples for conditioning by sewing a layer of flame resistant fabric to the cold weather insulation material prior to laundering with its removal following laundering or dry cleaning (paragraphs 8.4.3.1 through 8.4.3.3).

For supporting documentation see the doc info pages at www.nfpa.org/2112.
Emergency Nature: The proposed TIA intends to correct a circumstance in which the revised NFPA Standard has resulted in an adverse impact on a product or method that was inadvertently overlooked in the total revision process or was without adequate technical (safety) justification for the action. As currently written, NFPA 2112 includes criteria that create a bias against cold weather insulation materials that is inconsistent with their use and in consistent with demonstrated levels of safety.

The OSHA interpretation of March 2010 encouraging employers to provide their employees with garments certified to a consensus standard like NFPA 2112 has created a need and demand for outerwear garments for cold weather protection that are certified to the NFPA 2112 standard. The current edition of the NFPA 2112 standard does not provide clear methods to properly test and certify garments that incorporate insulation for additional protection from cold weather.

Response Message:
Public Input No. 16-NFPA 2112-2013 [Section No. 7.1.4 [Excluding any Sub-Sections]]
Interlinings, collar stays, elastics, closures, and hook and pile fasteners, when not in direct contact with the skin, shall not be required to be tested for heat resistance.

Submitter Information Verification

Submitter Full Name: Eric Nette
Organization: [Not Specified]
Street Address: 
City: 
State: 
Zip: 
Submittal Date: Thu Nov 06 16:28:40 CST 2014

Committee Statement

Committee Statement: The requirements of 7.1.4.2 applied to closures conflicted with the requirements of 7.3. 7.3 is modified to clarify this requirement in FR-77.
Specimen garments shall be tested for overall flash fire exposure as specified in Section 8.5 as a qualification test for the material and shall have an average predicted body burn of not more than 50 percent based on the total surface area covered by sensors, excluding hands and feet.

Submitter Information Verification

Submitter Full Name: Eric Nette
Organization: [Not Specified]
Street Address:
City:
State:
Zip:
Submittal Date: Thu Nov 06 15:18:25 CST 2014

Committee Statement

Committee Statement: ASTM F1930 for this performance specification is not a flash fire test. It is a standardized diffusion fire (excess fuel) test utilizing multiple burners producing an engulfing jet fire from propane.

Response Message:
Public Input No. 42-NFPA 2112-2014 [Section No. 7.1.5 [Excluding any Sub-Sections]]
7.1.5.1 Garments consisting of separable layers, such as a removable cold weather insulation material layer, that are intended to be worn together or separately shall be tested in all wearable configurations identified by the manufacturer. Where the flame-resistant garment consists of multiple and separable layers intended to be worn separately, both of the following shall apply:

1. Specimen garments consisting of the outer layer only shall be tested.

2. Specimen garments consisting of the inner layer or layers only shall be tested.

7.1.5.2 Where the flame-resistant garment consists of multiple layers intended only to be worn together, specimen garments consisting of the outer layer only shall be tested.

Submitter Information Verification

Submitter Full Name: Eric Nette
Organization: [ Not Specified ]
Street Address: 
City: 
State: 
Zip: 
Submittal Date: Tue Nov 04 09:26:02 CST 2014

Committee Statement

Committee Statement: The current language does not provide requirements for all perceived wearable configurations of garments that consist of multiple layers. This leaves room for interpretation of testing requirements where a garment's finished application was not identified by the standard. The new wording adds this necessary clarification.

Where garments do have removable lining materials, but those lining materials are never intended to be worn without the outer protective layer, the current standard requires redundant testing with little to no benefit of the user. NFPA 2112 has identified TPP, Heat and Thermal Shrinkage and Flame Resistance requirements for fabric materials to identify the minimum testing that would demonstrate a contribution to burn injuries in a flash fire exposure. If the outer layer has been tested and complies with the full scale, manikin test, and the inner layer has been tested and complies with all the fabric tests that have been chosen to identify materials that would contribute to burn injuries, then adding those two layers together should not negatively impact the performance of that composite on the manikin test. By requiring this redundant testing, manufacturers have chosen to not certify these products and therefore they are encouraging users to wear non-certified configurations of these garments.

Emergency Nature: The proposed TIA intends to correct a circumstance in which the revised document has resulted in an adverse impact on a product or method that was inadvertently overlooked in the total revision process. Products consisting of multiple and separable layers are not being submitted for certification because there is confusion regarding the application of this section which mandates redundant evaluation of each layer of material. This leads to the wearing of non-compliant garments by the users and lessens the influence and credibility of NFPA 2112 in the field.

Response Message:

Public Input No. 2-NFPA 2112-2013 [Section No. 7.1.5.1]
7.3* Hardware Requirement.
Specimens of hardware used in the construction of flame-resistant garments, including but not limited to buttons, fasteners, and nonfabric-based closures, shall be individually tested for heat resistance in their original form as specified in Section 8.4; shall not melt and drip, separate, or ignite; and shall remain functional.

Supplemental Information

<table>
<thead>
<tr>
<th>File Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.7.3.docx</td>
<td></td>
</tr>
</tbody>
</table>

Submitter Information Verification

Submitter Full Name: Eric Nette
Organization: [ Not Specified ]
Street Address:
City:
State:
Zip:
Submittal Date: Thu Nov 06 16:30:39 CST 2014

Committee Statement

Committee Statement: The requirements of 7.1.4.2 applied to closures conflicted with the requirements of 7.3. 7.1.4.2 is modified to clarify this requirement in FR-76.
A.7.3 Hook and pile fasteners are considered to be fabric based components.
7.5 Shroud/Hood/Balaclava Requirements.

7.5.1 Fabric utilized in the construction of flame-resistant shrouds/hoods/balaclavas shall be tested for heat transfer protective performance (HTP) as specified in Section 8.2, and shall have a "spaced" HTP rating of not less than $25 \text{ J/cm}^2$ (6.0 cal/cm$^2$) and a "contact" HTP rating of not less than $12.6 \text{ J/cm}^2$ (3.0 cal/cm$^2$).

7.5.2 Fabric utilized in the construction of flame-resistant shrouds/hoods/balaclavas shall be tested for flame resistance as specified in Section 8.3, and shall have a char length of not more than 100 mm (4 in.) and an afterflame of not more than 2 seconds, and shall not melt and drip.

7.5.3 Fabric utilized in the construction of flame-resistant shrouds/hoods/balaclavas, excluding manufacturers' labels, shall be individually tested for thermal shrinkage resistance as specified in Section 8.4, and shall not shrink more than 10 percent in any direction.

7.5.4 Fabric and other textile materials other than those items described in 7.1.4.1 and 7.1.4.2 used in the construction of flame-resistant shrouds/hoods/balaclavas shall be individually tested for heat resistance in their original form as specified in Section 8.4, and shall not melt and drip, separate, or ignite.

7.5.4.1 Labels and emblems shall not be required to be tested for heat resistance.

7.5.4.2 Interlinings, elastics, closures, and hook and pile fasteners, when not in direct contact with the skin, shall not be required to be tested for heat resistance.

7.5.5 Sewing thread utilized in the construction of flame-resistant gloves, excluding embroidery, shall be made of an inherently flame-resistant fiber. Specimens of this thread shall be tested for heat resistance as specified in Section 8.6, and shall not melt.

7.5.6 Specimens of hardware used in the construction of flame-resistant shrouds/hoods/balaclavas, including but not limited to buttons, fasteners, and closures, shall be individually tested for heat resistance in their original form as specified in Section 8.4; shall not melt and drip, separate, or ignite; and shall remain functional.

7.5.7 Specimen labels used in the construction of flame-resistant shrouds/hoods/balaclavas shall be tested for printing durability as specified in Section 8.7, and shall remain legible.

7.5.8 Whole shrouds/hoods/balaclavas shall be tested for overall fire exposure as specified in Section 8.7.8 and shall have an average predicted burn of not more than 50 percent excluding any sensor not covered by the shroud/hood/balaclava.
<table>
<thead>
<tr>
<th>Committee Statement</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Committee Statement:</strong> This establishes performance requirements for shrouds/hoods/balaclavas. The committee would like to solicit Public Comments on the requirements for the test methods. It is understood that these test methods are currently under development. Data and refinements to the methods will be submitted and considered.</td>
</tr>
</tbody>
</table>

Note to editorial: The 8.X at the end of this section denotes the corresponding section in Chapter 8 that refers to Shrouds/Hoods/Balaclavas added in FR-68.
7.6  Glove Requirements.

7.6.1  Fabric utilized in the construction of flame-resistant gloves shall be tested for heat transfer protective performance (HTP) as specified in Section 8.2, and shall have a “spaced” HTP rating of not less than 25 J/cm\(^2\) (6.0 cal/cm\(^2\)) and a “contact” HTP rating of not less than 12.6 J/cm\(^2\) (3.0 cal/cm\(^2\)).

7.6.2  Fabric utilized in the construction of flame-resistant gloves shall be tested for flame resistance as specified in Section 8.8, and shall have a char length of not more than 100 mm (4 in.) and an afterflame of not more than 2 seconds, and shall not melt and drip.

7.6.3  Fabric utilized in the construction of flame-resistant gloves, excluding manufacturers’ labels, shall be individually tested for thermal shrinkage resistance as specified in Section 8.4, and shall not shrink more than 10 percent in any direction.

7.6.4  Fabric and other textile materials other than those items described in 7.1.4.1 and 7.1.4.2 used in the construction of flame-resistant gloves shall be individually tested for heat resistance in their original form as specified in Section 8.4, and shall not melt and drip, separate, or ignite.

7.6.4.1  Labels and emblems shall not be required to be tested for heat resistance.

7.6.4.2  Interlinings, elastics, closures, and hook and pile fasteners, when not in direct contact with the skin, shall not be required to be tested for heat resistance.

7.6.5  Sewing thread utilized in the construction of flame-resistant gloves, excluding embroidery, shall be made of an inherently flame-resistant fiber. Specimens of this thread shall be tested for heat resistance as specified in Section 8.6, and shall not melt.

7.6.6  Specimens of hardware used in the construction of flame-resistant gloves, including but not limited to buttons, fasteners, and closures, shall be individually tested for heat resistance in their original form as specified in Section 8.4; shall not melt and drip, separate, or ignite; and shall remain functional.

7.6.7  Specimen labels used in the construction of flame-resistant gloves shall be tested for printing durability as specified in Section 8.7 and shall remain legible.

7.6.8  Whole gloves shall be tested for overall fire exposure as specified in Section 8.7.7 and shall have an average predicted burn of not more than 50 percent excluding any sensor not covered by the glove.

Submitter Information Verification

Submitter Full Name: Eric Nette
Organization: [ Not Specified ]
Street Address: 
City: 
State: 
Zip: 
Submittal Date: Wed Nov 05 11:34:06 CST 2014

Committee Statement
<table>
<thead>
<tr>
<th>Committee Statement:</th>
<th>This establishes performance requirements for gloves. The committee would like to solicit Public Comments on the requirements for the test methods. It is understood that these test methods are currently under development. Data and refinements to the methods will be submitted and considered.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Editorial note:</td>
<td>7.X.2 should refer to the text added under FR-59. 7.X.8 should refer to the text added under FR-67.</td>
</tr>
<tr>
<td>Response Message:</td>
<td></td>
</tr>
</tbody>
</table>
7.7 Rainwear Requirements.

7.7.1 Fabric utilized in the construction of flame-resistant rainwear shall be tested for heat transfer protective performance (HTP) as specified in Section 8.2, and shall have a "spaced" HTP rating of not less than $25\text{ J/cm}^2 (6.0 \text{ cal/cm}^2)$ and a "contact" HTP rating of not less than $12.6 \text{ J/cm}^2 (3.0 \text{ cal/cm}^2)$.

7.7.2 Fabric utilized in the construction of flame-resistant rainwear shall be tested for flame resistance as specified in Section 8.3, and shall have a char length of not more than 100 mm (4 in.) and an afterflame of not more than 2 seconds, and shall not melt and drip.

7.7.3 Fabric utilized in the construction of flame-resistant rainwear, excluding manufacturers' labels, shall be individually tested for thermal shrinkage resistance as specified in Section 8.4, and shall not shrink more than 10 percent in any direction.

7.7.4 Fabric, and other textile materials other than those items described in 7.1.4.1 and 7.1.4.2, used in the construction of flame-resistant rainwear shall be individually tested for heat resistance in their original form as specified in Section 8.4, and shall not melt and drip, separate, or ignite.

7.7.4.1 Labels and emblems shall not be required to be tested for heat resistance.

7.7.4.2 Interlinings, elastics, closures, and hook and pile fasteners, when not in direct contact with the skin, shall not be required to be tested for heat resistance.

7.7.5 Sewing thread utilized in the construction of flame-resistant rainwear, excluding embroidery, shall be made of an inherently flame-resistant fiber. Specimens of this thread shall be tested for heat resistance as specified in Section 8.6, and shall not melt.

7.7.6 Specimens of hardware used in the construction of flame-resistant rainwear, including but not limited to buttons, fasteners, and closures, shall be individually tested for heat resistance in their original form as specified in Section 8.4; shall not melt and drip, separate, or ignite; and shall remain functional.

7.7.7 Specimen labels used in the construction of flame-resistant rainwear shall be tested for printing durability as specified in Section 8.7, and shall remain legible.

7.7.8 Rainwear fabric and seams shall meet the requirements of ASTM F2733 (09), Standard Specification for Flame Resistant Rainwear for Protection Against Flame Hazards, Section 7.3, Leak Resistance - Rainwear Material and Seams, and Section 9.2, Leak Resistance.

7.7.9 Specimen garments shall be tested for overall fire exposure as specified in Section 8.5, as a qualification test for the material and shall have an average predicted body burn of not more than 50 percent based on the total surface area covered by sensors, excluding hands and feet.

7.7.9.1 Where the flame-resistant garment consists of multiple and separable layers intended to be worn separately, both of the following shall apply:

(1) Specimen garments consisting of the outer layer only shall be tested,

(2) Specimen garments consisting of the inner layer or layers only shall be tested.
7.7.9.2
Where the flame-resistant garment consists of multiple layers intended only to be worn together, specimen garments consisting of the outer layer only shall be tested.

Submitter Information Verification
Submitter Full Name: Eric Nette
Organization: [ Not Specified ]
Street Address:
City:
State:
Zip:
Submittal Date: Wed Nov 05 13:50:24 CST 2014

Committee Statement
Committee Statement: This establishes performance requirements for rainwear.
Response Message:
7.4 Label Requirement.
Specimen labels used in the construction of flame-resistant garments shall be tested for printing durability, as specified in Section 8.7, for printing durability and shall remain legible and in place.

Submitter Information Verification

Submitter Full Name: Eric Nette
Organization: [ Not Specified ]
Street Address: 
City: 
State: 
Zip: 
Submittal Date: Thu Nov 06 15:24:01 CST 2014

Committee Statement

Committee Statement: If a label becomes detached from the clothing item during the laundering pre-conditioning process, the fact that it remains legible is of little meaning.
8.2.1 Application.
This test method shall apply to flame-resistant garment, shroud/hood/balaclava, glove, and rainwear fabrics.

8.2.2 Specimens.
8.2.2.1 HTP testing shall be conducted on six specimens measuring 150 mm ± 5 mm × 150 mm ± 5 mm (6 in. ± ¼ in. × 6 in. ± ¼ in.) and shall consist of all layers representative of the garment, shroud/hood/balaclava, glove, and rainwear to be tested. Three specimens shall be tested in the spaced configuration and three specimens shall be tested in the contact configuration.

8.2.2.2 Specimens shall consist of all layers used in the construction of the flame-resistant garment, shroud/hood/balaclava, glove, and rainwear, excluding any areas with special reinforcements.

8.2.2.3 Specimens shall not include seams.

8.2.2.4 Specimens shall not be stitched to hold individual layers together.

8.2.3 Sample Preparation.
8.2.3.1 For fabrics that are designated on the flame-resistant garment, shroud/hood/balaclava, glove, and rainwear labels to be washed, specimens shall be tested before and after three cycles of washing and drying as specified in 8.1.3.

8.2.3.2 For fabrics that are designated on the flame-resistant garment, shroud/hood/balaclava, glove, and rainwear labels to be dry-cleaned, specimens shall be tested before and after three cycles of dry cleaning as specified in 8.1.4.

8.2.3.3 For fabrics that are designated on the flame-resistant garment, shroud/hood/balaclava, glove, and rainwear labels to be either washed or dry-cleaned, specimens shall be tested before and after three cycles of washing and drying as specified in 8.1.3, or after three cycles of dry cleaning as specified in 8.1.4.

Submitter Information Verification

Submitter Full Name: Eric Nette
Organization: [ Not Specified ]
Street Address: 
City: 
State: 
Zip: 
Submittal Date: Thu Nov 06 06:00:41 CST 2014

Committee Statement

Committee Statement: Additional clothing items were added to the scope of the document. The committee would like to solicit Public Comments on the test method. Data and refinements to the methods will be submitted and considered.

Response Message:
8.3.1.1
This test method shall apply to each flame-resistant garment, shroud/hood/balaclava, and rainwear fabric layer.

Submitter Information Verification

Submitter Full Name: Eric Nette
Organization: [ Not Specified ]
Street Address:
City:
State:
Zip:
Submittal Date: Thu Nov 06 06:05:45 CST 2014

Committee Statement

Committee Statement: Additional clothing items were added to the scope of the document. The committee would like to solicit Public Comments on the test method. Data and refinements to the methods will be submitted and considered.

Response Message:
8.3.1.4
Modifications to this test method for testing nonwoven, coated, or laminated textile materials shall be as specified in 8.3.10.

Submitter Information Verification
Submitter Full Name: Eric Nette
Organization: [ Not Specified ]
Street Address: 
City: 
State: 
Zip: 
Submittal Date: Thu Nov 06 06:06:37 CST 2014

Committee Statement
Committee Statement: Additional clothing items were added to the scope of the document. Data and refinements to the methods will be submitted and considered. Accommodations were made for coated and laminated materials.
Response Message: 

Committee Statement

The current criteria in NFPA 2112-2012 are not workable to support the inclusion of cold weather insulation materials that provide safe and effective protection of flame resistant garments used for protection of workers against accident flash fires. Changes were made to the 2012 edition of NFPA 2112 without the benefit of a full validation effort. An effort intended to meet this purpose has now been completed by a task group under the direction of the Technical Committee where several prospective cold weather insulation materials were evaluated using existing and proposed test methods that included both current and modified flame resistance and heat/thermal shrinkage resistance testing. Additional evaluations were carried out using full scale manikin testing with garments incorporating the selected cold weather insulation materials in jackets of a simple design to assess effects of simulated flash fires on the clothing and insulation materials.

This effort produced the following two primary findings:

1. One of the cold weather insulation materials included in the investigation exhibited average afterflame times in excess of the 2-second requirement using the current flame resistance test procedures. When tested according to the proposed modified flame resistance test procedures, afterflame times were compliant or near compliant. In addition, the manikin-based testing for the same fabric exhibiting extended afterflame times, showed no unusual burning behavior during manikin testing of full garments where the liner consisted of the cold weather insulation material or showed shrinkage that differed radically from garments using materials that qualify to current NFPA 2112 performance criteria. Based on these findings, the modified flame resistance testing can be utilized for the evaluation of cold weather insulation materials.

   It was observed that after flame times were observed to be generally shorter when a 50 mm folded edge was used as compared to a 25 mm folded edge. It was also rationalized that more consistent results would be provided with the 50 mm folded edge for the modified flame test because the specimen is positioned 19 mm into a 38 mm high flame leaving only a 6 mm space between the top of the flame and the beginning of the unprotected (by the folded edge) batting. It was therefore reasoned and consistent with the observed test results that the modified flame resistance test should use a 50 mm folded edge.

   Specific changes to NFPA 2112 have been proposed in proposed modifications shown in Section 8.3.

2. Certain cold weather insulation materials exhibited significant distortion in heat/thermal shrinkage resistance testing and thermal shrinkage. Yet, these same materials when employed in the form of a liner in a flame resistant jacket utilizing a lightweight shell material did not show significant differences...
in their shrinkage (of the liner) with materials that would otherwise pass the NFPA 2112-2013 thermal shrinkage resistance criteria. This further included testing with the jacket samples inverted (turned inside out) representing a “worst case” exposure and wearing configuration where no adverse safety issues were observed. From these results, the exemption of cold weather insulation materials from the thermal shrinkage resistance requirement can be justified. Specific changes to NFPA 2112 implementing these modifications are provided as in paragraphs 7.1.3, 7.1.3.1 (deletion), 7.1.4, and Section 8.4.

It is important to point out that the cold weather insulation material is required to meet a heat resistance requirement and is always covered by an outer (shell) material (paragraph 7.1.4). If it is not, it would not qualify as a cold weather insulation material. It is also important to point out that while these changes were based on testing that did not show any safety of the protective garment to be compromised when presented to a simulated flash fire, conditions may exist for which cold weather insulation materials (and other garment materials) will fail to provide intended levels of protection.

The following substantiations are proposed for the additional changes in this amendment to address cold weather insulation material definitions, labeling, design criteria, performance criteria, and test methods:

• A clarification was added to the definition of cold weather insulation material to indicate that the material is not an interlining. Additional language was also added to distinguish an interlining that is not tested for heat resistance or thermal shrinkage resistance from a cold weather insulation material, which is tested for heat resistance but not thermal shrinkage resistance (paragraphs 3.3.6, 3.3.20, A.3.3.6, and A.3.3.20).

• Additional labeling language was added to require the identification of the cold weather insulation material fiber content, the inclusion of a warning that garments with cold weather insulation materials must be properly secured and that a separate label must be provided on the liner if detachable, that indicates that the liner must not be worn by itself. These changes are covered in paragraph 5.1.2, 5.1.9, 5.1.12, and 5.1.13).

• Design criteria were added to permit garment with sewn-in or detachable liners that utilize cold weather insulation materials but that manufacturers must design removable liners so that the liner cannot be worn without the outer layer (paragraphs 6.4 and A.6.4).

• Changes were made in the performance criteria to clarify to which requirements cold weather insulation materials are tested (paragraphs 7.1.2, 7.1.3, and 7.1.4).

• A clarification was provided to specify that the cold weather insulation material is not tested for thermal protective performance (paragraphs 7.1.1.1 and 7.1.1.2).

• Specific procedures were added to address the modified testing of the cold weather insulation material as specified in U.S. Air Force purchase description NCTRF PD N2-01-3A, Batting, Quilted, Aramid, involving the removal of 50 mm of batting and folding of the face cloth over the remaining batting, as supported by the test information provided above (paragraph 8.3.1.7 and Section 8.3.13). Additional instructions were provided for preparing samples for conditioning by sewing a layer of flame resistant fabric to the cold weather insulation material prior to laundering with its removal following laundering or dry cleaning (paragraphs 8.3.13.1 and 8.3.13.2).

• Modifications for the heat and thermal shrinkage resistance test method were made to clarify that the cold weather insulation materials are not evaluated for thermal shrinkage resistance as supported by the test information above (paragraphs 8.4.1.1 through 8.4.1.5, paragraph 8.4.2.1, and section 8.4.11). Additional instructions were provided for preparing samples for conditioning by sewing a layer of flame resistant fabric to the cold weather insulation material prior to laundering with its removal following laundering or dry cleaning (paragraphs 8.4.3.1 through 8.4.3.3).

For supporting documentation see the doc info pages at www.nfpa.org/2112.

Emergency Nature: The proposed TIA intends to correct a circumstance in which the revised NFPA Standard has resulted in an adverse impact on a product or method that was inadvertently
overlooked in the total revision process or was without adequate technical (safety) justification for the action. As currently written, NFPA 2112 includes criteria that create a bias against cold weather insulation materials that is inconsistent with their use and in consistent with demonstrated levels of safety.

The OSHA interpretation of March 2010 encouraging employers to provide their employees with garments certified to a consensus standard like NFPA 2112 has created a need and demand for outerwear garments for cold weather protection that are certified to the NFPA 2112 standard. The current edition of the NFPA 2112 standard does not provide clear methods to properly test and certify garments that incorporate insulation for additional protection from cold weather.

Response
Message:
Public Input No. 17-NFPA 2112-2013 [New Section after 8.3.1.6]
For fabrics that are designated on the flame-resistant shroud/hood/balaclava label to be washed, specimens shall be tested before and after 100 cycles of washing and drying as specified in 8.1.3.

For fabrics that are designated on the flame-resistant shroud/hood/balaclava label to be dry-cleaned, specimens shall be tested before and after 100 cycles of dry cleaning as specified in 8.1.4.

For fabrics that are designated on the flame-resistant shroud/hood/balaclava label to be either washed or dry-cleaned, specimens shall be tested before and after 100 cycles of washing and drying as specified in 8.1.3, or after 100 cycles of dry cleaning as specified in 8.1.4.

For fabrics that are designated on the flame-resistant rainwear label to be either washed or dry-cleaned, specimens shall be tested before and after three cycles of washing and drying as specified in 8.1.3, or after three cycles of dry cleaning as specified in 8.1.4.

Submitter Information Verification

Submitter Full Name: Eric Nette
Organization: [ Not Specified ]
Street Address: 
City: 
State: 
Zip: 
Submittal Date: Thu Nov 06 06:08:14 CST 2014

Committee Statement

Committee Statement: Additional clothing items were added to the scope of the document. The committee would like to solicit Public Comments on the test method. Data and refinements to the methods will be submitted and considered.

Response Message:
First Revision No. 14-NFPA 2112-2014 [ Section No. 8.3.3 ]

8.3.3.1
For fabrics and cold weather insulation materials that are designated on the flame-resistant garment label to be washed, specimens shall be tested before and after 100 cycles of washing and drying as specified in 8.1.3.

8.3.3.2
For fabrics and cold weather insulation materials that are designated on the flame-resistant garment label to be dry-cleaned, specimens shall be tested before and after 100 cycles of dry cleaning as specified in 8.1.4.

8.3.3.3
For fabrics and cold weather insulation materials that are designated on the flame-resistant garment label to be either washed or dry-cleaned, specimens shall be tested before and after 100 cycles of washing and drying as specified in 8.1.3, or after 100 cycles of dry cleaning as specified in 8.1.4.

Submitter Information Verification

Submitter Full Name: Eric Nette
Organization: [ Not Specified ]
Street Address: 
City: 
State: 
Zip: 
Submittal Date: Tue Nov 04 09:29:23 CST 2014

Committee Statement

Committee Statement: The current criteria in NFPA 2112-2012 are not workable to support the inclusion of cold weather insulation materials that provide safe and effective protection of flame resistant garments used for protection of workers against accident flash fires. Changes were made to the 2012 edition of NFPA 2112 without the benefit of a full validation effort. An effort intended to meet this purpose has now been completed by a task group under the direction of the Technical Committee where several prospective cold weather insulation materials were evaluated using existing and proposed test methods that included both current and modified flame resistance and heat/thermal shrinkage resistance testing. Additional evaluations were carried out using full scale manikin testing with garments incorporating the selected cold weather insulation materials in jackets of a simple design to assess effects of simulated flash fires on the clothing and insulation materials.

This effort produced the following two primary findings:

1. One of the cold weather insulation materials included in the investigation exhibited average afterflame times in excess of the 2-second requirement using the current flame resistance test procedures. When tested according to the proposed modified flame resistance test procedures, afterflame times were compliant or near compliant. In addition, the manikin-based testing for the same fabric exhibiting extended afterflame times, showed no unusual burning behavior during manikin testing of full garments where the liner consisted of the cold weather insulation material or showed shrinkage that differed radically from garments using materials that qualify to current NFPA 2112 performance criteria. Based on these findings, the modified flame resistance testing can be utilized for the evaluation of cold weather insulation materials.

It was observed that after flame times were observed to be generally shorter when a 50 mm folded edge was used as compared to a 25 mm folded edge. It was also rationalized that more consistent results would be provided with the 50 mm folded edge for the modified flame test because the
specimen is positioned 19 mm into a 38 mm high flame leaving only a 6 mm space between the top of the flame and the beginning of the unprotected (by the folded edge) batting. It was therefore reasoned and consistent with the observed test results that the modified flame resistance test should use a 50 mm folded edge.

Specific changes to NFPA 2112 have been proposed in proposed modifications shown in Section 8.3.

2. Certain cold weather insulation materials exhibited significant distortion in heat/thermal shrinkage resistance testing and thermal shrinkage. Yet, these same materials when employed in the form of a liner in a flame resistant jacket utilizing a lightweight shell material did not show significant differences in their shrinkage (of the liner) with materials that would otherwise pass the NFPA 2112-2013 thermal shrinkage resistance criteria. This further included testing with the jacket samples inverted (turned inside out) representing a “worst case” exposure and wearing configuration where no adverse safety issues were observed. From these results, the exemption of cold weather insulation materials from the thermal shrinkage resistance requirement can be justified. Specific changes to NFPA 2112 implementing these modifications are provided as in paragraphs 7.1.3, 7.1.3.1 (deletion), 7.1.4, and Section 8.4.

It is important to point out that the cold weather insulation material is required to meet a heat resistance requirement and is always covered by an outer (shell) material (paragraph 7.1.4). If it is not, it would not qualify as a cold weather insulation material. It is also important to point out that while these changes were based on testing that did not show any safety of the protective garment to be compromised when presented to a simulated flash fire, conditions may exist for which cold weather insulation materials (and other garment materials) will fail to provide intended levels of protection.

The following substantiations are proposed for the additional changes in this amendment to address cold weather insulation material definitions, labeling, design criteria, performance criteria, and test methods:

- A clarification was added to the definition of cold weather insulation material to indicate that the material is not an interlining. Additional language was also added to distinguish an interlining that is not tested for heat resistance or thermal shrinkage resistance from a cold weather insulation material, which is tested for heat resistance but not thermal shrinkage resistance (paragraphs 3.3.6, 3.3.20, A.3.3.6, and A.3.3.20).

- Additional labeling language was added to require the identification of the cold weather insulation material fiber content, the inclusion of a warning that garments with cold weather insulation materials must be properly secured and that a separate label must be provided on the liner if detachable, that indicates that the liner must not be worn by itself. These changes are covered in paragraph 5.1.2, 5.1.9, 5.1.12, and 5.1.13).

- Design criteria were added to permit garment with sewn-in or detachable liners that utilize cold weather insulation materials but that manufacturers must design removable liners so that the liner cannot be worn without the outer layer (paragraphs 6.4 and A.6.4).

- Changes were made in the performance criteria to clarify to which requirements cold weather insulation materials are tested (paragraphs 7.1.2, 7.1.3, and 7.1.4).

- A clarification was provided to specify that the cold weather insulation material is not tested for thermal protective performance (paragraphs 7.1.1.1 and 7.1.1.2).

- Specific procedures were added to address the modified testing of the cold weather insulation material as specified in U.S. Air Force purchase description NCTRF PD N2-01-3A, Batting, Quilted, Aramid, involving the removal of 50 mm of batting and folding of the face cloth over the remaining batting, as supported by the test information provided above (paragraph 8.3.1.7 and Section 8.3.13). Additional instructions were provided for preparing samples for conditioning by sewing a layer of flame resistant fabric to the cold weather insulation material prior to laundering with its removal following laundering or dry cleaning (paragraphs 8.3.13.1 and 8.3.13.2).

- Modifications for the heat and thermal shrinkage resistance test method were made to clarify that
the cold weather insulation materials are not evaluated for thermal shrinkage resistance as supported by the test information above (paragraphs 8.4.1.1 through 8.4.1.5, paragraph 8.4.2.1, and section 8.4.11). Additional instructions were provided for preparing samples for conditioning by sewing a layer of flame resistant fabric to the cold weather insulation material prior to laundering with its removal following laundering or dry cleaning (paragraphs 8.4.3.1 through 8.4.3.3).

For supporting documentation see the doc info pages at www.nfpa.org/2112.

Emergency Nature: The proposed TIA intends to correct a circumstance in which the revised NFPA Standard has resulted in an adverse impact on a product or method that was inadvertently overlooked in the total revision process or was without adequate technical (safety) justification for the action. As currently written, NFPA 2112 includes criteria that create a bias against cold weather insulation materials that is inconsistent with their use and in consistent with demonstrated levels of safety.

The OSHA interpretation of March 2010 encouraging employers to provide their employees with garments certified to a consensus standard like NFPA 2112 has created a need and demand for outerwear garments for cold weather protection that are certified to the NFPA 2112 standard. The current edition of the NFPA 2112 standard does not provide clear methods to properly test and certify garments that incorporate insulation for additional protection from cold weather.

Response
Message:
Public Input No. 18-NFPA 2112-2013 [Section No. 8.3.3]
8.3.10 Specific Requirements for Testing Nonwoven, Coated, or Laminated Textile Materials.

8.3.10.1 Five specimens from each of the machine and cross-machine directions shall be tested.

8.3.10.2 Testing shall be performed as described in 8.3.2 through 8.3.7.

Submitter Information Verification

Submitter Full Name: Eric Nette
Organization: [ Not Specified ]
Street Address:
City:
State:
Zip:

Submittal Date: Thu Nov 06 14:11:25 CST 2014

Committee Statement

Committee Statement: Additional clothing items were added to the scope of the document. Accommodations were made for coated and laminated materials.

Response Message:
8.3.13 Specific Requirements for Testing Cold Weather Insulation Materials.

8.3.13.1 Samples for wash or dry-clean conditioning shall be prepared by cutting a 66-cm × 66-cm (26-in. × 26-in.) panel of the cold weather insulation material. A similar-sized piece of 200-g/m$^2$ to 270-g/m$^2$ (6.0-oz/yd$^2$ to 8.0-oz/yd$^2$) flame-resistant fabric meeting all requirements of this standard shall be sewn around the perimeter of the cold weather insulation material such that the batting side is covered by the fabric.

8.3.13.2 Following wash or dry-clean conditioning, five specimens measuring 75 mm × 300 mm (3 in. × 12 in.) from each of the warp and filling directions shall be removed from the cold weather insulation material layer of the conditioned panels.

8.3.13.3 If applicable, all specimens shall be prepared for testing by trimming the scrim material, batting, or other layer(s) away from the face cloth by 50 mm ± 3 mm (2.0 in. ± 1/8 in.) such that the face cloth can be folded back covering the scrim, batting, or other layer(s) by 50 mm ± 3 mm (2.0 in. ± 1/8 in.); the folded specimen shall be secured in the specimen holder.

8.3.13.4 Testing shall be performed as described in 8.3.2 through 8.3.7.

Submitter Information Verification

Submitter Full Name: Eric Nette
Organization: [ Not Specified ]
Street Address:
City:
State:
Zip:
Submittal Date: Tue Nov 04 09:29:36 CST 2014

Committee Statement

Committee Statement: The current criteria in NFPA 2112-2012 are not workable to support the inclusion of cold weather insulation materials that provide safe and effective protection of flame resistant garments used for protection of workers against accident flash fires. Changes were made to the 2012 edition of NFPA 2112 without the benefit of a full validation effort. An effort intended to meet this purpose has now been completed by a task group under the direction of the Technical Committee where several prospective cold weather insulation materials were evaluated using existing and proposed test methods that included both current and modified flame resistance and heat/thermal shrinkage resistance testing. Additional evaluations were carried out using full scale manikin testing with garments incorporating the selected cold weather insulation materials in jackets of a simple design to assess effects of simulated flash fires on the clothing and insulation materials.

This effort produced the following two primary findings:

1. One of the cold weather insulation materials included in the investigation exhibited average afterflame times in excess of the 2-second requirement using the current flame resistance test procedures. When tested according to the proposed modified flame resistance test procedures, afterflame times were compliant or near compliant. In addition, the manikin-based testing for the same fabric exhibiting extended afterflame times, showed no unusual burning behavior during manikin testing of full garments where the liner consisted of the cold weather insulation material or
showed shrinkage that differed radically from garments using materials that qualify to current NFPA 2112 performance criteria. Based on these findings, the modified flame resistance testing can be utilized for the evaluation of cold weather insulation materials.

It was observed that after flame times were observed to be generally shorter when a 50 mm folded edge was used as compared to a 25 mm folded edge. It was also rationalized that more consistent results would be provided with the 50 mm folded edge for the modified flame test because the specimen is positioned 19 mm into a 38 mm high flame leaving only a 6 mm space between the top of the flame and the beginning of the unprotected (by the folded edge) batting. It was therefore reasoned and consistent with the observed test results that the modified flame resistance test should use a 50 mm folded edge.

Specific changes to NFPA 2112 have been proposed in proposed modifications shown in Section 8.3.

2. Certain cold weather insulation materials exhibited significant distortion in heat/thermal shrinkage resistance testing and thermal shrinkage. Yet, these same materials when employed in the form of a liner in a flame resistant jacket utilizing a lightweight shell material did not show significant differences in their shrinkage (of the liner) with materials that would otherwise pass the NFPA 2112-2013 thermal shrinkage resistance criteria. This further included testing with the jacket samples inverted (turned inside out) representing a “worst case” exposure and wearing configuration where no adverse safety issues were observed. From these results, the exemption of cold weather insulation materials from the thermal shrinkage resistance requirement can be justified. Specific changes to NFPA 2112 implementing these modifications are provided as in paragraphs 7.1.3, 7.1.3.1 (deletion), 7.1.4, and Section 8.4.

It is important to point out that the cold weather insulation material is required to meet a heat resistance requirement and is always covered by an outer (shell) material (paragraph 7.1.4). If it is not, it would not qualify as a cold weather insulation material. It is also important to point out that while these changes were based on testing that did not show any safety of the protective garment to be compromised when presented to a simulated flash fire, conditions may exist for which cold weather insulation materials (and other garment materials) will fail to provide intended levels of protection.

The following substantiations are proposed for the additional changes in this amendment to address cold weather insulation material definitions, labeling, design criteria, performance criteria, and test methods:

• A clarification was added to the definition of cold weather insulation material to indicate that the material is not an interlining. Additional language was also added to distinguish an interlining that is not tested for heat resistance or thermal shrinkage resistance from a cold weather insulation material, which is tested for heat resistance but not thermal shrinkage resistance (paragraphs 3.3.6, 3.3.20, A.3.3.6, and A.3.3.20).

• Additional labeling language was added to require the identification of the cold weather insulation material fiber content, the inclusion of a warning that garments with cold weather insulation materials must be properly secured and that a separate label must be provided on the liner if detachable, that indicates that the liner must not be worn by itself. These changes are covered in paragraph 5.1.2, 5.1.9, 5.1.12, and 5.1.13).

• Design criteria were added to permit garment with sewn-in or detachable liners that utilize cold weather insulation materials but that manufacturers must design removable liners so that the liner cannot be worn without the outer layer (paragraphs 6.4 and A.6.4).

• Changes were made in the performance criteria to clarify to which requirements cold weather insulation materials are tested (paragraphs 7.1.2, 7.1.3, and 7.1.4).

• A clarification was provided to specify that the cold weather insulation material is not tested for thermal protective performance (paragraphs 7.1.1.1 and 7.1.1.2).

• Specific procedures were added to address the modified testing of the cold weather insulation material as specified in U.S. Air Force purchase description NCTRF PD N2-01-3A, Batting, Quilted,
Aramid, involving the removal of 50 mm of batting and folding of the face cloth over the remaining batting, as supported by the test information provided above (paragraph 8.3.1.7 and Section 8.3.13). Additional instructions were provided for preparing samples for conditioning by sewing a layer of flame resistant fabric to the cold weather insulation material prior to laundering with its removal following laundering or dry cleaning (paragraphs 8.3.13.1 and 8.3.13.2).

- Modifications for the heat and thermal shrinkage resistance test method were made to clarify that the cold weather insulation materials are not evaluated for thermal shrinkage resistance as supported by the test information above (paragraphs 8.4.1.1 through 8.4.1.5, paragraph 8.4.2.1, and section 8.4.11). Additional instructions were provided for preparing samples for conditioning by sewing a layer of flame resistant fabric to the cold weather insulation material prior to laundering with its removal following laundering or dry cleaning (paragraphs 8.4.3.1 through 8.4.3.3).

For supporting documentation see the doc info pages at www.nfpa.org/2112.

Emergency Nature: The proposed TIA intends to correct a circumstance in which the revised NFPA Standard has resulted in an adverse impact on a product or method that was inadvertently overlooked in the total revision process or was without adequate technical (safety) justification for the action. As currently written, NFPA 2112 includes criteria that create a bias against cold weather insulation materials that is inconsistent with their use and in consistent with demonstrated levels of safety.

The OSHA interpretation of March 2010 encouraging employers to provide their employees with garments certified to a consensus standard like NFPA 2112 has created a need and demand for outerwear garments for cold weather protection that are certified to the NFPA 2112 standard. The current edition of the NFPA 2112 standard does not provide clear methods to properly test and certify garments that incorporate insulation for additional protection from cold weather.

Response
Message:
Public Input No. 19-NFPA 2112-2013 [New Section after 8.3.12]
8.4.1 Application.
The heat and thermal shrinkage resistance test method shall apply to flame-resistant garment fabrics, components, and hardware.

8.4.1.1 This test method shall apply to flame-resistant garment, shroud/hood/balaclava, glove, and rainwear fabrics, components, hardware, and cold weather insulation materials.

8.4.1.2 Modifications to this test method for testing flame-resistant garment textile materials shall be as specified in 8.4.8.

8.4.1.3 Modifications to this test method for testing other flame-resistant garment materials, including reflective striping, shall be as specified in 8.4.9.

8.4.1.4 Modifications to this test method for testing hardware shall be as specified in 8.4.10.

8.4.1.5 Modifications to this test method for testing cold weather insulation materials shall be as specified in 8.4.11.

8.4.1.6 Modifications to this test method for testing textile materials shall be as specified in 8.4.8.

8.4.1.7 Modifications to this test method for testing other flame-resistant materials including reflective striping shall be as specified in 8.4.9.

8.4.1.8 Modifications to this test method for testing hardware shall be as specified in 8.4.10.

8.4.1.9 Modifications to this test method for testing gloves shall be as specified in 8.4.12.

Submitter Information Verification

Submitter Full Name: Eric Nette
Organization: [ Not Specified ]
Street Address: 
City: 
State: 
Zip: 
Submittal Date: Tue Nov 04 09:29:49 CST 2014

Committee Statement

Committee Statement: Additional clothing items were added to the scope of the document. The committee would like to solicit Public Comments on the test method. Data and refinements to the methods will be submitted and considered.

The current criteria in NFPA 2112:2012 are not workable to support the inclusion of cold weather insulation materials that provide safe and effective protection of flame resistant garments used for protection of workers against accident flash fires. Changes were made to the 2012 edition of NFPA 2112 without the benefit of a full validation effort. An effort intended to meet this purpose has now been completed by a task group under the direction of the Technical Committee where several prospective cold weather insulation materials were evaluated using existing and proposed test
methods that included both current and modified flame resistance and heat/thermal shrinkage resistance testing. Additional evaluations were carried out using full scale manikin testing with garments incorporating the selected cold weather insulation materials in jackets of a simple design to assess effects of simulated flash fires on the clothing and insulation materials.

This effort produced the following two primary findings:

1. One of the cold weather insulation materials included in the investigation exhibited average afterflame times in excess of the 2-second requirement using the current flame resistance test procedures. When tested according to the proposed modified flame resistance test procedures, afterflame times were compliant or near compliant. In addition, the manikin-based testing for the same fabric exhibiting extended afterflame times, showed no unusual burning behavior during manikin testing of full garments where the liner consisted of the cold weather insulation material or showed shrinkage that differed radically from garments using materials that qualify to current NFPA 2112 performance criteria. Based on these findings, the modified flame resistance testing can be utilized for the evaluation of cold weather insulation materials.

It was observed that after flame times were observed to be generally shorter when a 50 mm folded edge was used as compared to a 25 mm folded edge. It was also rationalized that more consistent results would be provided with the 50 mm folded edge for the modified flame test because the specimen is positioned 19 mm into a 38 mm high flame leaving only a 6 mm space between the top of the flame and the beginning of the unprotected (by the folded edge) batting. It was therefore reasoned and consistent with the observed test results that the modified flame resistance test should use a 50 mm folded edge.

Specific changes to NFPA 2112 have been proposed in proposed modifications shown in Section 8.3.

2. Certain cold weather insulation materials exhibited significant distortion in heat/thermal shrinkage resistance testing and thermal shrinkage. Yet, these same materials when employed in the form of a liner in a flame resistant jacket utilizing a lightweight shell material did not show significant differences in their shrinkage (of the liner) with materials that would otherwise pass the NFPA 2112-2013 thermal shrinkage resistance criteria. This further included testing with the jacket samples inverted (turned inside out) representing a "worst case" exposure and wearing configuration where no adverse safety issues were observed. From these results, the exemption of cold weather insulation materials from the thermal shrinkage resistance requirement can be justified. Specific changes to NFPA 2112 implementing these modifications are provided as in paragraphs 7.1.3, 7.1.3.1 (deletion), 7.1.4, and Section 8.4.

It is important to point out that the cold weather insulation material is required to meet a heat resistance requirement and is always covered by an outer (shell) material (paragraph 7.1.4). If it is not, it would not qualify as a cold weather insulation material. It is also important to point out that while these changes were based on testing that did not show any safety of the protective garment to be compromised when presented to a simulated flash fire, conditions may exist for which cold weather insulation materials (and other garment materials) will fail to provide intended levels of protection.

The following substantiations are proposed for the additional changes in this amendment to address cold weather insulation material definitions, labeling, design criteria, performance criteria, and test methods:

• A clarification was added to the definition of cold weather insulation material to indicate that the material is not an interlining. Additional language was also added to distinguish an interlining that is not tested for heat resistance or thermal shrinkage resistance from a cold weather insulation material, which is tested for heat resistance but not thermal shrinkage resistance (paragraphs 3.3.6, 3.3.20, A.3.3.6, and A.3.3.20).

• Additional labeling language was added to require the identification of the cold weather insulation material fiber content, the inclusion of a warning that garments with cold weather insulation materials must be properly secured and that a separate label must be provided on the liner if detachable, that indicates that the liner must not be worn by itself. These changes are covered in paragraph 5.1.2, 5.1.9, 5.1.12, and 5.1.13).
Design criteria were added to permit garment with sewn-in or detachable liners that utilize cold weather insulation materials but that manufacturers must design removable liners so that the liner cannot be worn without the outer layer (paragraphs 6.4 and A.6.4).

Changes were made in the performance criteria to clarify to which requirements cold weather insulation materials are tested (paragraphs 7.1.2, 7.1.3, and 7.1.4).

A clarification was provided to specify that the cold weather insulation material is not tested for thermal protective performance (paragraphs 7.1.1.1 and 7.1.1.2).

Specific procedures were added to address the modified testing of the cold weather insulation material as specified in U.S. Air Force purchase description NCTRZ FD N2-01-3A, Batting, Quilted, Aramid, involving the removal of 50 mm of batting and folding of the face cloth over the remaining batting, as supported by the test information provided above (paragraph 8.3.1.7 and Section 8.3.13). Additional instructions were provided for preparing samples for conditioning by sewing a layer of flame resistant fabric to the cold weather insulation material prior to laundering with its removal following laundering or dry cleaning (paragraphs 8.3.13.1 and 8.3.13.2).

Modifications for the heat and thermal shrinkage resistance test method were made to clarify that the cold weather insulation materials are not evaluated for thermal shrinkage resistance as supported by the test information above (paragraphs 8.4.1.1 through 8.4.1.5, paragraph 8.4.2.1, and section 8.4.11). Additional instructions were provided for preparing samples for conditioning by sewing a layer of flame resistant fabric to the cold weather insulation material prior to laundering with its removal following laundering or dry cleaning (paragraphs 8.4.3.1 through 8.4.3.3).

For supporting documentation see the doc info pages at www.nfpa.org/2112.

Emergency Nature: The proposed TIA intends to correct a circumstance in which the revised NFPA Standard has resulted in an adverse impact on a product or method that was inadvertently overlooked in the total revision process or was without adequate technical (safety) justification for the action. As currently written, NFPA 2112 includes criteria that create a bias against cold weather insulation materials that is inconsistent with their use and in consistent with demonstrated levels of safety.

The OSHA interpretation of March 2010 encouraging employers to provide their employees with garments certified to a consensus standard like NFPA 2112 has created a need and demand for outerwear garments for cold weather protection that are certified to the NFPA 2112 standard. The current edition of the NFPA 2112 standard does not provide clear methods to properly test and certify garments that incorporate insulation for additional protection from cold weather.

Response Message:
Public Input No. 20-NFPA 2112-2013 [Section No. 8.4.1]
Only heat resistance testing shall be conducted on not fewer than three specimens for each hardware item, label material, and other flame-resistant garment fabrics not shroud/hood/balaclava, glove, and rainwear fabrics, and cold weather insulation materials not listed in 8.4.2.2 and 8.4.2.3.

Committee Statement

Additional clothing items were added to the scope of the document. The committee would like to solicit Public Comments on the test method. Data and refinements to the methods will be submitted and considered.

The current criteria in NFPA 2112-2012 are not workable to support the inclusion of cold weather insulation materials that provide safe and effective protection of flame resistant garments used for protection of workers against accident flash fires. Changes were made to the 2012 edition of NFPA 2112 without the benefit of a full validation effort. An effort intended to meet this purpose has now been completed by a task group under the direction of the Technical Committee where several prospective cold weather insulation materials were evaluated using existing and proposed test methods that included both current and modified flame resistance and heat/thermal shrinkage resistance testing. Additional evaluations were carried out using full scale manikin testing with garments incorporating the selected cold weather insulation materials in jackets of a simple design to assess effects of simulated flash fires on the clothing and insulation materials.

This effort produced the following two primary findings:

1. One of the cold weather insulation materials included in the investigation exhibited average afterflame times in excess of the 2-second requirement using the current flame resistance test procedures. When tested according to the proposed modified flame resistance test procedures, afterflame times were compliant or near compliant. In addition, the manikin-based testing for the same fabric exhibiting extended afterflame times, showed no unusual burning behavior during manikin testing of full garments where the liner consisted of the cold weather insulation material or showed shrinkage that differed radically from garments using materials that qualify to current NFPA 2112 performance criteria. Based on these findings, the modified flame resistance testing can be utilized for the evaluation of cold weather insulation materials.

It was observed that after flame times were observed to be generally shorter when a 50 mm folded edge was used as compared to a 25 mm folded edge. It was also rationalized that more consistent results would be provided with the 50 mm folded edge for the modified flame test because the specimen is positioned 19 mm into a 38 mm high flame leaving only a 6 mm space between the top of the flame and the beginning of the unprotected (by the folded edge) batting. It was therefore reasoned and consistent with the observed test results that the modified flame resistance test should use a 50 mm folded edge.
Specific changes to NFPA 2112 have been proposed in proposed modifications shown in Section 8.3.

2. Certain cold weather insulation materials exhibited significant distortion in heat/thermal shrinkage resistance testing and thermal shrinkage. Yet, these same materials when employed in the form of a liner in a flame resistant jacket utilizing a lightweight shell material did not show significant differences in their shrinkage (of the liner) with materials that would otherwise pass the NFPA 2112-2013 thermal shrinkage resistance criteria. This further included testing with the jacket samples inverted (turned inside out) representing a “worst case” exposure and wearing configuration where no adverse safety issues were observed. From these results, the exemption of cold weather insulation materials from the thermal shrinkage resistance requirement can be justified. Specific changes to NFPA 2112 implementing these modifications are provided as in paragraphs 7.1.3, 7.1.3.1 (deletion), 7.1.4, and Section 8.4.

It is important to point out that the cold weather insulation material is required to meet a heat resistance requirement and is always covered by an outer (shell) material (paragraph 7.1.4). If it is not, it would not qualify as a cold weather insulation material. It is also important to point out that while these changes were based on testing that did not show any safety of the protective garment to be compromised when presented to a simulated flash fire, conditions may exist for which cold weather insulation materials (and other garment materials) will fail to provide intended levels of protection.

The following substantiations are proposed for the additional changes in this amendment to address cold weather insulation material definitions, labeling, design criteria, performance criteria, and test methods:

• A clarification was added to the definition of cold weather insulation material to indicate that the material is not an interlining. Additional language was also added to distinguish an interlining that is not tested for heat resistance or thermal shrinkage resistance from a cold weather insulation material, which is tested for heat resistance but not thermal shrinkage resistance (paragraphs 3.3.6, 3.3.20, A.3.3.6, and A.3.3.20).

• Additional labeling language was added to require the identification of the cold weather insulation material fiber content, the inclusion of a warning that garments with cold weather insulation materials must be properly secured and that a separate label must be provided on the liner if detachable, that indicates that the liner must not be worn by itself. These changes are covered in paragraph 5.1.2, 5.1.9, 5.1.12, and 5.1.13).

• Design criteria were added to permit garment with sewn-in or detachable liners that utilize cold weather insulation materials but that manufacturers must design removable liners so that the liner cannot be worn without the outer layer (paragraphs 6.4 and A.6.4).

• Changes were made in the performance criteria to clarify to which requirements cold weather insulation materials are tested (paragraphs 7.1.2, 7.1.3, and 7.1.4).

• A clarification was provided to specify that the cold weather insulation material is not tested for thermal protective performance (paragraphs 7.1.1.1 and 7.1.1.2).

• Specific procedures were added to address the modified testing of the cold weather insulation material as specified in U.S. Air Force purchase description NCTRF PD N2-01-3A, Batting, Quilted, Aramid, involving the removal of 50 mm of batting and folding of the face cloth over the remaining batting, as supported by the test information provided above (paragraph 8.3.1.7 and Section 8.3.13). Additional instructions were provided for preparing samples for conditioning by sewing a layer of flame resistant fabric to the cold weather insulation material prior to laundering with its removal following laundering or dry cleaning (paragraphs 8.3.13.1 and 8.3.13.2).

• Modifications for the heat and thermal shrinkage resistance test method were made to clarify that the cold weather insulation materials are not evaluated for thermal shrinkage resistance as supported by the test information above (paragraphs 8.4.1.1 through 8.4.1.5, paragraph 8.4.2.1, and section 8.4.11). Additional instructions were provided for preparing samples for conditioning by sewing a layer of flame resistant fabric to the cold weather insulation material prior to laundering with its removal following laundering or dry cleaning (paragraphs 8.4.3.1 through 8.4.3.3).
For supporting documentation see the doc info pages at www.nfpa.org/2112.

Emergency Nature: The proposed TIA intends to correct a circumstance in which the revised NFPA Standard has resulted in an adverse impact on a product or method that was inadvertently overlooked in the total revision process or was without adequate technical (safety) justification for the action. As currently written, NFPA 2112 includes criteria that create a bias against cold weather insulation materials that is inconsistent with their use and in consistent with demonstrated levels of safety.

The OSHA interpretation of March 2010 encouraging employers to provide their employees with garments certified to a consensus standard like NFPA 2112 has created a need and demand for outerwear garments for cold weather protection that are certified to the NFPA 2112 standard. The current edition of the NFPA 2112 standard does not provide clear methods to properly test and certify garments that incorporate insulation for additional protection from cold weather.

Response Message:

Public Input No. 21-NFPA 2112-2013 [Section No. 8.4.2.1]
First Revision No. 55-NFPA 2112-2014 [ Section No. 8.4.2.2 ]

8.4.2.2
Both heat and thermal shrinkage resistance testing shall be conducted on a minimum of three specimens for each flame-resistant garment, shroud/hood/balaclava, glove, and rainwear fabric.

Submitter Information Verification

Submitter Full Name: Eric Nette
Organization: [ Not Specified ]
Street Address:
City:
State:
Zip:
Submittal Date: Thu Nov 06 06:11:32 CST 2014

Committee Statement

Committee Statement: Additional clothing items were added to the scope of the document. The committee would like to solicit Public Comments on the test method. Data and refinements to the methods will be submitted and considered.

Response Message:
8.4.3.1 For fabrics and cold weather insulation materials that are designated on the flame-resistant garment, shroud/hood/balaclava, glove, and rainwear label to be washed, specimens shall be tested before and after three cycles of washing and drying as specified in 8.1.3.

8.4.3.2 For fabrics and cold weather insulation materials that are designated on the flame-resistant garment, shroud/hood/balaclava, glove, and rainwear label to be dry-cleaned, specimens shall be tested before and after three cycles of dry cleaning as specified in 8.1.4.

8.4.3.3 For fabrics and cold weather insulation materials that are designated on the flame-resistant garment, shroud/hood/balaclava, glove, and rainwear label to be either washed or dry-cleaned, specimens shall be tested before and after three cycles of washing and drying as specified in 8.1.3, or after three cycles of dry cleaning as specified in 8.1.4.

Submitter Information Verification

Submitter Full Name: Eric Nette
Organization: [ Not Specified ]
Street Address: 
City: 
State: 
Zip: 
Submittal Date: Tue Nov 04 09:30:14 CST 2014

Committee Statement

Committee Statement: Additional clothing items were added to the scope of the document. The committee would like to solicit Public Comments on the test method. Data and refinements to the methods will be submitted and considered.

The current criteria in NFPA 2112-2012 are not workable to support the inclusion of cold weather insulation materials that provide safe and effective protection of flame resistant garments used for protection of workers against accident flash fires. Changes were made to the 2012 edition of NFPA 2112 without the benefit of a full validation effort. An effort intended to meet this purpose has now been completed by a task group under the direction of the Technical Committee where several prospective cold weather insulation materials were evaluated using existing and proposed test methods that included both current and modified flame resistance and heat/thermal shrinkage resistance testing. Additional evaluations were carried out using full scale manikin testing with garments incorporating the selected cold weather insulation materials in jackets of a simple design to assess effects of simulated flash fires on the clothing and insulation materials.

This effort produced the following two primary findings:

1. One of the cold weather insulation materials included in the investigation exhibited average afterflame times in excess of the 2-second requirement using the current flame resistance test procedures. When tested according to the proposed modified flame resistance test procedures, afterflame times were compliant or near compliant. In addition, the manikin-based testing for the same fabric exhibiting extended afterflame times, showed no unusual burning behavior during manikin testing of full garments where the liner consisted of the cold weather insulation material or showed shrinkage that differed radically from garments using materials that qualify to current NFPA 2112 performance criteria. Based on these findings, the modified flame resistance testing can be...
utilized for the evaluation of cold weather insulation materials.

It was observed that after flame times were observed to be generally shorter when a 50 mm folded edge was used as compared to a 25 mm folded edge. It was also rationalized that more consistent results would be provided with the 50 mm folded edge for the modified flame test because the specimen is positioned 19 mm into a 38 mm high flame leaving only a 6 mm space between the top of the flame and the beginning of the unprotected (by the folded edge) batting. It was therefore reasoned and consistent with the observed test results that the modified flame resistance test should use a 50 mm folded edge.

Specific changes to NFPA 2112 have been proposed in proposed modifications shown in Section 8.3.

2. Certain cold weather insulation materials exhibited significant distortion in heat/thermal shrinkage resistance testing and thermal shrinkage. Yet, these same materials when employed in the form of a liner in a flame resistant jacket utilizing a lightweight shell material did not show significant differences in their shrinkage (of the liner) with materials that would otherwise pass the NFPA 2112-2013 thermal shrinkage resistance criteria. This further included testing with the jacket samples inverted (turned inside out) representing a “worst case” exposure and wearing configuration where no adverse safety issues were observed. From these results, the exemption of cold weather insulation materials from the thermal shrinkage resistance requirement can be justified. Specific changes to NFPA 2112 implementing these modifications are provided as in paragraphs 7.1.3, 7.1.3.1 (deletion), 7.1.4, and Section 8.4.

It is important to point out that the cold weather insulation material is required to meet a heat resistance requirement and is always covered by an outer (shell) material (paragraph 7.1.4). If it is not, it would not qualify as a cold weather insulation material. It is also important to point out that while these changes were based on testing that did not show any safety of the protective garment to be compromised when presented to a simulated flash fire, conditions may exist for which cold weather insulation materials (and other garment materials) will fail to provide intended levels of protection.

The following substantiations are proposed for the additional changes in this amendment to address cold weather insulation material definitions, labeling, design criteria, performance criteria, and test methods:

• A clarification was added to the definition of cold weather insulation material to indicate that the material is not an interlining. Additional language was also added to distinguish an interlining that is not tested for heat resistance or thermal shrinkage resistance from a cold weather insulation material, which is tested for heat resistance but not thermal shrinkage resistance (paragraphs 3.3.6, 3.3.20, A.3.3.6, and A.3.3.20).

• Additional labeling language was added to require the identification of the cold weather insulation material fiber content, the inclusion of a warning that garments with cold weather insulation materials must be properly secured and that a separate label must be provided on the liner if detachable, that indicates that the liner must not be worn by itself. These changes are covered in paragraph 5.1.2, 5.1.9, 5.1.12, and 5.1.13).

• Design criteria were added to permit garment with sewn-in or detachable liners that utilize cold weather insulation materials but that manufacturers must design removable liners so that the liner cannot be worn without the outer layer (paragraphs 6.4 and A.6.4).

• Changes were made in the performance criteria to clarify to which requirements cold weather insulation materials are tested (paragraphs 7.1.2, 7.1.3, and 7.1.4).

• A clarification was provided to specify that the cold weather insulation material is not tested for thermal protective performance (paragraphs 7.1.1.1 and 7.1.1.2).

• Specific procedures were added to address the modified testing of the cold weather insulation material as specified in U.S. Air Force purchase description NCTRF PD N2-01-3A, Batting, Quilted, Aramid, involving the removal of 50 mm of batting and folding of the face cloth over the remaining batting, as supported by the test information provided above (paragraph 8.3.1.7 and Section 8.3.13).
Additional instructions were provided for preparing samples for conditioning by sewing a layer of flame resistant fabric to the cold weather insulation material prior to laundering with its removal following laundering or dry cleaning (paragraphs 8.3.13.1 and 8.3.13.2).

- Modifications for the heat and thermal shrinkage resistance test method were made to clarify that the cold weather insulation materials are not evaluated for thermal shrinkage resistance as supported by the test information above (paragraphs 8.4.1.1 through 8.4.1.5, paragraph 8.4.2.1, and section 8.4.11). Additional instructions were provided for preparing samples for conditioning by sewing a layer of flame resistant fabric to the cold weather insulation material prior to laundering with its removal following laundering or dry cleaning (paragraphs 8.4.3.1 through 8.4.3.3).

For supporting documentation see the doc info pages at www.nfpa.org/2112.

Emergency Nature: The proposed TIA intends to correct a circumstance in which the revised NFPA Standard has resulted in an adverse impact on a product or method that was inadvertently overlooked in the total revision process or was without adequate technical (safety) justification for the action. As currently written, NFPA 2112 includes criteria that create a bias against cold weather insulation materials that is inconsistent with their use and in consistent with demonstrated levels of safety.

The OSHA interpretation of March 2010 encouraging employers to provide their employees with garments certified to a consensus standard like NFPA 2112 has created a need and demand for outerwear garments for cold weather protection that are certified to the NFPA 2112 standard. The current edition of the NFPA 2112 standard does not provide clear methods to properly test and certify garments that incorporate insulation for additional protection from cold weather.

Response
Message:
Public Input No. 22-NFPA 2112-2013 [Sections 8.4.3.1, 8.4.3.2, 8.4.3.3]
First Revision No. 19-NFPA 2112-2014 [ Sections 8.4.8.2, 8.4.8.3 ]

8.4.8.2
Measurements of cold weather insulation material thermal shrinkage shall be made on the side of the fabric facing the wearer as used in the construction of the garment. Testing shall be performed in accordance with 8.4.2 through 8.4.7.

8.4.8.3
Testing shall be performed in accordance with 8.4.2 through 8.4.7.

Submitter Information Verification

Submitter Full Name: Eric Nette
Organization: [ Not Specified ]
Street Address:
City:
State:
Zip:
Submittal Date: Tue Nov 04 09:30:27 CST 2014

Committee Statement

Committee Statement: The current criteria in NFPA 2112-2012 are not workable to support the inclusion of cold weather insulation materials that provide safe and effective protection of flame resistant garments used for protection of workers against accident flash fires. Changes were made to the 2012 edition of NFPA 2112 without the benefit of a full validation effort. An effort intended to meet this purpose has now been completed by a task group under the direction of the Technical Committee where several prospective cold weather insulation materials were evaluated using existing and proposed test methods that included both current and modified flame resistance and heat/thermal shrinkage resistance testing. Additional evaluations were carried out using full scale manikin testing with garments incorporating the selected cold weather insulation materials in jackets of a simple design to assess effects of simulated flash fires on the clothing and insulation materials.

This effort produced the following two primary findings:

1. One of the cold weather insulation materials included in the investigation exhibited average afterflame times in excess of the 2-second requirement using the current flame resistance test procedures. When tested according to the proposed modified flame resistance test procedures, afterflame times were compliant or near compliant. In addition, the manikin-based testing for the same fabric exhibiting extended afterflame times, showed no unusual burning behavior during manikin testing of full garments where the liner consisted of the cold weather insulation material or showed shrinkage that differed radically from garments using materials that qualify to current NFPA 2112 performance criteria. Based on these findings, the modified flame resistance testing can be utilized for the evaluation of cold weather insulation materials.

It was observed that after flame times were observed to be generally shorter when a 50 mm folded edge was used as compared to a 25 mm folded edge. It was also rationalized that more consistent results would be provided with the 50 mm folded edge for the modified flame test because the specimen is positioned 19 mm into a 38 mm high flame leaving only a 6 mm space between the top of the flame and the beginning of the unprotected (by the folded edge) batting. It was therefore reasoned and consistent with the observed test results that the modified flame resistance test should use a 50 mm folded edge.

Specific changes to NFPA 2112 have been proposed in proposed modifications shown in Section 8.3.
2. Certain cold weather insulation materials exhibited significant distortion in heat/thermal shrinkage resistance testing and thermal shrinkage. Yet, these same materials when employed in the form of a liner in a flame resistant jacket utilizing a lightweight shell material did not show significant differences in their shrinkage (of the liner) with materials that would otherwise pass the NFPA 2112-2013 thermal shrinkage resistance criteria. This further included testing with the jacket samples inverted (turned inside out) representing a "worst case" exposure and wearing configuration where no adverse safety issues were observed. From these results, the exemption of cold weather insulation materials from the thermal shrinkage resistance requirement can be justified. Specific changes to NFPA 2112 implementing these modifications are provided as in paragraphs 7.1.3, 7.1.3.1 (deletion), 7.1.4, and Section 8.4.

It is important to point out that the cold weather insulation material is required to meet a heat resistance requirement and is always covered by an outer (shell) material (paragraph 7.1.4). If it is not, it would not qualify as a cold weather insulation material. It is also important to point out that while these changes were based on testing that did not show any safety of the protective garment to be compromised when presented to a simulated flash fire, conditions may exist for which cold weather insulation materials (and other garment materials) will fail to provide intended levels of protection.

The following substantiations are proposed for the additional changes in this amendment to address cold weather insulation material definitions, labeling, design criteria, performance criteria, and test methods:

• A clarification was added to the definition of cold weather insulation material to indicate that the material is not an interlining. Additional language was also added to distinguish an interlining that is not tested for heat resistance or thermal shrinkage resistance from a cold weather insulation material, which is tested for heat resistance but not thermal shrinkage resistance (paragraphs 3.3.6, 3.3.20, A.3.3.6, and A.3.3.20).

• Additional labeling language was added to require the identification of the cold weather insulation material fiber content, the inclusion of a warning that garments with cold weather insulation materials must be properly secured and that a separate label must be provided on the liner if detachable, that indicates that the liner must not be worn by itself. These changes are covered in paragraph 5.1.2, 5.1.9, 5.1.12, and 5.1.13).

• Design criteria were added to permit garment with sewn-in or detachable liners that utilize cold weather insulation materials but that manufacturers must design removable liners so that the liner cannot be worn without the outer layer (paragraphs 6.4 and A.6.4).

• Changes were made in the performance criteria to clarify to which requirements cold weather insulation materials are tested (paragraphs 7.1.2, 7.1.3, and 7.1.4).

• A clarification was provided to specify that the cold weather insulation material is not tested for thermal protective performance (paragraphs 7.1.1.1 and 7.1.1.2).

• Specific procedures were added to address the modified testing of the cold weather insulation material as specified in U.S. Air Force purchase description NCTRF PD N2-01-3A, Batting, Quilted, Aramid, involving the removal of 50 mm of batting and folding of the face cloth over the remaining batting, as supported by the test information provided above (paragraph 8.3.1.7 and Section 8.3.13). Additional instructions were provided for preparing samples for conditioning by sewing a layer of flame resistant fabric to the cold weather insulation material prior to laundering with its removal following laundering or dry cleaning (paragraphs 8.3.13.1 and 8.3.13.2).

• Modifications for the heat and thermal shrinkage resistance test method were made to clarify that the cold weather insulation materials are not evaluated for thermal shrinkage resistance as supported by the test information above (paragraphs 8.4.1.1 through 8.4.1.5, paragraph 8.4.2.1, and section 8.4.11). Additional instructions were provided for preparing samples for conditioning by sewing a layer of flame resistant fabric to the cold weather insulation material prior to laundering with its removal following laundering or dry cleaning (paragraphs 8.4.3.1 through 8.4.3.3).

For supporting documentation see the doc info pages at www.nfpa.org/2112.
Emergency Nature: The proposed TIA intends to correct a circumstance in which the revised NFPA Standard has resulted in an adverse impact on a product or method that was inadvertently overlooked in the total revision process or was without adequate technical (safety) justification for the action. As currently written, NFPA 2112 includes criteria that create a bias against cold weather insulation materials that is inconsistent with their use and in consistent with demonstrated levels of safety.

The OSHA interpretation of March 2010 encouraging employers to provide their employees with garments certified to a consensus standard like NFPA 2112 has created a need and demand for outerwear garments for cold weather protection that are certified to the NFPA 2112 standard. The current edition of the NFPA 2112 standard does not provide clear methods to properly test and certify garments that incorporate insulation for additional protection from cold weather.

Response
Message:

Public Input No. 23-NFPA 2112-2013 [Sections 8.4.8.2, 8.4.8.3]
8.4.11 Specific Requirements for Testing Cold Weather Insulation Materials.

8.4.11.1 Samples for wash or dry-clean conditioning shall be prepared by cutting a 50 cm × 20 cm (20 in. × 8 in.) panel of the cold weather insulation material. A similar-sized cloth piece of 200 g/m² to 270 g/m² (6.0 oz/yd² to 8.0 oz/yd²) flame-resistant fabric meeting all requirements of this standard shall be sewn around the perimeter of the cold weather insulation material such that the batting side is covered by the fabric.

8.4.11.2 Following wash or dry-clean conditioning, three specimens measuring 152 mm × 152 mm (6 in. × 6 in.) shall be removed from the cold weather insulation material layer of the conditioned panel.

8.4.11.3 Testing shall be performed in accordance with 8.4.2 through 8.4.7, and thermal shrinkage shall not be measured.

Submitter Information Verification

Submitter Full Name: Eric Nette
Organization: [Not Specified]
Street Address: 
City: 
State: 
Zip: 
Submittal Date: Tue Nov 04 09:30:39 CST 2014

Committee Statement

The current criteria in NFPA 2112-2012 are not workable to support the inclusion of cold weather insulation materials that provide safe and effective protection of flame resistant garments used for protection of workers against accident flash fires. Changes were made to the 2012 edition of NFPA 2112 without the benefit of a full validation effort. An effort intended to meet this purpose has now been completed by a task group under the direction of the Technical Committee where several prospective cold weather insulation materials were evaluated using existing and proposed test methods that included both current and modified flame resistance and heat/thermal shrinkage resistance testing. Additional evaluations were carried out using full scale manikin testing with garments incorporating the selected cold weather insulation materials in jackets of a simple design to assess effects of simulated flash fires on the clothing and insulation materials.

This effort produced the following two primary findings:

1. One of the cold weather insulation materials included in the investigation exhibited average afterflame times in excess of the 2-second requirement using the current flame resistance test procedures. When tested according to the proposed modified flame resistance test procedures, afterflame times were compliant or near compliant. In addition, the manikin-based testing for the same fabric exhibiting extended afterflame times, showed no unusual burning behavior during manikin testing of full garments where the liner consisted of the cold weather insulation material or showed shrinkage that differed radically from garments using materials that qualify to current NFPA 2112 performance criteria. Based on these findings, the modified flame resistance testing can be utilized for the evaluation of cold weather insulation materials.

It was observed that after flame times were observed to be generally shorter when a 50 mm folded
edge was used as compared to a 25 mm folded edge. It was also rationalized that more consistent results would be provided with the 50 mm folded edge for the modified flame test because the specimen is positioned 19 mm into a 38 mm high flame leaving only a 6 mm space between the top of the flame and the beginning of the unprotected (by the folded edge) batting. It was therefore reasoned and consistent with the observed test results that the modified flame resistance test should use a 50 mm folded edge.

Specific changes to NFPA 2112 have been proposed in proposed modifications shown in Section 8.3.

2. Certain cold weather insulation materials exhibited significant distortion in heat/thermal shrinkage resistance testing and thermal shrinkage. Yet, these same materials when employed in the form of a liner in a flame resistant jacket utilizing a lightweight shell material did not show significant differences in their shrinkage (of the liner) with materials that would otherwise pass the NFPA 2112-2013 thermal shrinkage resistance criteria. This further included testing with the jacket samples inverted (turned inside out) representing a “worst case” exposure and wearing configuration where no adverse safety issues were observed. From these results, the exemption of cold weather insulation materials from the thermal shrinkage resistance requirement can be justified. Specific changes to NFPA 2112 implementing these modifications are provided as in paragraphs 7.1.3, 7.1.3.1 (deletion), 7.1.4, and Section 8.4.

It is important to point out that the cold weather insulation material is required to meet a heat resistance requirement and is always covered by an outer (shell) material (paragraph 7.1.4). If it is not, it would not qualify as a cold weather insulation material. It is also important to point out that while these changes were based on testing that did not show any safety of the protective garment to be compromised when presented to a simulated flash fire, conditions may exist for which cold weather insulation materials (and other garment materials) will fail to provide intended levels of protection.

The following substantiations are proposed for the additional changes in this amendment to address cold weather insulation material definitions, labeling, design criteria, performance criteria, and test methods:

• A clarification was added to the definition of cold weather insulation material to indicate that the material is not an interlining. Additional language was also added to distinguish an interlining that is not tested for heat resistance or thermal shrinkage resistance from a cold weather insulation material, which is tested for heat resistance but not thermal shrinkage resistance (paragraphs 3.3.6, 3.3.20, A.3.3.6, and A.3.3.20).

• Additional labeling language was added to require the identification of the cold weather insulation material fiber content, the inclusion of a warning that garments with cold weather insulation materials must be properly secured and that a separate label must be provided on the liner if detachable, that indicates that the liner must not be worn by itself. These changes are covered in paragraph 5.1.2, 5.1.9, 5.1.12, and 5.1.13).

• Design criteria were added to permit garment with sewn-in or detachable liners that utilize cold weather insulation materials but that manufacturers must design removable liners so that the liner cannot be worn without the outer layer (paragraphs 6.4 and A.6.4).

• Changes were made in the performance criteria to clarify to which requirements cold weather insulation materials are tested (paragraphs 7.1.2, 7.1.3, and 7.1.4).

• A clarification was provided to specify that the cold weather insulation material is not tested for thermal protective performance (paragraphs 7.1.1.1 and 7.1.1.2).

• Specific procedures were added to address the modified testing of the cold weather insulation material as specified in U.S. Air Force purchase description NCTRF PD N2-01-3A, Batting, Quilted, Aramid, involving the removal of 50 mm of batting and folding of the face cloth over the remaining batting, as supported by the test information provided above (paragraph 8.3.1.7 and Section 8.3.13). Additional instructions were provided for preparing samples for conditioning by sewing a layer of flame resistant fabric to the cold weather insulation material prior to laundering with its removal following laundering or dry cleaning (paragraphs 8.3.13.1 and 8.3.13.2).
• Modifications for the heat and thermal shrinkage resistance test method were made to clarify that
the cold weather insulation materials are not evaluated for thermal shrinkage resistance as supported
by the test information above (paragraphs 8.4.1.1 through 8.4.1.5, paragraph 8.4.2.1, and section
8.4.11). Additional instructions were provided for preparing samples for conditioning by sewing a layer
of flame resistant fabric to the cold weather insulation material prior to laundering with its removal
following laundering or dry cleaning (paragraphs 8.4.3.1 through 8.4.3.3).

For supporting documentation see the doc info pages at www.nfpa.org/2112.

Emergency Nature: The proposed TIA intends to correct a circumstance in which the revised NFPA
Standard has resulted in an adverse impact on a product or method that was inadvertently
overlooked in the total revision process or was without adequate technical (safety) justification for the
action. As currently written, NFPA 2112 includes criteria that create a bias against cold weather
insulation materials that is inconsistent with their use and in consistent with demonstrated levels of
safety.

The OSHA interpretation of March 2010 encouraging employers to provide their employees with
garments certified to a consensus standard like NFPA 2112 has created a need and demand for
outerwear garments for cold weather protection that are certified to the NFPA 2112 standard. The
current edition of the NFPA 2112 standard does not provide clear methods to properly test and certify
garments that incorporate insulation for additional protection from cold weather.

Response
Message:
Public Input No. 24-NFPA 2112-2013 [New Section after 8.4.10.5]
8.4.12 Specific Requirements for Testing Gloves.

8.4.12.1 Specimens shall include complete gloves.

8.4.12.2 Specimen gloves shall be preconditioned as specified in 8.1.2. Specimens shall then be placed in a circulating oven for not less than 4 hours at 49°C, 2°/−0°C (120°F, 5°/−0°F).

8.4.12.3 The glove body shall be filled with 4 mm (\(\frac{3}{16}\) in.) perforated soda-lime glass beads, with care taken to tightly pack the glass beads into the fingers of the glove and into the glove body.

8.4.12.4 The opening of the glove shall be clamped together, and the specimen shall be suspended by the clamp in the oven so that the entire glove is not less than 50 mm (2 in.) from any oven surface or other specimen, and airflow is parallel to the plane of the glove.

8.4.12.5 The test oven shall be heated and the test thermometer stabilized at 260°C, 6°/−0°C (500°F, 10°/−0°F) for a minimum of 30 seconds.

8.4.12.6 After 5 minutes, 15/−0 seconds, oven exposure at 260°C, 6°/−0°C (500°F, 10°/−0°F), the sample gloves shall be removed and allowed to cool for a minimum of 2 minutes.

8.4.12.7 An assessment of the glove donnability and flexibility shall be made after the heat exposure by having a test subject, whose hand dimensions are appropriate for wearing the glove, put the glove on and attempt to clutch the hands into a fist five times.

8.4.12.8 The dimensions of the glove specimen shall also be measured to determine pass/fail.

8.4.12.8.1 Glove measurements shall be made following preconditioning and after the oven heat exposure specified in 8.4.12.6.

8.4.12.8.2 The length measurement of the glove specimen shall be from the tip of the middle finger to the end of the glove body on the palm side.

8.4.12.8.3 The width measurement of the glove specimen shall be the width measurement of the palm side 25 mm (1 in.) below the base of the fingers.

8.4.12.9 The percentage of change in the width and length dimensions of the specimen shall be calculated. Results shall be reported as the average of all three specimens in each direction.

8.4.12.10 Testing shall be performed as described in 8.4.2 through 8.4.8.
Committee Statement

Committee Statement: Additional clothing items were added to the scope of the document. The committee would like to solicit Public Comments on the test method. Data and refinements to the methods will be submitted and considered. It should be noted that this method is derived from the test method in NFPA 1977 8.4.13.
8.5.2.2
Fabrics to be tested shall be used to construct the standard garment design specified in 8.3.2 of ASTM F1930, Standard Test Method for Evaluation of Flame Resistant Clothing for Protection Against Flash Fire Simulations Using an Instrumented Manikin.

Submitter Information Verification

Submitter Full Name: Eric Nette
Organization: [ Not Specified ]
Street Address: 
City: 
State: 
Zip: 
Submittal Date: Tue Nov 04 10:47:06 CST 2014

Committee Statement

Committee Statement: Corrected the title of the ASTM F1930 standard test method noted in this section.
Response Message: 

Public Input No. 43-NFPA 2112-2014 [Section No. 8.5.2.2]
8.5.4.1
Specimens shall be tested in accordance with ASTM F 1930, Standard Test Method for Evaluation of Flame Resistant Clothing for Protection Against Flash Fire Simulations Using an Instrumented Manikin, using an exposure heat flux of 84 kW/m² (2.02 cal/cm²·sec) with an exposure time of 3 seconds.

Submitter Information Verification

Submitter Full Name: Eric Nette
Organization: [ Not Specified ]
Street Address:
City:
State:
Zip:
Submittal Date: Tue Nov 04 10:47:39 CST 2014

Committee Statement

Committee Statement: Corrected the title of the ASTM F1930 standard test method noted in this section.
Response Message:
Public Input No. 44-NFPA 2112-2014 [Section No. 8.5.4.1]
8.6.4 Procedure.
Specimens shall be tested to a temperature of 260°C (500°F) in accordance with Method 1534, Melting Point of Synthetic Fibers, of Federal Test Method Standard 191A, Textile Test Methods ASTM D7138, Standard Test Method to Determine Melting Temperature of Synthetic Fibers, Method 2.

Submitter Information Verification

Submitter Full Name: Eric Nette
Organization: [ Not Specified ]
Street Address:
City:
State:
Zip:
Submittal Date: Tue Nov 04 14:14:12 CST 2014

Committee Statement

Committee Statement: Current method was replaced with the referenced ASTM Method.
Response Message:
8.10 Protective Glove Flame Resistance Test.

8.10.1 Application.

This test method shall be applied to glove materials.

8.10.2 Specimens.

Each specimen to be tested shall be a rectangle at least 50 mm (2 in.) wide by 150 mm (6 in.) long. Specimens shall be the composite used in actual glove construction consisting of each single layer, with all layers arranged in proper order. In each test, the specimen's normal outer surface shall be exposed to the flame.

8.10.2.1 Three specimens shall be tested for each composite.

8.10.2.2 If a proposed glove construction has stitched-through seams, three additional specimens containing these seams shall be tested. The seam shall be in the direction of the 150 mm (6 in.) dimension.

8.10.3 Sample Preparation.

8.10.3.1 Specimens shall be tested after conditioning as specified in 8.1.2.

8.10.3.2 Additional specimens shall be tested after three cycles of washing and drying as specified in 8.1.3, or after three cycles of dry cleaning as specified in 8.1.4 followed by conditioning as specified in 8.1.2.

8.10.4 Apparatus.

8.10.4.1 The test apparatus shall consist of a burner, crucible tongs, support stand, utility clamp, stopwatch, butane gas, gas regulator valve system, and measuring scale.

8.10.4.1.1 The burner shall be a high-temperature, liquefied type Fisher burner.

8.10.4.1.2 The stopwatch or other timing device shall measure the burning time to the nearest 0.1 second.

8.10.4.1.3 The butane shall be commercial grade, 99.0 percent pure or better.

8.10.4.1.4 The gas regulator system shall consist of a control valve system with a delivery rate designed to furnish gas to the burner under a pressure of 17.3 kPa, ± 1.7 kPa (2.5 psi, ± 0.25 psi) at the reducing valve. The flame height shall be adjusted at the reducing valve to produce a pressure of 0.7 kPa, ± 0.07 kPa (0.1 psi, ± 0.01 psi).

8.10.4.2 A freestanding flame height indicator shall be used to assist in adjustment of the burner flame height. The indicator shall mark a flame height of 75 mm (3 in.) above the top of the burner.

8.10.4.3 A specimen support assembly shall be used that consists of a frame and steel rod of 2 mm (⅛ in.) diameter to support the specimen in an L-shaped position, as shown in Figure 8.10.4.3.

Figure 8.10.4.3 Specimen Support Assembly.

8.10.4.4 The horizontal portion of the specimen shall be not less than 50 mm (2 in.), and the vertical portion shall be not less than 150 mm (6 in.). The specimen shall be held at each end by spring clips under light tension, as shown in Figure 8.10.4.3.

8.10.5 Procedure.


8.10.5.1
The burner shall be ignited, and the test flame shall be adjusted to a height of 75 mm (3 in.) with the gas on/off valve fully open and the air supply completely and permanently off, so that the flame height is closely controlled. The 75 mm (3 in.) height shall be obtained by adjusting the orifice in the bottom of the burner so that the top of the flame is level with the marked flame height indicator.

8.10.5.2
With the specimen mounted in the support assembly, the burner shall be moved such that the middle of the folded corner contacts the flame, as shown in Figure 8.10.4.3.

8.10.5.3
The burner flame shall be applied to the specimen for 12 seconds. After 12 seconds, the burner shall be removed.

8.10.5.4
The afterflame time shall be measured as the time, in seconds, to the nearest 0.2 second, that the specimen continues to flame after the burner is removed from the flame.

8.10.5.5
Each layer of the specimen shall be examined for melting or dripping.

8.10.5.6
The specimen shall then be further examined for char length. The char length shall be determined by measuring the length of the tear through the center of the charred area as specified in 8.10.5.6.1 through 8.10.5.6.4.

8.10.5.6.1
The specimen shall be folded lengthwise and creased, by hand, along a line through the highest peak of the charred area.

8.10.5.6.2
A hook shall be inserted in the specimen or a hole that is 6 mm (1/4 in.) in diameter or less that is punched out for the hook, at one side of the charred area 6 mm (1/4 in.) from the adjacent outside edge at the point where the specimen contacted the steel rod, and 6 mm (1/4 in.) in from the lower end.

8.10.5.6.3
A weight of sufficient size such that the weight and hook together shall equal the total tearing load required in Table 8.10.5.6.3 shall be attached to the hook. The specific load for determining char length applicable to the weight of the composite specimen shall be as listed in Table 8.10.5.6.3.

<table>
<thead>
<tr>
<th>Specified Weight of Material Before Any Fire-Retardant Treatment or Coating</th>
<th>Total Tearing Weight for Determining Charred Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>g/m²</td>
<td>oz/yd²</td>
</tr>
<tr>
<td>68–203</td>
<td>2.0–6.0</td>
</tr>
<tr>
<td>Over 203–508</td>
<td>Over 6.0–15.0</td>
</tr>
<tr>
<td>Over 508–780</td>
<td>Over 15.0–23.0</td>
</tr>
<tr>
<td>Over 780</td>
<td>Over 23.0</td>
</tr>
</tbody>
</table>

8.10.5.6.4
A tearing force shall be applied gently to the specimen by grasping the side of the material at the edge of the char opposite from the load and raising the 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 shall be made along the undamaged edge.

8.10.6 Report.

8.10.6.1
The afterflame time and char length shall be recorded and reported for each specimen.

8.10.6.2
The average afterflame time and char length shall be calculated, recorded, and reported.

8.10.6.3
The afterflame time shall be recorded and reported to the nearest 0.2 second, and the char length shall be recorded and reported to the nearest 2.5 mm (1/4 in.).
8.10.6.4
Observations of melting or dripping for each specimen shall be recorded and reported.

8.10.7 Interpretation.
Pass or fail performance shall be based on any observed hole formation, melting or dripping, the average afterflame time, and the average char length.

Supplemental Information

<table>
<thead>
<tr>
<th>File Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Figure_8.8.4.3.jpg</td>
<td>Pulled from NFPA 1977</td>
</tr>
<tr>
<td>Table_8.8.5.6.3.jpg</td>
<td>Pulled from NFPA 1977</td>
</tr>
</tbody>
</table>

Submitter Information Verification

Submitter Full Name: Eric Nette
Organization: [ Not Specified ]
Street Address:
City:
State:
Zip:
Submittal Date: Thu Nov 06 06:25:21 CST 2014

Committee Statement

Committee Statement: Additional clothing items were added to the scope of the document. The committee would like to solicit Public Comments on the test method. Data and refinements to the methods will be submitted and considered. It should be noted that this method is derived from the test method in NFPA 1951 and 1977.
<table>
<thead>
<tr>
<th>Specified Weight of Material Before Any Fire-Retardant Treatment or Coating</th>
<th>Total Tearing Weight for Determining Charred Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>g/m²</td>
<td>kg</td>
</tr>
<tr>
<td>68–203</td>
<td>0.1</td>
</tr>
<tr>
<td>Over 203–508</td>
<td>0.2</td>
</tr>
<tr>
<td>Over 508–780</td>
<td>0.3</td>
</tr>
<tr>
<td>Over 780</td>
<td>0.45</td>
</tr>
<tr>
<td>oz/yd²</td>
<td></td>
</tr>
<tr>
<td>2.0–6.0</td>
<td></td>
</tr>
<tr>
<td>Over 6.0–15.0</td>
<td></td>
</tr>
<tr>
<td>Over 15.0–23.0</td>
<td></td>
</tr>
<tr>
<td>Over 23.0</td>
<td></td>
</tr>
</tbody>
</table>
8.7 Label Print Durability Test.

8.7.1 Application.
This test method shall apply to flame-resistant garment product labels.

8.7.2 Specimens.
A total of three different specimen labels shall be evaluated.

8.7.3 Sample Preparation.
8.7.3.1 For fabrics that are designated on the flame-resistant garment label to be washed, specimens shall be tested before and after 100 cycles of washing and drying as specified in 8.1.3.

8.7.3.2 For fabrics that are designated on the flame-resistant garment label to be dry-cleaned, specimens shall be tested before and after 100 cycles of dry cleaning as specified in 8.1.4.

8.7.3.3 For fabrics that are designated on the flame-resistant garment label to be either washed or dry-cleaned, specimens shall be tested before and after 100 cycles of washing and drying as specified in 8.1.3, or after 100 cycles of dry cleaning as specified in 8.1.4.

8.7.3.4 Samples for conditioning by laundering or dry cleaning shall include labels sewn onto a square sample of fabric measuring 0.84 m$^2$ (1 yd$^2$), meeting the requirements of Section 7.1. The labels shall be no closer than 51 mm (2 in.) apart in parallel strips. For fabrics that are designated on the flame-resistant shroud/hood/balaclava label to be washed, specimens shall be tested before and after 100 cycles of washing and drying as specified in 8.1.3.

8.7.3.5 For fabrics that are designated on the flame-resistant shroud/hood/balaclava label to be dry-cleaned, specimens shall be tested before and after 100 cycles of dry cleaning as specified in 8.1.4.

8.7.3.6 For fabrics that are designated on the flame-resistant shroud/hood/balaclava label to be either washed or dry-cleaned, specimens shall be tested before and after 100 cycles of washing and drying as specified in 8.1.3, or after 100 cycles of dry cleaning as specified in 8.1.4.

8.7.3.7 For fabrics that are designated on the flame-resistant rainwear label to be either washed or dry-cleaned, specimens shall be tested before and after three cycles of washing and drying as specified in 8.1.3, or after three cycles of dry cleaning as specified in 8.1.4.

8.7.3.8 Samples for conditioning by laundering or dry cleaning shall include labels sewn onto a square sample of fabric measuring 0.84 m$^2$ (1 yd$^2$), meeting the requirements of Section 7.1. The labels shall be no closer than 51 mm (2 in.) apart in parallel strips.

8.7.4 Procedure.
Specimens shall be examined for legibility at a distance of 30.5 cm (12 in.) by the unaided eye with 20/20 vision, or vision corrected to 20/20, for legibility to determine pass/fail.

8.7.5 Report.
The pass/fail results for each specimen tested shall be reported.

8.7.6 Interpretation.
One or more label specimens failing this test shall constitute a failing performance.

Supplemental Information

<table>
<thead>
<tr>
<th>File Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.7_Changes_EN_12.1.14.docx</td>
<td></td>
</tr>
<tr>
<td>Committee Statement</td>
<td></td>
</tr>
<tr>
<td>---------------------</td>
<td></td>
</tr>
<tr>
<td>Committee Statement:</td>
<td>Additional clothing items were added to the scope of the document. The revisions to the conditioning procedures are to accommodate these new items.</td>
</tr>
</tbody>
</table>

### Committee Statement

**Committee Statement:**

Additional clothing items were added to the scope of the document. The revisions to the conditioning procedures are to accommodate these new items.
8.7 Label Print Durability Test.

8.7.1 Application.

This test method shall apply to flame-resistant garment product labels.

8.7.2 Specimens.

A total of three different specimen labels shall be evaluated.

8.7.3 Sample Preparation.

8.7.3.1 For fabrics that are designated on the flame-resistant garment label to be washed, specimens shall be tested before and after 100 cycles of washing and drying as specified in 8.1.3.

8.7.3.2 For fabrics that are designated on the flame-resistant garment label to be dry-cleaned, specimens shall be tested before and after 100 cycles of dry cleaning as specified in 8.1.4.

8.7.3.3 For fabrics that are designated on the flame-resistant garment label to be either washed or dry-cleaned, specimens shall be tested before and after 100 cycles of washing and drying as specified in 8.1.3, or after 100 cycles of dry cleaning as specified in 8.1.4.

8.7.3.4 For fabrics that are designated on the flame-resistant shroud/hood/balaclava label to be washed, specimens shall be tested before and after 100 cycles of washing and drying as specified in 8.1.3.

8.7.3.5 For fabrics that are designated on the flame-resistant shroud/hood/balaclava label to be dry-cleaned, specimens shall be tested before and after 100 cycles of dry cleaning as specified in 8.1.4.

8.7.3.6 For fabrics that are designated on the flame-resistant shroud/hood/balaclava label to be either washed or dry-cleaned, specimens shall be tested before and after 100 cycles of washing and drying as specified in 8.1.3, or after 100 cycles of dry cleaning as specified in 8.1.4.

8.7.3.7 For fabrics that are designated on the flame-resistant rainwear label to be either washed or dry-cleaned, specimens shall be tested before and after three cycles of washing and drying as specified in 8.1.3, or after three cycles of dry cleaning as specified in 8.1.4.
8.7.3.8

Samples for conditioning by laundering or dry cleaning shall include labels sewn onto a square sample of fabric measuring 0.84 m\(^2\) (1 yd\(^2\)), meeting the requirements of Section 7.1. The labels shall be no closer than 51 mm (2 in.) apart in parallel strips.

8.7.4 Procedure.

Specimens shall be examined at a distance of 30.5 cm (12 in.) by the unaided eye with 20/20 vision, or vision corrected to 20/20, for legibility to determine pass/fail.

8.7.5 Report.

The pass/fail results for each specimen tested shall be reported.

8.7.6 Interpretation.

One or more label specimens failing this test shall constitute failing performance.
8.8 Whole Glove Thermal Protection Performance Test.

8.8.1 Application.
This test method shall apply to protective gloves as exposed to short duration thermal exposure resulting from a fire.

8.8.2 Samples.
One set of gloves consisting of right and left shall be provided, size Large-dimensions TBD.

8.8.3 Specimens.
Five specimen pairs shall be tested.

8.8.4 Apparatus.

8.8.4.1 Instrumented Hands
Two hands with specified dimensions that represents two adult human hands shall be used. Fingers/thumbs can be removable and the thumb can have a hinge to facilitate donning of glove.

8.8.4.1.1 Size and Shape.
The hand dimensions shall correspond to those required for standard size L gloves because deviations in fit will affect the results.

8.8.4.1.2 The hands shall be constructed of flame resistant, thermally stable, nonmetallic materials that will not contribute fuel to the combustion process. A flame resistant, thermally stable, glass fiber–reinforced vinyl ester resin at least 3 mm (1/8 in.) thick has proven effective.

8.8.4.2 Apparatus for Burn Injury Assessment.

8.8.4.2.1 Hands Construction.
A minimum of 10 thermal energy sensors shall be used per hand (three on the palm, four on the wrist, and three on the back of the hand). They shall be distributed as uniformly as possible within each area on the hands.

8.8.4.2.2 Thermal Energy Sensors.
Each sensor shall have the capacity to measure the incident heat flux over a range from 0.0 to 165 kW/m² (0.0 to 4.0 cal/cm²•s). This range permits the use of the sensors to set the exposure level by directly exposing the instrumented hands to the controlled flash fire in a test without the gloves. Sensors will also have the capability to measure the heat transfer to the hands when covered with test gloves or protective glove ensemble.

8.8.4.2.2.1 The sensors shall be constructed of a material with known thermal and physical characteristics that can be used to indicate the time varying heat flux received by the sensors. One type of sensor that has been used successfully is a copper slug calorimeter. The minimum response time for the sensors shall be ≤0.1 seconds. Coating the sensor with a thin layer of flat black, high temperature paint with an absorptivity of at least 0.9 has been found effective. The outer surface shall have an emissivity of at least 0.9.

8.8.4.2.2 The calibration determined for each sensor shall be recorded, and the most recent calibration results shall be used to carry out the burn injury analysis.

8.8.4.2.3 Thermal Energy (Heat Flux) Calibration Sensor.
Use a NIST traceable heat flux measuring device to calibrate the energy source used to calibrate the thermal energy (heat flux) sensors. A permanent record shall be kept of the sensor calibrations during their operating life.

8.8.4.2.4 Data Acquisition System.
A system shall be provided with the capability of acquiring and storing the results of the measurement from each sensor at least 10 times per second for the data acquisition period.

8.8.4.2.5 Burn Assessment Program.
Computer software that has the capability of receiving the output of the thermal sensors shall be used to
calculate the time dependent surface heat flux. The software shall predict second- and third-degree burn
injuries for each sensor, using the skin burn injury model and determine the total predicted burn injury
area as a result of the simulated flash fire exposure.

8.8.4.2.5.1
The average heat flux to the surface of the hands shall be determined by exposing the nude hands for 3
seconds. The total and average values of all sensors shall be determined taking into account the sensor
calibrations and characteristics. The values calculated for each sensor at each time step shall be placed
in a file for future use in estimating the temperature history within human skin for the burn injury
calculation.

8.8.4.2.5.2
The predicted time necessary to cause second- and third-degree burn injuries for each sensor shall be
calculated.

8.8.4.2.5.3
The sum of the areas represented by the sensors that received sufficient heat to result in a predicted
second-degree burn shall be the predicted second-degree percentage burn area assessment. The sum
of the area represented by the sensors that received sufficient heat to result in a predicted third-degree
burn shall be the predicted third-degree percentage burn area assessment. The sum of these two areas
shall be the total predicted percentage of burn injury resulting from the exposure to the flash fire
condition. The sum of all sensors shall represent 100 percent of the hands.

8.8.4.2.6
Exposure Chamber.
A ventilated, fire-resistant enclosure with viewing windows and access door(s) shall be provided to
contain the hands and exposure apparatus.

8.8.4.2.6.1 Exposure Chamber Size.
The chamber size shall be sufficient to provide a uniform flame exposure over the surface of the test
gloves and shall have sufficient space to allow safe movement around the hands for dressing without
accidentally jarring and displacing the burners.

8.8.4.2.6.2 Burner and Manikin Alignment.
Apparatus and procedures for checking the alignment of the burners and hands position prior to each
test shall be available.

8.8.4.2.6.3 Chamber Air Flow.
The chamber shall be isolated from air movement other than the natural air flow required for the
combustion process so that the pilot flames and exposure flames are not affected before and during the
test exposure and data acquisition periods. A forced air exhaust system for rapid removal of combustion
gas products after the data acquisition period shall be provided.

8.8.4.2.6.4 Chamber Safety Devices.
The exposure chamber shall be equipped with sufficient safety devices, detectors, and suppression
systems to provide safe operation of the test apparatus. These safety devices, detectors, and
suppression systems include propane gas detectors, motion detectors, door closure detectors, hand
held fire extinguishers, and any other devices necessary.

8.8.4.2.7 Fuel Delivery System.
A system of piping, pressure regulators, valves, and pressure sensors including a double block and
bleed burner management scheme, (see NFPA 58), or similar system consistent with local codes shall
be provided to safely deliver gaseous propane to the ignition system and exposure burners. This
delivery system shall be sufficient to provide an average heat flux of at least 2.0 cal/s•cm$^2$ for an
exposure time of at least 3 seconds. Fuel delivery shall be controlled to provide known exposure
duration within ± 0.1 seconds of the set exposure time.

8.8.4.2.7.1 Fuel.
The propane gas used in the system shall be from a liquid propane supply with sufficient purity and
constancy to provide a uniform flame from the exposure burners. It is recommended that the fuel meet
the HD-5 specifications. (See Specification D1835, CAN/CGSB 3.14 M88, or equivalent.)

8.8.4.2.7.2 Burner System.
The burner system shall consist of one ignition pilot flame for each exposure burner, and sufficient
burners to provide the required range of heat fluxes with a flame distribution uniformity to meet the
requirements in 10.3.2.

8.8.4.2.7.3 Exposure Burners.
Large, induced-combustion air, industrial-style, propane burners are positioned around the hands to produce a uniform laboratory simulation of a fire. These burners produce a large fuel rich reddish-yellow flame. If necessary, enlarge the burner gas jet, or remove it, to yield a fuel to air mixture for a long luminous reddish-yellow flame that engulfs the hands. A minimum of four burners has been shown to yield the exposure level and uniformity as described in 8.8.5.3.5.

8.8.4.2.7.3.1 Ignition Pilot Flame.
Each exposure burner shall be equipped with a pilot flame positioned near the exit of the burner, but not in the direct path of the flames to interfere with the exposure flame pattern. The pilot flame shall be interlocked to the burner gas supply valves to prevent premature or erroneous opening of these valves.

8.8.4.2.8 Image Recording System.
A system for recording a visual image of the hands before, during, and after the flame exposure shall be provided.

8.8.4.2.9 Safety Check List.
A checklist shall be included in the computer program to ensure that all safety features have been satisfied before the flame exposure can occur. The procedural safety checks shall be documented. This list shall include, but is not limited to, the following:

(1) Confirm that the hands have been properly dressed in the test garment.
(2) Confirm that the chamber doors are closed.
(3) Confirm that no person is in the burn chamber.
(4) Confirm that safety requirements are met.

8.8.4.2.10 Garment Conditioning Area.
The area shall be maintained at 21 ± 2°C (70 ± 5°F) and 65 ± 5 percent relative humidity. It shall be large enough to have good air circulation around the test specimens.

8.8.5 Preparation and Calibration of Apparatus
8.8.5.1 Preparation of Apparatus.
Exposing the instrumented hands to a fire exposure in a safe manner and evaluating the test specimen requires a startup and exposure sequence that is specific to the test apparatus. Depending on the individual apparatus, some of the steps listed require manual execution; others are initiated by the computer. Perform the steps as specified in the apparatus operating procedure. Some of the steps that shall be included are the following:

(1) Burn chamber purging: Ventilate the chamber for a time sufficient to remove a volume of air at least 10 times the volume of the chamber. The degree of ventilating the chamber shall at a minimum comply with NFPA 86.
(2) Gas line charging: The following procedure or a comparable procedure shall be used for gas line charging. Close the supply line vent valves and open the valves to the fuel supply to charge the system with propane gas at the operating pressure up to, but not into, the chamber. Charge and initiate the pilots first, before charging the header in the exposure chamber for the torches.
(3) Confirmation of exposure conditions: Using the procedure that follows, expose the hands to the test fire for 3 seconds. Confirm that the calculated heat flux standard deviation is not greater than 0.50 cal/cm² • s and the exposure is within ± 2.5 percent of the specified test condition. If the calculated heat flux or standard deviation is not within these specifications, determine the cause of the deviations and correct before proceeding with garment testing.

8.8.5.2 Calibration of Sensor and Data System.
8.8.5.2.1 Calibration Principles.
8.8.5.2.1.1 Thermal energy sensors are used to measure the fire exposure intensity and the thermal energy transferred to the manikin during the exposure. Calibrate the individual sensors performance against a suitable NIST or other recognized standards body traceable reference. Calibrate to the exposure and heat transfer conditions experienced during test setup and garment testing, typically over a range of 0.07 cal/cm² • s to 3.0 cal/cm² • s.
8.8.5.2.1.2
Verify the heat fluxes produced by the calibration device to within ± 2.5 percent of the required exposure level with the heat flux calibration sensor.

8.8.5.2.1.3
Test the thermal energy sensors used in the manikin to ensure that the heat flux response is accurate over the range of heat fluxes produced by the exposure and under the test specimen. If the response is linear but not within 2.5 percent of the known calibration exposure energy, include a correction factor in the heat flux calculations. If the response is not linear and within 2.5 percent of the known calibration exposure energy, determine a correction factor curve for each sensor for use in the heat flux calculations.

8.8.5.3
[***Text Needed Here***]

8.8.5.3.1
Measure the intensity and uniformity of the fire exposure by exposing the nude hands to the flames. Software capable of converting the measured data into time varying surface heat fluxes at each sensor is required. Calculate the average heat flux over the steady region as shown in Figure 8.8.5.3.1 during the exposure for each sensor. Calculate the area weighted average of these values and the standard deviation. The weighted average is the average exposure heat flux level for the test conditions, and the standard deviation is a measure of the exposure uniformity.

Figure 8.8.5.3.1 Average Heat Flux Determination for a Nude Exposure.

8.8.5.3.2
Position the exposure burners and adjust the flames so that the standard deviation of the average exposure heat flux level of all of the hands sensors does not exceed 0.50 cal/cm² • s. Confirm the standard deviation of the average heat flux level to be equal to or less than 0.50 cal/cm² • s for each nude hands exposure, and if necessary, adjust the burners to obtain the exposure uniformity.

8.8.5.3.3
Expose the nude hands to the flames before testing a set of specimens and repeat the exposure at the conclusion of the testing of the set. If the average exposure heat flux for the test conditions differs by more than 5 percent between the before and after measurements, report this and consider repeating the sequence of specimen tests. As a minimum, check the hands exposure level at the beginning and at the end of the workday.

8.8.5.3.4
Use a 3-second fire exposure for these calibrations, and monitor the fuel pressure of the supply line close to the burner fuel supply header. The measured absolute fuel pressure at this location shall not fall more than 10 percent during a single fire exposure. The duration of the fire exposure shall be controlled by the internal clock of the data acquisition system.

8.8.5.3.5
The average heat flux calculated in 8.8.5.3.1 shall be 2.0 cal/s•cm² ± 2.5 percent. If not, adjust the fuel flow rate by modifying the gas pressure or flow at the burner heads. Repeat the calibration run(s) until the specified value is obtained. Repeat nude calibrations shall be conducted only when no single sensor temperature exceeds 38°C (100°F) in order to minimize corrections required for nonlinear temperature dependent sensor response.

8.8.5.3.6
The computer controlled data acquisition system shall be capable of recording the output from each sensor at least 10 times per second during the calibration. The accuracy of the measurement system shall be less than 2 percent of the reading or ± 1.0°C (± 1.8°F) if a temperature sensor is used. Set the sampling rate during an exposure to provide a minimum of two readings for each sensor every second.

8.8.5.3.7
Calibration of the fire exposure on the hands shall be done as the first and last test for each test day. Report the results of this exposure as the average absorbed heat flux in cal/cm² • s and exposure duration in seconds. Also, report the standard deviation of the hands sensors, the area weighted percent of sensors indicating second- and third-degree burns, and the sum of these two values as a total percent burn.

8.8.5.4
Defective Sensor Replacement.
Any defective sensor shall be replaced with a calibrated sensor prior to glove testing.

8.8.6
Procedure.
8.8.6.1 Sensor Temperatures.

Before starting an exposure, ensure that the average temperature of all the sensors located under the test specimen are 32 ± 2°C (90 ± 4°F) and that no single sensor exceeds 38°C (100°F).

8.8.6.2 Dress the Hands.

Dress the hands with the test specimens. Arrange the gloves on the hands in the way they are expected to be used by the end-user/wearer or as specified by the test author. All fingers/thumbs shall be installed on their respective hands. Note in the test report how the hands are dressed. Use the same fit and placement of the gloves for each test to minimize variability in the test results. It is common that the wrist sensors might not covered by the gloves. If this is the case, a protective sleeve/insulation should be placed over the respective sensors for protection.

8.8.6.3 Record the Test Attributes.

Record the information that relates to the test, including purpose of test, test series, glove identification, layering, fit on the hands, glove style, number or pattern description, test conditions, test remarks, exposure duration, data acquisition time, persons observing the test, and any other information relevant to the test series.

8.8.6.4 Burner Alignment.

Verify that burner alignment is correct as established in x.xx.x.

8.8.6.5 Hand Alignment.

Verify that the hands are spatially positioned and aligned in the exposure chamber via a centering or alignment device.

8.8.6.6 Set Test Parameters.

Enter into the burner management control system the specified exposure time and data acquisition time.

8.8.6.6.1 The minimum data acquisition time shall be 60 seconds for all exposures with garments. The data acquisition time shall be long enough to ensure that none of the thermal energy stored in the gloves is contributing to burn injury. Confirm that the acquisition time is sufficient by inspecting the calculated burn injury versus time information to determine that the total burn injury of all of the sensors has leveled off and is not continuing to rise at the end of the data acquisition time. If the amount of burn injury is not constant for the last 10 seconds of acquisition time, increase the time of acquisition to achieve this requirement.

8.8.6.7 Confirm Safe Operation Conditions.

Follow the operating instructions in the computer program and fill in the fields on the safety screen to ensure that all of the safety requirements have been met and that it is safe to proceed with the garment exposure.

8.8.6.8 Light Pilot Flames.

When all of the safety requirements are met, light the pilot flames and confirm that all of the pilot flames on the burners that will be used in the test exposure are actually lit. Warning: Visually confirm the presence of each pilot flame in addition to the panel light or computer indication. The test exposure shall be initiated only when all of the safety requirements are met, the pilot flames are ignited and visually confirmed, and the final valve in the gas supply line is opened.

8.8.6.9 Start Image Recording System.

Start the video or film system used to visually document each test.

8.8.6.10 Expose the Test Gloves.

Initiate the test exposure by pressing the appropriate computer key. The computer will start the data acquisition, open the burner gas supply solenoid valves for the time of the exposure, and stop the data acquisition at the end of the specified time.

8.8.6.11 Acquire the Heat Transfer Data.

Collect the data from all installed thermal energy sensors. Note that data collection after the fire exposure shall be done in a quiescent environment.

8.8.6.12 Record Garment Response Remarks.

Record observations of test gloves to the exposure. These remarks include but are not limited to the following: occurrence of afterflame (time, intensity, and location), ignition, melting, smoke generation, unexpected glove or material failures, material shrinkage, and charring or observed degradation. These remarks become a permanent part of the test record.
8.8.6.13 Initiate Test Report Preparation.
Initiate the computer program to perform the calculations to determine the amount of total burn injury
and to prepare the test report. Perform these operations immediately or, if warranted, delay them for
later processing.

8.8.6.14 Initiate Forced Air Exhaust System.
Start the forced air exhaust system to remove the combustion products and gasses produced from the
fire exposure. Run the system long enough to ensure a safe working environment in the exposure
chamber prior to entering.

8.8.6.15 Prepare for the Next Test Exposure.
Carefully remove the exposed gloves from the hands. Wipe the hands and sensor surfaces with a damp
cloth to remove residue from the test garment exposure. If the sensors are too hot, run the ventilating
fan(s) to cool them so that the average temperature of all sensors is \( 32 \pm 2 \)°C (90 ± 4°F) and no single
sensor exceeds 38°C (100°F). The hands and sensors shall be inspected to ensure that they are free of
any decomposition materials, and if a deposit is present, carefully clean the manikin and sensors with
soap and water or a petroleum solvent. Use the gentlest method that is effective in cleaning the sensor.
If required, repaint the surface of the sensor and dry the paint. Ensure that the manikin and sensors are
dry, and if necessary dry them, for example, with the ventilating fan(s) before conducting the next test.
Visually inspect the sensors for damage, e.g., cracks or discontinuities in the sensor surface.

8.8.6.16 Sensor Replacement.
Repair or replace damaged or inoperative sensors. Calibrate repaired or replaced sensors before using.

8.8.6.17 Test Remaining Specimens.
Test the remaining specimens at the same exposure conditions.

8.8.7 Calculated Results

8.8.7.1 Skin Burn Injury Prediction and Determination of Hand Manikin Sensor Heat Flux Values.

8.8.7.1.1 Convert the recorded thermal energy sensor responses at each time step into their respective
time-dependent absorbed heat flux values in kW/m\(^2\) (cal/s•cm\(^2\)) using the method appropriate for the
sensor.

8.8.7.1.1.1 Discussion.
Different laboratories use different sensor technologies in their manikins. Each requires a different
method to convert the measured responses into respective absorbed heat flux values.

8.8.7.2 Determination of the predicted skin and subcutaneous fat (adipose) internal temperature field.

8.8.7.2.1 For all hand locations, assume the thermal exposure is represented as a transient, one-dimensional
heat diffusion problem in which the temperature within the skin and subcutaneous layers (adipose)
varies with both position (depth) and time, and is described by the linear parabolic differential equation
(Fourier's Field Equation):

\[
\rho C_p(x) \frac{\partial T(x,t)}{\partial t} = \frac{\partial}{\partial x} [k(x) \frac{\partial T(x,t)}{\partial x}]
\]  

8.8.7.2.1.1 Table 8.8.7.2.1 Model Thickness Values for Sensor Locations on Hand Manikin (in µm)

<table>
<thead>
<tr>
<th>Sensor Location</th>
<th>Epidermis</th>
<th>Dermis</th>
<th>Subcutaneous Tissue</th>
<th>Bone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Palm</td>
<td>550</td>
<td>1100</td>
<td>3800</td>
<td></td>
</tr>
<tr>
<td>Back of hand</td>
<td>85</td>
<td>965</td>
<td>600</td>
<td>3200</td>
</tr>
<tr>
<td>Wrist/forearm</td>
<td>75</td>
<td>1125</td>
<td>3885</td>
<td></td>
</tr>
</tbody>
</table>
8.8.7.2.1 Discussion.
Use of absolute temperatures is recommended when solving Equation 8.8.7.2.1 because Equation 8.8.7.2.1, which is used for the calculation of Ω, the burn injury parameter, requires absolute temperatures.

8.8.7.2.1.2
Table 8.8.7.2.1.2 Thermo Physical Properties for Each Layer of Model

<table>
<thead>
<tr>
<th>Property</th>
<th>Epidermis</th>
<th>Dermis</th>
<th>Subcutaneous Tissue</th>
<th>Bone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal Conductivity, k W/m•K (cal/s•cm•K)</td>
<td>0.6280</td>
<td>0.5902</td>
<td>0.2930</td>
<td>0.3000</td>
</tr>
<tr>
<td></td>
<td>(0.0015)</td>
<td>(0.00141)</td>
<td>(0.0007)</td>
<td></td>
</tr>
<tr>
<td>Volumetric Heat Capacity, ρCp J/m^2•K</td>
<td>4.40 x 10^6</td>
<td>10^6</td>
<td>2.60 x 10^6</td>
<td>10^6</td>
</tr>
<tr>
<td>(cal/cm^2•K)</td>
<td>(1.05)</td>
<td>(1.00)</td>
<td>(0.62)</td>
<td></td>
</tr>
</tbody>
</table>

(A) Solve Equation 8.8.7.2.1 numerically using a sensor location specific skin model that takes into account the depth dependency of the thermal conductivity and volumetric heat capacity values as identified in Table 8.8.7.2.1 and Table 8.8.7.2.1.2. Each of the layers shall be constant thickness, lying parallel to the surface.

(B) The discretization methods to solve Equation 8.8.7.2.1 that have been found effective are the finite differences method (following the “combined method” — central differences representation where truncation errors are expected to be second order in both ∆t and ∆x), finite elements method (for example, the Galerkin method), and the finite volume method (sometimes called the control volume method).

(C) Equally spaced depth intervals (∆x), denoted as nodes or meshes, are recommended for highest accuracy in all numerical models. A value for ∆x of 15 x 10^-6 m has been found effective. Sparse or unstructured meshes are not recommended for use in the finite difference method.

8.8.7.2.2
Use the following initial and boundary conditions:

(1) The initial temperature within the layers shall have a linear increase with depth from 305.65 K (32.5ºC) at the surface to 306.65 K (33.5ºC) at the back of the subcutaneous layer (adipose). The deep temperature shall be constant for all time at 306.65 K (33.5ºC).

(2) Pennes measured the temperature distributions in the forearms of volunteers. For the overall thickness of the skin and subcutaneous layers (adipose) listed in Table 8.8.7.2.1.2, the measured rise was 1 K (1ºC). The skin surface temperature of the volunteers in the experiments by Stoll and Greene was kept very near to 305.65 K (32.5ºC).

(3) Due to very thin subcutaneous values for the back of the hand, a layer of bone was needed for the isothermal temperature boundary condition to be applied. A thickness of bone is specified so that these two areas of the hands have back layer tissue thicknesses similar to the subcutaneous layers of the other hand locations.

8.8.7.2.2.1

(A) The absorbed heat flux is applied only at the skin surface and it is assumed that heat conduction is the only mode of heat transfer in the skin and subcutaneous layers (adipose). This calculation excludes any thermal radiation components that could penetrate the skin.

(B) Assuming heat conduction only within the skin and deeper layers ignores enhanced heat transfer due to changing blood flow in the dermis and subcutaneous layers (adipose). The in vivo (living) values listed in Table 8.8.7.2.1.2 are back calculated from the experimental results of Stoll and Greene and numerical extensions by Weaver and Stoll (4). The values account to a large degree for the blood flow in the test subjects.

8.8.7.2.2.2

The absorbed heat flux at the skin surface at time t = 0 (start of the exposure) is zero (0).
The absorbed heat flux values at the skin surface at all times $t > 0$ are the time dependent absorbed heat flux values determined in 8.8.7.1.1. No corrections are made for radiant heat losses or emissivity/absorptivity differences between the sensors and the skin surface used in the model.

Calculate an associated internal temperature field for the skin model at each sensor sampling time interval for the entire sampling time by applying each of the sensor's time-dependent heat flux values to individual skin modeled surfaces (a skin model is evaluated for each measurement sensor). These internal temperature fields shall include, as a minimum, the calculation of temperature values at the surface (depth = 0.0 m), at the skin model epidermis/dermis interface (used to predict second-degree burn injury), and the skin model dermis/subcutaneous interface (used to predict a third-degree burn injury).

### Determination of the Predicted Skin Burn Injury

Table 8.8.7.3 Constants for Calculation of Omega Using Eq 8.8.7.3.1

<table>
<thead>
<tr>
<th>Skin Injury</th>
<th>Temperature Range</th>
<th>$P$</th>
<th>$\Delta E/R$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Second-degree</td>
<td>$317.15 , K \leq T \leq 323.15 , K$ (44°C $\leq T \leq 50°C$)</td>
<td>$2.185 \times 10^{124} , s^{-1}$</td>
<td>93534.9 K</td>
</tr>
<tr>
<td></td>
<td>$T &gt; 323.15 , K$ (T $&gt; 50°C$), use:</td>
<td>$1.823 \times 10^{51} , s^{-1}$</td>
<td>39109.8 K</td>
</tr>
<tr>
<td>Third-degree</td>
<td>$317.15 , K \leq T \leq 323.15 , K$ (44°C $\leq T \leq 50°C$)</td>
<td>$4.322 \times 10^{64} , s^{-1}$</td>
<td>50000 K</td>
</tr>
<tr>
<td></td>
<td>$T &gt; 323.15 , K$ (T $&gt; 50°C$), use:</td>
<td>$9.389 \times 10^{104} , s^{-1}$</td>
<td>80000 K</td>
</tr>
</tbody>
</table>

The Damage Integral Model of Henriques (5), Equation 8.8.7.3.1, is used to predict skin burn injury parameters based on skin temperature values at each measurement time interval at skin model depths of $75 \times 10^{-6}$ m (second-degree burn injury prediction) and $1200 \times 10^{-6}$ m (third-degree burn injury prediction).

$$\Omega = \int P e^{-\left(\frac{\Delta E}{RT}\right)} dt$$

where:
- $\Omega =$ Burn injury parameter; value $\geq 1$ indicates predicted burn injury
- $P =$ Pre-exponential term, dependent on depth and temperature, 1/sec
- $\Delta E =$ Activation energy, dependent on depth and temperature, J/kmol
- $R =$ Universal gas constant, 8314.5 J/mol $\cdot$ K
- $t =$ time of exposure and data collection period in sec

Determine the second- and third-degree burn injury parameter values, $\Omega_s$, by numerically integrating Eq 8.8.7.3.1 using the closed composite, extended trapezoidal rule, or Simpson’s rule, for the total time that data was gathered.

The integration is performed at each measured time interval for each sensor at the second- and third-degree skin depths (epidermis/dermis interface and dermis/subcutaneous interface depths, respectively) when the temperature, $T$, is $\geq 317.15 \, K$ (44°C). (See Table 8.8.7.2.1.)

A second-degree burn injury occurs when the value of $\Omega \geq 1.0$ for depths $\geq$ epidermis/dermis interface depth and $<$ the dermis/subcutaneous interface depth (Table 8.8.7.2.1).

A third-degree burn injury occurs when the value of $\Omega \geq 1.0$ for depths $\geq$ the dermis/subcutaneous interface depth (Table 8.8.7.2.1).

For the second- and third-degree burn injury predictions, the temperature dependent values for $P$ and $\Delta E/R$ are listed in Table 8.8.7.3.

Skin Burn Injury Test Cases.
Table 8.8.7.4 Skin Model Validation Data Set A

<table>
<thead>
<tr>
<th>Absorbed Exposure Heat Flux (constant for the exposure)</th>
<th>Exposure Duration</th>
<th>Required Size of Time Step</th>
</tr>
</thead>
<tbody>
<tr>
<td>W/m²</td>
<td>(cal/s•cm²)</td>
<td>S</td>
</tr>
<tr>
<td>3935</td>
<td>(0.094)</td>
<td>35.9</td>
</tr>
<tr>
<td>5903</td>
<td>(0.141)</td>
<td>21.09</td>
</tr>
<tr>
<td>11805</td>
<td>(0.282)</td>
<td>8.30</td>
</tr>
<tr>
<td>15740</td>
<td>(0.376)</td>
<td>5.55</td>
</tr>
<tr>
<td>23609</td>
<td>(0.564)</td>
<td>3.00</td>
</tr>
<tr>
<td>31479</td>
<td>(0.752)</td>
<td>1.95</td>
</tr>
<tr>
<td>39348</td>
<td>(0.940)</td>
<td>1.41</td>
</tr>
<tr>
<td>47218</td>
<td>(1.128)</td>
<td>1.08</td>
</tr>
<tr>
<td>55088</td>
<td>(1.316)</td>
<td>0.862</td>
</tr>
<tr>
<td>62957</td>
<td>(1.504)</td>
<td>0.713</td>
</tr>
<tr>
<td>70827</td>
<td>(1.692)</td>
<td>0.603</td>
</tr>
<tr>
<td>78697</td>
<td>(1.880)</td>
<td>0.522</td>
</tr>
</tbody>
</table>

8.8.7.4.1
The calculation method used in 8.8.7.2 and 8.8.7.3 shall meet the validation requirements identified in Table 8.8.7.4 when using the skin thickness values specific for the wrist/forearm portion of the manikin from Table 8.8.7.2.1 (75 µm, 1225 µm, and 3885 µm).

8.8.7.4.1.1
Skin models using the absorbed heat flux and exposure times in Table 8.8.7.4, along with the thickness values specific to the wrist/forearm in Table 8.8.7.2.1 (75 µm, 1225 µm, and 3885 µm) shall result in values of 1 ± 0.10 for all test cases at the epidermis/dermis interface at the time when the interface temperature has cooled to or below 317.15 K (44ºC). The skin layer properties listed in Table 8.8.7.2.1.2 and the calculation constants in Table 8.8.7.3 shall be used for these calculations. In addition, the time when $\Omega = 1$ shall never be less than the exposure duration listed. This latter requirement is to keep the prediction consistent with the observations of Stoll and Greene. Note that the parameter, $\Omega$, is a cumulative value and having epidermis/dermis interface temperatures lower than 317.15 K (44ºC) does not produce negative values that are subtracted.

8.8.7.4.2
When validating the skin burn injury model, use the layer thickness specific to the wrist/forearm in Table 8.8.7.2.1 (75 µm, 1225 µm, and 3885 µm), the thermal conductivity and volumetric heat capacity values specified in Table 8.8.7.2.1.2, and the boundary and initial conditions of 8.8.7.2.2 with the exception that the exposure heat fluxes in 8.8.7.2.2.4 become the constant valued ones listed in Table 8.8.7.4. The total calculation time shall be chosen so that the temperatures at the epidermis/dermis and dermis/subcutaneous interfaces both fall below 317.15 K (44ºC) during the cooling phase. For these test cases the skin surface shall be assumed to be adiabatic during the cooling phase, that is, no heat losses from the surface during cooling. Minor changes in the values of thermal conductivity and volumetric heat capacity listed in Table 8.8.7.2.1.2 are permitted providing the validation requirements specified in Table 8.8.7.4 are met with one set of values for all 12 test cases.

8.8.7.4.2.1 Discussion.
The adiabatic boundary condition during cooling is selected because of the lack of detail in the published documents on the orientation of the forearms and the proximity of surrounding equipment used to conduct the experiments. Furthermore, the data gathered from the thermal energy sensors when conducting this test method takes into account convection and radiation heat losses inherently through the calculation of the net energy absorbed by the thermal energy sensors. Therefore this adiabatic assumption only applies to the model validation data set and not the entire test method.
8.8.7.5 Calculated Results.
For all glove evaluation and specification test reports, include results of the computer program. Base the predicted burn injury on the total area of the hands containing sensors and on the total area of the hands covered by the test gloves.

(1) Total area (percent) of hands containing sensors
   (a) Hands area of second-degree burn injury (percent).
   (b) Hands area of third-degree burn injury (percent).
   (c) Total hands area of burn injury (sum of second- and third-degree burn injury) (percent), and associated variation statistic.

(2) Total area (percent) of hands covered by the test gloves
   (a) Covered area of second-degree burn injury (percent)
   (b) Covered area of third-degree burn injury (percent)

(3) Other calculated information used in assessing performance

(4) Diagram of the hands showing location and burn injury levels as second- and third-degree areas

8.8.8 Report.
8.8.8.1 State that the specimens were tested as directed in Test Method XX. Describe the material sampled, the method of sampling used, and any deviations from the method.
8.8.8.1.1 In the material description, include for each glove layer the glove type, size, fabric weight, fiber type, color, and nonstandard or special glove features and design characteristics.
8.8.8.1.2 Report the information in 8.8.7.3 through 8.8.7.5.
8.8.8.1.3 Type of Test.
Material of construction evaluation, glove design evaluation, or end-use glove evaluation.
8.8.8.1.4 Exposure Conditions.
The information that describes the exposure conditions includes the following:
   (1) The average of the exposure heat flux and the standard deviation of the average heat flux from all sensors determined from the nude exposures taken before and after each test series
   (2) The nominal heat flux, the duration of the exposure, and the duration of the data acquisition time for each test
   (3) The temperature and relative humidity in the room where the gloves were held prior to testing
   (4) Any other information relating to the exposure conditions shall be included to assist in interpretation of the test specimen results

8.8.9 Interpretation
Pass or fail determinations shall be based on the average total covered area of second- and third-degree burn injury (percent) < 50 percent.

Supplemental Information

<table>
<thead>
<tr>
<th>File Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PyroHands_Rev1.docx</td>
<td>This document was provided by NC State which was derived from ASTM F1930 that is a current work in progress under work item number WK46354.</td>
</tr>
</tbody>
</table>

Submitter Information Verification

Submitter Full Name: Eric Nette
**Committee Statement**

**Committee Statement:** The committee would like to solicit Public Comments on the requirements for the test methods. It is understood that these test methods are currently under development. Data and refinements to the methods will be submitted and considered.
8.XX Whole Glove Thermal Protection Performance Test

8.XX.1 Application

8.XX.1.1 This test method shall apply to protective gloves as exposed to short duration thermal exposure resulting from a fire.

8.XX.2. Samples

8.XX.2.1 One set of gloves consisting of right and left shall be provided, size Large-dimensions TBD

8.XX.3 Specimens A total of five specimen pairs shall be tested.

8.XX.4 Apparatus

8.XX.4.1 Instrumented Hands—two Hands with specified dimensions that represents two adult human hands shall be used. Fingers/thumbs may be removable and the thumb may have a hinge to facilitate donning of glove.

8.XX.4.1.1 Size and Shape—The Hand dimensions shall correspond to those required for standard L size of gloves because deviations in fit will affect the results.

8.XX.4.1.2 The Hands shall be constructed of flame resistant, thermally stable, nonmetallic materials which will not contribute fuel to the combustion process. A flame resistant thermally stable, glass fiber reinforced vinyl ester resin at least 3 mm (1/8 in.) thick, has proven effective

8.XX.4.2 Apparatus for Burn Injury Assessment:

8.XX.4.2.1 Hands Construction—a minimum of 10 thermal energy sensors shall be used per hand (3 on the palm, 4 on the wrist and 3 on the back of the hand). They shall be distributed as uniformly as possible within each area on the hands.

8.XX.4.2.2 Thermal Energy Sensors—each sensor shall have the capacity to measure the incident heat flux over a range from 0.0 to 165 kW/m2 (0.0 to 4.0 cal/cm2•s). This range permits the use of the sensors to set the exposure level by directly exposing the instrumented Hands to the controlled flash fire in a test without the gloves and also having the capability to measure the heat transfer to the Hands when covered with test gloves or protective glove ensemble.

8.XX.4.2.3 The sensors shall be constructed of a material with known thermal and physical characteristics that can be used to indicate the time varying heat flux received by the sensors. One type of sensor which has been used successfully is a copper slug calorimeter. The minimum response time for the sensors shall be ≤0.1 s. Coating the sensor with a thin layer of flat black high temperature paint\(^1\) with an absorptivity of at least 0.9\(^1\) has been found effective. The outer surface shall have an emissivity of at least 0.9.

8.XX.4.2.4 The calibration determined for each sensor shall be recorded, and the most recent calibration results used to carry out the burn injury analysis.

\(^1\) Krylon # 1618 BBQ and Stove; Krylon #1316 Sandable Primer; Krylon #1614 High Heat and Radiator paint have been found to be effective. See ASTM Study "Evaluation of Black Paint and Calorimeters used for Electric Arc Testing", ASTM contract #F18-103601, Kinectrics Report:8046-003-RC-0001-R00, August 22, 2000.
8.XX.4.3 Thermal Energy (Heat Flux) Calibration Sensor—use a NIST traceable heat flux measuring device to calibrate the energy source used to calibrate the thermal energy (heat flux) sensors. A permanent record shall be kept of the sensor calibrations during their operating life.

8.XX.4.4 Data Acquisition System—a system shall be provided with the capability of acquiring and storing the results of the measurement from each sensor at least ten times per second for the data acquisition period.

8.XX.4.5 Burn Assessment Program—a computer software program shall be used that has the capability of receiving the output of the thermal sensors, calculating the time dependent surface heat flux, predicting a second degree and third degree burn injury for each sensor utilizing the skin burn injury model and determining the total predicted burn injury area as a result of the simulated flash fire exposure.

8.XX.4.5.1 Incident Heat Calculation—the average heat flux to the surface of the Hands shall be determined by exposing the nude Hands for 3 seconds. The total and average value of all sensors shall be determined taking into account the sensor calibrations and characteristics. The values calculated for each sensor at each time step shall be placed in a file for future use in estimating the temperature history within human skin for the burn injury calculation.

8.XX.4.5.2 Burn Injury Calculation—the predicted time necessary to cause second-degree and third-degree burn injury for each sensor shall be calculated.

8.XX.4.5.3 Burn Injury Assessment—the sum of the areas represented by the sensors that received sufficient heat to result in a predicted second-degree burn shall be the predicted second-degree percentage burn area assessment. The sum of the area represented by the sensors that received sufficient heat to result in a predicted third-degree burn shall be the predicted third-degree percentage burn area assessment. The sum of these two areas shall be the total predicted percentage of burn injury resulting from the exposure to the flash fire condition. The sum of all sensors shall represent 100% of the Hands.

8.XX.4.6 Exposure Chamber—a ventilated, fire-resistant enclosure with viewing windows and access door(s) shall be provided to contain the Hands and exposure apparatus.

8.XX.4.6.1 Exposure Chamber Size—The chamber size shall be sufficient to provide a uniform flame exposure over the surface of the test gloves and shall have sufficient space to allow safe movement around the Hands for dressing without accidentally jarring and displacing the burners.

8.XX.4.6.2 Burner and Manikin Alignment-apparatus and procedures for checking the alignment of the burners and Hands position prior to each test shall be available.

8.XX.4.6.3 Chamber Air Flow—the chamber shall be isolated from air movement other than the natural air flow required for the combustion process so that the pilot flames and exposure flames are not affected before and during the test exposure and data acquisition periods. A forced air exhaust system for rapid removal of combustion gas products after the data acquisition period shall be provided.

8.XX.4.6.5 Chamber Safety Devices—the exposure chamber shall be equipped with sufficient safety devices, detectors and suppression systems to provide safe operation of the test apparatus. These safety devices, detectors and suppression systems include propane gas detectors, motion detectors, door closure detectors, hand held fire extinguishers and any other devices necessary.
8.XX.4.7 Fuel Delivery System—A system of piping, pressure regulators, valves, and pressure sensors including a double block and bleed burner management scheme (see NFPA 58) or similar system consistent with local codes shall be provided to safely deliver gaseous propane to the ignition system and exposure burners. This delivery system shall be sufficient to provide an average heat flux of at least $2.0 \text{ cal/s\cdot cm}^2$ for an exposure time of at least 3 s. Fuel delivery shall be controlled to provide known exposure duration within $\pm 0.1$ seconds of the set exposure time.

8.XX.4.7.1 Fuel—the propane gas used in the system shall be from a liquid propane supply with sufficient purity and constancy to provide a uniform flame from the exposure burners. It is recommended that the fuel meet the HD-5 specifications. (See Specification D1835, CAN/CGSB 3.14 M88, or equivalent)

8.XX.4.7.2 Burner System—the burner system shall consist of one ignition pilot flame for each exposure burner, and sufficient burners to provide the required range of heat fluxes with a flame distribution uniformity to meet the requirements in 10.3.2.

8.XX.4.7.3 Exposure Burners—Large, induced combustion air, industrial style propane burners are positioned around the hands to produce a uniform laboratory simulation of a fire. These burners produce a large fuel rich reddish-yellow flame. If necessary, enlarge the burner gas jet, or remove it, to yield a fuel to air mixture for a long luminous reddish-yellow flame that engulfs the hands. A minimum of four burners has been shown to yield the exposure level and uniformity as described in 8.XX.5.3.5.

8.XX.4.7.3.1 Ignition Pilot Flame—each exposure burner shall be equipped with a pilot flame positioned near the exit of the burner, but not in the direct path of the flames to interfere with the exposure flame pattern. The pilot flame shall be interlocked to the burner gas supply valves to prevent premature or erroneous opening of these valves.

8.XX.4.8 Image Recording System—a system for recording a visual image of the Hands before, during, and after the flame exposure shall be provided.

8.XX.4.9 Safety Check List—a check list shall be included in the computer operating program to ensure that all safety features have been satisfied before the flame exposure can occur. This list shall include, but is not limited to, the following: confirm that the Hands have been properly dressed in the test garment; confirm that the chamber doors are closed; confirm that no person is in the burn chamber; and all safety requirements are met. The procedural safety checks shall be documented.

8.XX.4.10 Garment Conditioning Area—the area shall be maintained at $21 \pm 2^\circ\text{C} (70 \pm 5^\circ\text{F})$ and $65 \pm 5\%$ relative humidity. It shall be large enough to have good air circulation around the test specimens.

8.XX.5 Preparation and Calibration of Apparatus

8.XX.5.1 Preparation of Apparatus—exposing the instrumented Hands to a fire exposure in a safe manner and evaluating the test specimen requires a startup and exposure sequence that is specific to the test apparatus. Some of the steps listed require manual execution, others are initiated by the computer program, depending upon the individual apparatus. Perform the steps as specified in the apparatus operating procedure. Some of the steps that shall be included are:

8.XX.5.1.1 Burn Chamber Purging—ventilate the chamber for a period of time sufficient to remove a volume of air at least ten times the volume of the chamber. The degree of ventilating the chamber shall at a minimum comply with NFPA 86.
8.XX.5.1.2 Gas Line Charging—the following procedure or a comparable procedure shall be used for gas line charging. Close the supply line vent valves and open the valves to the fuel supply to charge the system with propane gas at the operating pressure up to, but not into, the chamber. Charge and initiate the pilots first, before charging the header in the exposure chamber for the torches.

8.XX.5.1.3 Confirmation of Exposure Conditions—using the procedure described below expose the Hands to the test fire for 3 s. Confirm that the calculated heat flux standard deviation is not greater than 0.50 cal/cm²•s and the exposure is within ± 2.5% of the specified test condition. If the calculated heat flux or standard deviation is not within these specifications, determine the cause of the deviations and correct before proceeding with garment testing.

8.XX.5.2 Calibration of Sensor and Data System:

8.XX.5.2.1 Calibration Principles:

8.XX.5.2.1.1 Thermal energy sensors are used to measure the fire exposure intensity and the thermal energy transferred to the manikin during the exposure. Calibrate the individual sensors performance against a suitable NIST (or other recognized standards body) traceable reference. Calibrate to the exposure and heat transfer conditions experienced during test setup and garment testing, typically over a range of 0.07 cal/cm²•s to 3.0 cal/cm²•s.

8.XX.5.2.1.2 Verify the heat fluxes produced by the calibration device to within ±2.5% of the required exposure level with the heat flux calibration sensor.

8.XX.5.2.1.3 Test the thermal energy sensors used in the manikin to ensure that the heat flux response is accurate over the range of heat fluxes produced by the exposure and under the test specimen. If the response is linear but not within 2.5% of the known calibration exposure energy, include a correction factor in the heat flux calculations. If the response is not linear and within 2.5% of the known calibration exposure energy, determine a correction factor curve for each sensor for use in the heat flux calculations.
8.XX.5.3.1 Measure the intensity and uniformity of the fire exposure by exposing the nude Hands to the flames. Software capable of converting the measured data into time varying surface heat fluxes at each sensor is required. Calculate the average heat flux over the steady region as shown in Fig. 1 during the exposure for each sensor. Calculate the area weighted average of these values and the standard deviation. The weighted average is the average exposure heat flux level for the test conditions, and the standard deviation is a measure of the exposure uniformity.

![Figure 1: Average Heat Flux Determination for a Nude Exposure](image)

(Exposure begins – Burner gas valve opens)
(Exposure ends – Burner gas valve closes)

8.XX.5.3.2 Position the exposure burners and adjust the flames so that the standard deviation of the average exposure heat flux level of all of the Hands sensors does not exceed 0.50 cal/cm²•s. Confirm the standard deviation of the average heat flux level to be equal to or less than 0.50 cal/cm²•s for each nude Hands exposure, and if necessary, adjust the burners to obtain the exposure uniformity.

8.XX.5.3.3 Expose the nude Hands to the flames before testing a set of specimens and repeat the exposure at the conclusion of the testing of the set. If the average exposure heat flux for the test conditions differs by more than 5% between the before and after measurements, report this and give consideration to repeating the sequence of specimen tests. As a minimum, check the Hands exposure level at the beginning and at the end of the work day.

8.XX.5.3.4 Use a 3 seconds fire exposure for these calibrations, and monitor the fuel pressure of the supply line close to the burner fuel supply header. The measured absolute fuel pressure at this location shall not fall more than 10% during a single fire exposure. The duration of the fire exposure shall be controlled by the internal clock of the data acquisition system.

8.XX.5.3.5 The average heat flux calculated in 8.XX.5.3.1 shall be 2.0 cal/s•cm² ± 2.5%. If not, adjust the fuel flow rate by modifying the gas pressure or flow at the burner heads. Repeat the calibration run(s) until the specified value is obtained. Repeat nude calibrations shall only be conducted when no single sensor temperature exceeds 38°C (100°F) in order to minimize corrections required for nonlinear temperature dependent sensor response.
8.XX.5.3.6 The computer controlled data acquisition system shall be capable of recording the output from each sensor at least ten times per second during the calibration. The accuracy of the measurement system shall be less than 2% of the reading or ± 1.0°C (± 1.8°F) if a temperature sensor is used. Set the sampling rate during an exposure to provide a minimum of two readings for each sensor every second.

8.XX.5.3.7 Calibration of the fire exposure on the Hands shall be done as the first and last test for each test day. Report the results of this exposure as the average absorbed heat flux in cal/cm²•s and exposure duration in seconds. Also report the standard deviation of the Hands sensors, the area weighted percent of sensors indicating second-degree and third-degree burns, and the sum of these two values as a total percent burn.

8.XX.5.4 Defective sensor replacement - any defective sensor shall be replaced with a calibrated sensor prior to glove testing.

8.XX.6. Procedure

8.XX.6.1 Sensor Temperatures—Before starting an exposure ensure that the average temperature of all the sensors located under the test specimen are 32 ± 2°C (90 ± 4°F) and no single sensor exceeds 38°C (100°F)

8.XX.6.2 Dress the Hands —Dress the Hands with the test specimens. Arrange the gloves on the Hands in the way they are expected to be used by the end-user/wearer or as specified by the test author. All fingers/thumbs shall be installed on their respective hands. Note in the test report how the Hands are dressed. Use the same fit and placement of the gloves for each test to minimize variability in the test results. It is common that the wrist sensors might not covered by the gloves. If this is the case, a protective sleeve/insulation should be placed over the respective sensors for protection

8.XX.6.3 Record the Test Attributes—Record the information that relates to the test, including: Purpose of test, test series, glove identification, layering, fit on the Hands, glove style, number or pattern description, test conditions, test remarks, exposure duration, data acquisition time, persons observing the test, and any other information relevant to the test series.

8.XX.6.3 Burner Alignment - verify that burner alignment is correct as established in x.xx.x

8.XX.6.4 Hand Alignment - verify that the Hands are spatially positioned and aligned in the exposure chamber via a centering or alignment device.

8.XX.6.5 Set Test Parameters – enter into the burner management control system the specified exposure time and data acquisition time.

8.XX.6.5.1 The minimum data acquisition time shall be 60 seconds for all exposures with garments. The data acquisition time shall be long enough to ensure that all of the thermal energy stored in the gloves is no longer contributing to burn injury. Confirm that the acquisition time is sufficient by inspecting the calculated burn injury versus time information to determine that the total burn injury of all of the sensors has leveled off and is not continuing to rise at the end of the data acquisition time. If the amount of burn injury is not constant for the last 10 seconds of acquisition time, increase the time of acquisition to achieve this requirement.
8.XX.6.6 Confirm Safe Operation Conditions—follow the operating instructions in the computer program and fill in the fields on the safety screen to ensure that all of the safety requirements have been met and that it is safe to proceed with the garment exposure.

8.XX.6.7 Light Pilot Flames—when all of the safety requirements are met, light the pilot flames and confirm that all of the pilot flames on the burners that will be used in the test exposure are actually lit. Warning: Visually confirm the presence of each pilot flame in addition to the panel light or computer indication. The test exposure shall be initiated only when all of the safety requirements are met, the pilot flames are ignited and visually confirmed, and the final valve in the gas supply line is opened.

8.XX.6.8 Start Image Recording System—start the video or film system used to visually document each test.

8.XX.6.9 Expose the Test Gloves—initiate the test exposure by pressing the appropriate computer key. The computer program will start the data acquisition, open the burner gas supply solenoid valves for the time of the exposure, and stop the data acquisition at the end of the specified time.

8.XX.6.10 Acquire the Heat Transfer Data—collect the data from all installed thermal energy sensors. Note that data collection after the fire exposure shall be done in a quiescent environment.

8.XX.6.11 Record Garment Response Remarks—record observations of test gloves to the exposure. These remarks include but are not limited to the following: occurrence of after-flame (time, intensity and location), ignition, melting, smoke generation, unexpected glove or material failures, material shrinkage, and charring or observed degradation. These remarks become a permanent part of the test record.

8.XX.6.12 Initiate Test Report Preparation—initiate the computer program to perform the calculations to determine the amount of total burn injury and to prepare the test report. Perform these operations immediately or, if warranted delay them for later processing.

8.XX.6.13 Initiate Forced Air Exhaust System—start the forced air exhaust system to remove the combustion products and gasses produced from the fire exposure. Run the system long enough to ensure a safe working environment in the exposure chamber prior to entering.

8.XX.6.14 Prepare for the Next Test Exposure—carefully remove the exposed gloves from the Hands. Wipe the Hands and sensor surfaces with a damp cloth to remove residue from the test garment exposure. If the sensors are too hot, run the ventilating fan(s) to cool them so that the average temperature of all sensors is 32 ± 2°C (90 ± 4°F) and no single sensor exceeds 38°C (100°F). The Hands and sensors shall be inspected to ensure that they are free of any decomposition materials, and if a deposit is present, carefully clean the manikin and sensors with soap and water or a petroleum solvent. Use the gentlest method that is effective in cleaning the sensor. If required, repaint the surface of the sensor and dry the paint. Ensure that the manikin and sensors are dry, and if necessary, dry them, for example with the ventilating fan(s), before conducting the next test. Visually inspect the sensors for damage, e.g. cracks or discontinuities in the sensor surface.

8.XX.6.15 Sensor Replacement—repair or replace damaged or inoperative sensors. Calibrate repaired or replaced sensors before using.

8.XX.6.16 Test Remaining Specimens—test the remaining specimens at the same exposure conditions.
8.XX.7 Calculated Results

8.XX.7.1 Skin Burn Injury Prediction and determination of hand manikin sensor heat flux values.

8.XX.7.1.1 Convert the recorded thermal energy sensor responses at each time step into their respective time-dependent absorbed heat flux values in kW/m² (cal/s•cm²) using the method appropriate for the sensor.

8.XX.7.1.1 Discussion—Different laboratories use different sensor technologies in their manikins. Each requires a different method to convert the measured responses into respective absorbed heat flux values.

8.XX.7.2 Determination of the predicted skin and subcutaneous fat (adipose) internal temperature field.

8.XX.7.2.1 For all hand locations assume the thermal exposure is represented as a transient one dimensional heat diffusion problem in which the temperature within the skin and subcutaneous layers (adipose) varies with both position (depth) and time, and is described by the linear parabolic differential equation (Fourier’s Field Equation):

$$\rho C_p(x) \frac{\partial [T(x,t)]}{\partial t} = \frac{\partial [k(x) \frac{\partial [T(x,t)]}{\partial x}]}{\partial x} \quad (1)$$

where:

\[ \rho C_p(x) = \text{Volumetric heat capacity, J/m}^3\cdot\text{K (cal/cm}^3\cdot\text{K)} \]
\[ t = \text{Time, s} \]
\[ x = \text{Depth from skin surface, m [cm]} \]
\[ T(x,t) = \text{Temperature at depth x, time t, K} \]
\[ k(x) = \text{Thermal Conductivity, W/m}\cdot\text{K (cal/s}\cdot\text{cm}\cdot\text{K)} \]

8.XX.7.2.1.1 Discussion—Use of absolute temperatures is recommended when solving Eq 1 because Eq 2, which is used for the calculation of \( \Omega \), the burn injury parameter, requires absolute temperatures.

8.XX.7.2.2. Solve Eq 1 numerically using a sensor location specific skin model that takes into account the depth dependency of the thermal conductivity and volumetric heat capacity values as identified in Tables 8.XX.7.2.1 and 8.XX.7.2.2. Each of the layers shall be constant thickness, lying parallel to the surface.

<table>
<thead>
<tr>
<th>Sensor Location</th>
<th>Epidermis</th>
<th>Dermis</th>
<th>Subcutaneous Tissue</th>
<th>Bone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Palm</td>
<td>550</td>
<td>1100</td>
<td>3800</td>
<td></td>
</tr>
<tr>
<td>Back of Hand</td>
<td>85</td>
<td>965</td>
<td>600</td>
<td>3200</td>
</tr>
<tr>
<td>Property</td>
<td>Epidermis</td>
<td>Dermis</td>
<td>Subcutaneous Tissue</td>
<td>Bone</td>
</tr>
<tr>
<td>----------------------------------------------</td>
<td>--------------------</td>
<td>-------------------</td>
<td>---------------------</td>
<td>-------</td>
</tr>
<tr>
<td>Thermal Conductivity, k</td>
<td>0.6280 (0.0015)</td>
<td>0.5902 (0.00141)</td>
<td>0.2930 (0.0007)</td>
<td>0.3000 ()</td>
</tr>
<tr>
<td>(W/m•K)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(cal/s•cm•K)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Volumetric Heat Capacity, ρC&lt;sub&gt;p&lt;/sub&gt;</td>
<td>4.40x10&lt;sup&gt;6&lt;/sup&gt; (1.05)</td>
<td>4.186x10&lt;sup&gt;6&lt;/sup&gt; (1.00)</td>
<td>2.60x10&lt;sup&gt;6&lt;/sup&gt; (0.62)</td>
<td>2.619x10&lt;sup&gt;6&lt;/sup&gt; ()</td>
</tr>
<tr>
<td>(J/m&lt;sup&gt;2&lt;/sup&gt;•K)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(cal/cm&lt;sup&gt;2&lt;/sup&gt;•K)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

8XX.7.2.2 The discretization methods to solve Eq 1 that have been found effective are: the finite differences method (following the “combined method” central differences representation where truncation errors are expected to be second order in both Δt and Δx), finite elements method (for example the Galerkin method), and the finite volume method (sometimes called the control volume method).

(1) Discussion—Equally spaced depth intervals (Δx), denoted as “nodes” or “meshes”, are recommended for highest accuracy in all numerical models. A value for Δx of 15 x 10<sup>-6</sup> m has been found effective. Sparse or unstructured meshes are not recommended for use in the finite difference method.

8XX.7.2.3 Use the following initial and boundary conditions:

8XX.7.2.3.1 The initial temperature within the layers shall have a linear increase with depth from 305.65 K (32.5ºC) at the surface to 306.65 K (33.5ºC) at the back of the subcutaneous layer (adipose). The deep temperature shall be constant for all time at 306.65 K (33.5ºC).

(1) Discussion—Pennes (3) measured the temperature distributions in the forearms of volunteers. For the overall thickness of the skin and subcutaneous layers (adipose) listed in Table 8XX.7.2.2, the measured rise was 1 K (1ºC). The skin surface temperature of the volunteers in the experiments by Stoll and Greene (2) was kept very near to 305.65 K (32.5ºC).

(2) Discussion – Due to very thin subcutaneous values for the back of the hand a layer of bone was needed for the isothermal temperature boundary condition to be applied. A thickness of bone is specified so that these two areas of the hands have back layer tissue thicknesses similar to the subcutaneous layers of the other hand locations.

8XX.7.2.3.2 The absorbed heat flux is applied only at the skin surface and it is assumed that heat conduction is the only mode of heat transfer in the skin and subcutaneous layers (adipose). This calculation excludes any thermal radiation components that could penetrate the skin.

(1) Discussion—Assuming heat conduction only within the skin and deeper layers ignores enhanced heat transfer due to changing blood flow in the dermis and subcutaneous layers (adipose). The in vivo (living) values listed in Table 8XX.7.2.2 are back calculated from the experimental results of Stoll and Greene (2) and numerical extensions by Weaver and Stoll (4). The values account to a large degree for the blood flow in the test subjects.
8XX.7.2.3.3 The absorbed heat flux at the skin surface at time \( t = 0 \) (start of the exposure) is zero (0).

8XX.7.2.3.4 The absorbed heat flux values at the skin surface at all times \( t > 0 \) are the time dependent absorbed heat flux values determined in 8XX.7.1.1. No corrections are made for radiant heat losses or emissivity/absorptivity differences between the sensors and the skin surface used in the model.

8XX.7.2.4 Calculate an associated internal temperature field for the skin model at each sensor sampling time interval for the entire sampling time by applying each of the sensor’s time-dependent heat flux values to individual skin modeled surfaces (a skin model is evaluated for each measurement sensor). These internal temperature fields shall include, as a minimum, the calculation of temperature values at the surface (depth = 0.0 m), at the skin model epidermis/dermis interface (used to predict second-degree burn injury), and the skin model dermis/subcutaneous interface (used to predict a third-degree burn injury).

8XX.7.3 Determination of the Predicted Skin Burn Injury:

8XX.7.3.1 The Damage Integral Model of Henriques (5), Eq 2, is used to predict skin burn injury parameter based on skin temperature values at each measurement time interval at skin model depths of 75 × 10^{-6} m (second-degree burn injury prediction) and 1200 × 10^{-6} m (third-degree burn injury prediction).

\[
\Omega = \int Pe^{-\frac{(\Delta E/RT)}{t}}dt \tag{2}
\]

where:

\( \Omega \) = Burn Injury Parameter; Value, \( \geq 1 \) indicates predicted burn injury

\( t \) = time of exposure and data collection period, s

\( P \) = Pre-exponential term, dependent on depth and temperature, 1/s

\( \Delta E \) = Activation energy, dependent on depth and temperature, J/kmol

\( R \) = Universal gas constant, 8314.5 J/mol • K

\( T \) = Temperature at specified depth (in kelvin) K

8XX.7.3.2 Determine the second-degree and third-degree burn injury parameter values, \( \Omega \)'s, by numerically integrating Eq 2 using the closed composite, extended trapezoidal rule or Simpson’s rule, for the total time that data was gathered.

8XX.7.3.3 The integration is performed at each measured time interval for each sensor at the second-degree and third-degree skin depths (epidermis/dermis interface and dermis/subcutaneous interface depths, respectively) when the temperature, \( T \), is \( \geq 317.15 \) K (44°C). (See Table 8XX.7.2.1)

8XX.7.3.4 A second-degree burn injury occurs when the value of \( \Omega \geq 1.0 \) for depths \( \geq \) epidermis/dermis interface depth and < the dermis/subcutaneous interface depth. (Table 8XX.7.2.1).
8XX.7.3.5 A third-degree burn injury occurs when the value of $\Omega \geq 1.0$ for depths $\geq$ the dermis/subcutaneous interface depth (Table 8XX.7.2.1).

8XX.7.3.6 For the second-degree and third-degree burn injury predictions, the temperature dependent values for $P$ and $\Delta E/R$ are listed in Table 8XX.7.3.

**TABLE 8XX.7.3 Constants for Calculation of Omega Using Eq 2**

<table>
<thead>
<tr>
<th>Skin Injury</th>
<th>Temperature Range</th>
<th>$P$ $\times 10^{12}$ s$^{-1}$</th>
<th>$\Delta E/R$ K</th>
</tr>
</thead>
<tbody>
<tr>
<td>Second-degree (4)</td>
<td>$317.15 \leq T \leq 323.15$ K ($44^\circ$C $\leq T \leq 50$°C)</td>
<td>$2.185 \times 10^{12}$ s$^{-1}$</td>
<td>93 534.9 K</td>
</tr>
<tr>
<td></td>
<td>$T &gt; 323.15$ K ($T &gt; 50$°C), use:</td>
<td>$1.823 \times 10^{11}$ s$^{-1}$</td>
<td>39 109.8 K</td>
</tr>
<tr>
<td>Third-degree (9)</td>
<td>$317.15 \leq T \leq 323.15$ K ($44^\circ$C $\leq T \leq 50$°C)</td>
<td>$4.322 \times 10^{14}$ s$^{-1}$</td>
<td>50 000 K</td>
</tr>
<tr>
<td></td>
<td>$T &gt; 323.15$ K ($T &gt; 50$°C), use:</td>
<td>$9.389 \times 10^{10}$ s$^{-1}$</td>
<td>80 000 K</td>
</tr>
</tbody>
</table>

8XX.7.4 Skin burn injury test cases

8XX.7.4.1 The calculation method used in 8XX.7.2 and 8XX.7.3 shall meet the validation requirements identified in Table 8XX.7.4 when using the skin thickness values specific for the Wrist/Forearm portion of the manikin from Table 8XX.7.2.1 (75 µm, 1225 µm, and 3885 µm).

**TABLE 8XX.7.4 Skin Model Validation Data SetA**

<table>
<thead>
<tr>
<th>Absorbed Exposure Heat Flux (constant for the exposure)</th>
<th>Exposure Duration</th>
<th>Required Size of Time Step</th>
</tr>
</thead>
<tbody>
<tr>
<td>W/m$^2$</td>
<td>(cal/s•cm$^2$)</td>
<td>s</td>
</tr>
<tr>
<td>3935</td>
<td>(0.094)</td>
<td>35.9</td>
</tr>
<tr>
<td>5903</td>
<td>(0.141)</td>
<td>21.09</td>
</tr>
<tr>
<td>11 805</td>
<td>(0.282)</td>
<td>8.30</td>
</tr>
<tr>
<td>15 740</td>
<td>(0.376)</td>
<td>5.55</td>
</tr>
<tr>
<td>23 609</td>
<td>(0.564)</td>
<td>3.00</td>
</tr>
<tr>
<td>31 479</td>
<td>(0.752)</td>
<td>1.95</td>
</tr>
<tr>
<td>39 348</td>
<td>(0.940)</td>
<td>1.41</td>
</tr>
<tr>
<td>47 218</td>
<td>(1.128)</td>
<td>1.08</td>
</tr>
</tbody>
</table>
Skin models using the absorbed heat flux and exposure times in Table 8XX.7.4, along with the thickness values specific to the Wrist/Forearm in Table 8XX.7.2.1 (75 µm, 1225 µm, and 3885 µm) shall result in values of $1 \pm 0.10$ for all test cases at the epidermis/dermis interface at the time when the interface temperature has cooled to or below 317.15 K (44ºC). The skin layer properties listed in Table 8XX.7.2.2 and the calculation constants in Table 8XX.7.3 shall be used for these calculations. In addition, the time when $\Omega = 1$ shall never be less than the exposure duration listed. This latter requirement is to keep the prediction consistent with the observations of Stoll and Greene (2). Note that the parameter, $\Omega$, is a cumulative value and having epidermis/dermis interface temperatures lower than 317.15 K (44ºC) does not produce negative values that are subtracted.

8XX.7.4.2 When validating the skin burn injury model, use the layer thickness specific to the Wrist/Forearm in Table 8XX.7.2.1 (75 µm, 1225 µm, and 3885 µm), the thermal conductivity and volumetric heat capacity values specified in Table 8XX.7.2.2, and the boundary and initial conditions of 8XX.7.2.3 with the exception that the exposure heat fluxes in 8XX.7.2.4 become the constant valued ones listed in Table 8XX.7.4. The total calculation time shall be chosen so that the temperatures at the epidermis/dermis and dermis/subcutaneous interfaces both fall below 317.15 K (44ºC) during the cooling phase. For these test cases the skin surface shall be assumed to be adiabatic during the cooling phase, that is, no heat losses from the surface during cooling. Minor changes in the values of thermal conductivity and volumetric heat capacity listed in Table 8XX.7.2.2 are permitted providing the validation requirements specified in Table 8XX.7.4 are met with one set of values for all twelve test cases.

8XX.7.4.2.1 Discussion—The adiabatic boundary condition during cooling is selected because of the lack of detail in the published documents on the orientation of the forearms and the proximity of surrounding equipment used to conduct the experiments. Furthermore, the data gathered from the thermal energy sensors when conducting this test method takes into account convection and radiation heat losses inherently through the calculation of the net energy absorbed by the thermal energy sensors. Therefore this adiabatic assumption only applies to the model validation data set and not the entire test method.

8X.7.5 Calculated Results—for all glove evaluation and specification test reports, include results of the computer program. Base the predicted burn injury on the total area of the Hands containing sensors and on the total area of the Hands covered by the test gloves.

1) Total area (%) of Hands containing sensors.

1a) Hands area of second-degree burn injury (%).

1b) Hands area of third-degree burn injury (%).
1c) Total Hands area of burn injury (sum of second- and third-degree burn injury) (%), and associated variation statistic.

2) Total area (%) of Hands covered by the test gloves.

2a) Covered area of second-degree burn injury (%).

2b) Covered area of third-degree burn injury (%)

3) Other calculated information used in assessing performance.

3a) Diagram of the Hands showing location and burn injury levels as second-degree and third-degree areas.

8.XX.8 Report

8.XX.8.1 State that the specimens were tested as directed in Test Method xxx. Describe the material sampled, the method of sampling used, and any deviations from the method.

8.XX.8.1.1 In the material description include for each glove layer: glove type, size, fabric weight, fiber type, color, and non-standard or special glove features and design characteristics.

8.XX.8.2 Report the information in 8.XX.7.3–8.XX.7.6

8.XX.8.3 Type of Test—material of construction evaluation, glove design evaluation, or end-use glove evaluation.

8.XX.8.4 Exposure Conditions—the information that describes the exposure conditions, including:

8.XX.8.4.1 The average of the exposure heat flux and the standard deviation of the average heat flux from all sensors determined from the nude exposures taken before and after each test series.

8.XX.8.4.2 The nominal heat flux, the duration of the exposure, and the duration of the data acquisition time for each test.

8.XX.8.4.3 The temperature and relative humidity in the room where the gloves were held prior to testing.

8.XX.8.4.4 Any other information relating to the exposure conditions shall be included to assist in interpretation of the test specimen results.

8.XX.69 Interpretation

8.XX.9.1 Pass or fail determinations shall be based on the average total covered area second and third-degree burn injury (%) <50%.
8.9 Whole Shroud/Hood/Balaclava Thermal Protection Performance Test.

8.9.1 Application.
This test method shall apply to a protective shroud/hood/balaclava as exposed to short duration thermal exposure resulting from a fire.

8.9.2 Samples.
One set of a shroud/hood/balaclava shall be provided, size TBD.

8.9.3 Specimens.
Five specimens shall be tested.

8.9.4 Apparatus.

8.9.4.1 Instrumented Head.
One head with specified dimensions (TBD) shall be used.

8.9.4.1.1 Size and Shape.
The head dimensions shall correspond to those required for size (TBD) of the shroud/hood/balaclava because deviations in fit will affect the results.

8.9.4.1.2 The head shall be constructed of flame resistant, thermally stable, nonmetallic materials that will not contribute fuel to the combustion process. A flame resistant, thermally stable, glass fiber–reinforced vinyl ester resin at least 3 mm (\(\frac{1}{8}\) in.) thick has proven effective.

8.9.4.2 Apparatus for Burn Injury Assessment.

8.9.4.2.1 Head Construction.
A minimum of 22 thermal energy sensors shall be used per head. They shall be distributed as uniformly as possible within each area on the head.

8.9.4.2.2 Thermal Energy Sensors.
Each sensor shall have the capacity to measure the incident heat flux over a range from 0.0 to 165 kW/m^2 (0.0 to 4.0 cal/cm^2 •s). This range permits the use of the sensors to set the exposure level by directly exposing the instrumented head to the controlled flash fire in a test without the shroud/hood/balaclava. Sensors will also have the capability to measure the heat transfer to the head when covered with test shroud/hood/balaclava or protective shroud/hood/balaclava ensemble.

8.9.4.2.2.1 The sensors shall be constructed of a material with known thermal and physical characteristics that can be used to indicate the time varying heat flux received by the sensors. One type of sensor that has been used successfully is a copper slug calorimeter. The minimum response time for the sensors shall be ≤ 0.1 seconds. Coating the sensor with a thin layer of flat black, high temperature paint \(1\) with an absorptivity of at least 0.9 \(\frac{16}{16}\) has been found effective. The outer surface shall have an emissivity of at least 0.9.

8.9.4.2.2.2 The calibration determined for each sensor shall be recorded, and the most recent calibration results shall be used to carry out the burn injury analysis.

8.9.4.3 Thermal Energy (Heat Flux) Calibration Sensor.
Use a NIST traceable heat flux measuring device to calibrate the energy source used to calibrate the thermal energy (heat flux) sensors. A permanent record shall be kept of the sensor calibrations during their operating life.

8.9.4.4 Data Acquisition System.
A system shall be provided with the capability of acquiring and storing the results of the measurement from each sensor at least 10 times per second for the data acquisition period.

8.9.4.5 Burn Assessment Program.
Computer software that has the capability of receiving the output of the thermal sensors shall be used to calculate the time dependent surface heat flux. The software shall predict second- and third-degree burn injuries for each sensor using the skin burn injury model and determine the total predicted burn injury area as a result of the simulated flash fire exposure.
8.9.4.5 Incident Heat Calculation.
The average heat flux to the surface of the head shall be determined by exposing the nude head for 3 seconds. The total and average values of all sensors shall be determined taking into account the sensor calibrations and characteristics. The values calculated for each sensor at each time step shall be placed in a file for future use in estimating the temperature history within human skin for the burn injury calculation.

8.9.4.5.2 Burn Injury Calculation.
The predicted time necessary to cause second- and third-degree burn injuries for each sensor shall be calculated.

8.9.4.5.3 Burn Injury Assessment.
The sum of the areas represented by the sensors that received sufficient heat to result in a predicted second-degree burn shall be the predicted second-degree percentage burn area assessment. The sum of the area represented by the sensors that received sufficient heat to result in a predicted third-degree burn shall be the predicted third-degree percentage burn area assessment. The sum of these two areas shall be the total predicted percentage of burn injury resulting from the exposure to the flash fire condition. The sum of all sensors shall represent 100 percent of the head.

8.9.4.6 Exposure Chamber.
A ventilated, fire-resistant enclosure with viewing windows and access door(s) shall be provided to contain the head and exposure apparatus.

8.9.4.6.1 Exposure Chamber Size.
The chamber size shall be sufficient to provide a uniform flame exposure over the surface of the test shroud/hood/balaclava s and shall have sufficient space to allow safe movement around the head for dressing without accidentally jarring and displacing the burners.

8.9.4.6.2 Burner and Manikin Alignment.
Apparatus and procedures for checking the alignment of the burners and head position prior to each test shall be available.

8.9.4.6.3 Chamber Air Flow.
The chamber shall be isolated from air movement other than the natural air flow required for the combustion process so that the pilot flames and exposure flames are not affected before and during the test exposure and data acquisition periods. A forced air exhaust system for rapid removal of combustion gas products after the data acquisition period shall be provided.

8.9.4.6.4 Chamber Safety Devices.
The exposure chamber shall be equipped with sufficient safety devices, detectors, and suppression systems to provide safe operation of the test apparatus. These safety devices, detectors, and suppression systems include propane gas detectors, motion detectors, door closure detectors, head held fire extinguishers, and any other devices necessary.

8.9.4.7 Fuel Delivery System.
A system of piping, pressure regulators, valves, and pressure sensors including a double block and bleed burner management scheme, (see NFPA 58), or similar system consistent with local codes shall be provided to safely deliver gaseous propane to the ignition system and exposure burners. This delivery system shall be sufficient to provide an average heat flux of at least 2.0 cal/s•cm² for an exposure time of at least 3 seconds. Fuel delivery shall be controlled to provide known exposure duration within ± 0.1 seconds of the set exposure time.

8.9.4.7.1 Fuel.
The propane gas used in the system shall be from a liquid propane supply with sufficient purity and constancy to provide a uniform flame from the exposure burners. It is recommended that the fuel meet the HD-5 specifications. (See Specification D1835, CAN/CGSB 3.14 M88, or equivalent.)

8.9.4.7.2 Burner System.
The burner system shall consist of one ignition pilot flame for each exposure burner, and sufficient burners to provide the required range of heat fluxes with a flame distribution uniformity to meet the requirements in 10.3.2.

8.9.4.7.3 Exposure Burners.
Large, induced-combustion air, industrial-style, propane burners are positioned around the head to produce a uniform laboratory simulation of a fire. These burners produce a large fuel rich reddish-yellow flame. If necessary, enlarge the burner gas jet, or remove it, to yield a fuel to air mixture for a long luminous reddish-yellow flame that engulfs the head. A minimum of four burners has been shown to yield the exposure level and uniformity as described in 8.9.5.3.5.
8.9.4.7.3.1 Ignition Pilot Flame.
Each exposure burner shall be equipped with a pilot flame positioned near the exit of the burner, but not in the direct path of the flames to interfere with the exposure flame pattern. The pilot flame shall be interlocked to the burner gas supply valves to prevent premature or erroneous opening of these valves.

8.9.4.8 Image Recording System.
A system for recording a visual image of the head before, during, and after the flame exposure shall be provided.

8.9.4.9 Safety Check List.
A checklist shall be included in the computer program to ensure that all safety features have been satisfied before the flame exposure can occur. The procedural safety checks shall be documented. This list shall include, but is not limited to, the following:

1. Confirm that the head has been properly dressed in the test garment.
2. Confirm that the chamber doors are closed.
3. Confirm that no person is in the burn chamber.
4. Confirm that safety requirements are met.

8.9.4.10 Garment Conditioning Area.
The area shall be maintained at 21 ± 2°C (70 ± 5°F) and 65 ± 5 percent relative humidity. It shall be large enough to have good air circulation around the test specimens.

8.9.5 Preparation and Calibration of Apparatus.
8.9.5.1 Preparation of Apparatus.
8.9.5.1.1 Exposing the instrumented head to a fire exposure in a safe manner and evaluating the test specimen requires a startup and exposure sequence that is specific to the test apparatus. Depending on the individual apparatus, some of the steps listed require manual execution; others are initiated by the computer. Perform the steps as specified in the apparatus operating procedure. Some of the steps that shall be included are the following:

8.9.5.1.2 Burn chamber purging: Ventilate the chamber for a time sufficient to remove a volume of air at least 10 times the volume of the chamber. The degree of ventilating the chamber shall be at a minimum comply with NFPA 86.

8.9.5.1.3 Gas line charging: The following procedure or a comparable procedure shall be used for gas line charging. Close the supply line vent valves and open the valves to the fuel supply to charge the system with propane gas at the operating pressure up to, but not into, the chamber. Charge and initiate the pilots first, before charging the header in the exposure chamber for the torches.

8.9.5.1.4 Confirmation of exposure conditions: Using the procedure that follows, expose the Pyrohead® to the test fire for 3 seconds. Confirm that the calculated heat flux standard deviation is not greater than 0.50 cal/cm² • s and the exposure is within ± 2.5 percent of the specified test condition. If the calculated heat flux or standard deviation is not within these specifications, determine the cause of the deviations and correct before proceeding with garment testing.

8.9.5.2 Calibration of Sensor and Data System.
8.9.5.2.1 Calibration Principles.
Thermal energy sensors are used to measure the fire exposure intensity and the thermal energy transferred to the manikin during the exposure. Calibrate the individual sensors performance against a suitable NIST or other recognized standards body traceable reference. Calibrate to the exposure and heat transfer conditions experienced during test setup and garment testing, typically over a range of 0.07 cal/cm² • s to 3.0 cal/cm² • s.

8.9.5.2.1.1 Verify the heat fluxes produced by the calibration device to within ± 2.5 percent of the required exposure level with the heat flux calibration sensor.
8.9.5.2.2
Test the thermal energy sensors used in the manikin to ensure that the heat flux response is accurate over the range of heat fluxes produced by the exposure and under the test specimen. If the response is linear but not within 2.5 percent of the known calibration exposure energy, include a correction factor in the heat flux calculations. If the response is not linear and within 2.5 percent of the known calibration exposure energy, determine a correction factor curve for each sensor for use in the heat flux calculations.

8.9.5.3

8.9.5.3.1
Measure the intensity and uniformity of the fire exposure by exposing the nude head to the flames. Software capable of converting the measured data into time varying surface heat fluxes at each sensor is required. Calculate the average heat flux over the steady region as shown in Figure 8.9.5.3.1 during the exposure for each sensor. Calculate the area weighted average of these values and the standard deviation. The weighted average is the average exposure heat flux level for the test conditions, and the standard deviation is a measure of the exposure uniformity.

Figure 8.9.5.3.1 Average Heat Flux Determination for a Nude Exposure.

8.9.5.3.2
Position the exposure burners and adjust the flames so that the standard deviation of the average exposure heat flux level of all of the head sensors does not exceed 0.50 cal/cm$^2$ s. Confirm the standard deviation of the average heat flux level to be equal to or less than 0.50 cal/cm$^2$ s for each nude head exposure, and if necessary, adjust the burners to obtain the exposure uniformity.

8.9.5.3.3
Expose the nude head to the flames before testing a set of specimens and repeat the exposure at the conclusion of the testing of the set. If the average exposure heat flux for the test conditions differs by more than 5 percent between the before and after measurements, report this and consider repeating the sequence of specimen tests. As a minimum, check the head exposure level at the beginning and at the end of the workday.

8.9.5.3.4
Use a 3-second fire exposure for these calibrations, and monitor the fuel pressure of the supply line close to the burner fuel supply header. The measured absolute fuel pressure at this location shall not fall more than 10 percent during a single fire exposure. The duration of the fire exposure shall be controlled by the internal clock of the data acquisition system.

8.9.5.3.5
The average heat flux calculated in 8.9.5.3.1 shall be 2.0 cal/s cm$^2$ ± 2.5 percent. If not, adjust the fuel flow rate by modifying the gas pressure or flow at the burner head. Repeat the calibration run(s) until the specified value is obtained. Repeat nude calibrations shall be conducted only when no single sensor temperature exceeds 38°C (100°F) in order to minimize corrections required for nonlinear temperature dependent sensor response.

8.9.5.3.6
The computer controlled data acquisition system shall be capable of recording the output from each sensor at least 10 times per second during the calibration. The accuracy of the measurement system shall be less than 2 percent of the reading or ± 1.0°C (± 1.8°F) if a temperature sensor is used. Set the sampling rate during an exposure to provide a minimum of two readings for each sensor every second.

8.9.5.3.7
Calibration of the fire exposure on the head shall be done as the first and last test for each test day. Report the results of this exposure as the average absorbed heat flux in cal/cm2s and exposure duration in seconds. Also, report the standard deviation of the head sensors, the area weighted percent of sensors indicating second- and third-degree burns, and the sum of these two values as a total percent burn.

8.9.5.4 Defective Sensor Replacement.

Any defective sensor shall be replaced with a calibrated sensor prior to shroud/hood/balaclava testing.

8.9.6 Procedure.

8.9.6.1 Sensor Temperatures.

Before starting an exposure, ensure that the average temperature of all the sensors located under the test specimen are $32 ± 2°C (90 ± 4°F)$ and that no single sensor exceeds 38°C (100°F).
8.9.6.2 Dress the Hands.
Dress the head with the test specimens. Arrange the shroud/hood/balaclava on the head in the way they are expected to be used by the end-user/wearer or as specified by the test author. Note in the test report how the head is dressed. Use the same fit and placement of the shroud/hood/balaclava for each test to minimize variability in the test results.

8.9.6.3 Record the Test Attributes.
Record the information that relates to the test, including purpose of test, test series, shroud/hood/balaclava identification, layering, fit on the head, shroud/hood/balaclava style, number or pattern description, test conditions, test remarks, exposure duration, data acquisition time, persons observing the test, and any other information relevant to the test series.

8.9.6.4 Burner Alignment.
Verify that burner alignment is correct as established in x.xx.x.

8.9.6.5 Head Alignment.
Verify that the head is spatially positioned and aligned in the exposure chamber via a centering or alignment device.

8.9.6.6 Set Test Parameters.
Enter into the burner management control system the specified exposure time and data acquisition time.

8.9.6.6.1 The minimum data acquisition time shall be 60 seconds for all exposures with garments. The data acquisition time shall be long enough to ensure that none of the thermal energy stored in the shroud/hood/balaclava is contributing to burn injury. Confirm that the acquisition time is sufficient by inspecting the calculated burn injury versus time information to determine that the total burn injury of all of the sensors has leveled off and is not continuing to rise at the end of the data acquisition time. If the amount of burn injury is not constant for the last 10 seconds of acquisition time, increase the time of acquisition to achieve this requirement.

8.9.6.7 Confirm Safe Operation Conditions.
Follow the operating instructions in the computer program and fill in the fields on the safety screen to ensure that all of the safety requirements have been met and that it is safe to proceed with the garment exposure.

8.9.6.8 Light Pilot Flames.
When all of the safety requirements are met, light the pilot flames and confirm that all of the pilot flames on the burners that will be used in the test exposure are actually lit. Warning: Visually confirm the presence of each pilot flame in addition to the panel light or computer indication. The test exposure shall be initiated only when all of the safety requirements are met, the pilot flames are ignited and visually confirmed, and the final valve in the gas supply line is opened.

8.9.6.9 Start Image Recording System.
Start the video or film system used to visually document each test.

8.9.6.10 Expose the Test Shroud/Hood/Balaclava.
Initiate the test exposure by pressing the appropriate computer key. The computer will start the data acquisition, open the burner gas supply solenoid valves for the time of the exposure, and stop the data acquisition at the end of the specified time.

8.9.6.11 Acquire the Heat Transfer Data.
Collect the data from all installed thermal energy sensors. Note that data collection after the fire exposure shall be done in a quiescent environment.

8.9.6.12 Record Garment Response Remarks.
Record observations of test shroud/hood/balaclava to the exposure. These remarks include but are not limited to the following: occurrence of afterflame (time, intensity, and location), ignition, melting, smoke generation, unexpected shroud/hood/balaclava or material failures, material shrinkage, and charring or observed degradation. These remarks become a permanent part of the test record.

8.9.6.13 Initiate Test Report Preparation.
Initiate the computer program to perform the calculations to determine the amount of total burn injury and to prepare the test report. Perform these operations immediately or, if warranted, delay them for later processing.

8.9.6.14 Initiate Forced Air Exhaust System.
Start the forced air exhaust system to remove the combustion products and gasses produced from the fire exposure. Run the system long enough to ensure a safe working environment in the exposure chamber prior to entering.
8.9.6.15 Prepare for the Next Test Exposure.
Carefully remove the exposed shroud/hood/balaclava from the head. Wipe the head and sensor surfaces with a damp cloth to remove residue from the test garment exposure. If the sensors are too hot, run the ventilating fan(s) to cool them so that the average temperature of all sensors is 32 ± 2°C (90 ± 4°F) and no single sensor exceeds 38°C (100°F). The head and sensors shall be inspected to ensure that they are free of any decomposition materials, and if a deposit is present, carefully clean the manikin and sensors with soap and water or a petroleum solvent. Use the gentlest method that is effective in cleaning the sensor. If required, repaint the surface of the sensor and dry the paint. Ensure that the manikin and sensors are dry, and if necessary dry them, for example with the ventilating fan(s), before conducting the next test. Visually inspect the sensors for damage, e.g., cracks or discontinuities in the sensor surface.

8.9.6.16 Sensor Replacement.
Repair or replace damaged or inoperative sensors. Calibrate repaired or replaced sensors before using.

8.9.6.17 Test Remaining Specimens.
Test the remaining specimens at the same exposure conditions.

8.9.7 Calculated Results.
8.9.7.1 Skin Burn Injury Prediction and Determination of Head Manikin Sensor Heat Flux Values.
8.9.7.1.1 Convert the recorded thermal energy sensor responses at each time step into their respective time-dependent absorbed heat flux values in kW/m² (cal/s•cm²) using the method appropriate for the sensor.

8.9.7.1.1.1 Discussion.
Different laboratories use different sensor technologies in their manikins. Each requires a different method to convert the measured responses into respective absorbed heat flux values.

8.9.7.2 Determination of the predicted skin and subcutaneous fat (adipose) internal temperature field.
8.9.7.2.1 For all hand locations, assume the thermal exposure is represented as a transient, one-dimensional heat diffusion problem in which the temperature within the skin and subcutaneous layers (adipose) varies with both position (depth) and time (see Table 8.9.7.2.1), and is described by the linear parabolic differential equation (Fourier’s Field Equation):

\[
\rho C_p(x) \frac{\partial T(x,t)}{\partial t} = k(x) \frac{\partial [T(x,t)]}{\partial x} \quad \text{[8.9.7.2.1]}
\]

where:
\(\rho C_p(x)\) = Volumetric heat capacity, J/m³•K (cal/cm³•K)
\(\frac{\partial}{\partial t}\) = Time in sec
\(x\) = Depth from skin surface, m [cm]
\(T(x,t)\) = Temperature at depth x, time t, K
\(k(x)\) = Thermal conductivity, W/m•K (cal/s•cm•K)

Table 8.9.7.2.1 Model Thickness Values for Sensor Locations on Head Manikin (in µm)

<table>
<thead>
<tr>
<th>Sensor Location</th>
<th>Epidermis</th>
<th>Dermis</th>
<th>Subcutaneous Tissue</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cranium</td>
<td>70</td>
<td>1430</td>
<td>3400</td>
</tr>
<tr>
<td>Temple</td>
<td>50</td>
<td>1800</td>
<td>3400</td>
</tr>
<tr>
<td>Ears</td>
<td>50</td>
<td>750</td>
<td>600</td>
</tr>
<tr>
<td>Cheek</td>
<td>85</td>
<td>1665</td>
<td>4000</td>
</tr>
<tr>
<td>Neck</td>
<td>85</td>
<td>1765</td>
<td>9900</td>
</tr>
<tr>
<td>Forehead</td>
<td>75</td>
<td>1675</td>
<td>3400</td>
</tr>
<tr>
<td>Eyelids</td>
<td>50</td>
<td>550</td>
<td>600</td>
</tr>
<tr>
<td>Chin</td>
<td>85</td>
<td>1865</td>
<td>1300</td>
</tr>
</tbody>
</table>

8.9.7.2.1.1 Discussion.
Use of absolute temperatures is recommended when solving Eq 8.9.7.2.1 because Eq 8.9.7.3.1, which is used for the calculation of \(\Omega\), the burn injury parameter, requires absolute temperatures.
Solve Eq 8.9.7.2.1 numerically using a sensor location specific skin model that takes into account the depth dependency of the thermal conductivity and volumetric heat capacity values as identified in Table 8.9.7.2.1 and Table 8.9.7.2.2.1. Each of the layers shall be constant thickness, lying parallel to the surface.

The discretization methods to solve Eq 8.9.7.2.1 that have been found effective are the finite differences method (following the “combined method” — central differences representation where truncation errors are expected to be second order in both $\Delta t$ and $\Delta x$), finite elements method (for example, the Galerkin method), and the finite volume method (sometimes called the control volume method).

Table 8.9.7.2.2.1 Thermo Physical Properties for Each Layer of Model

<table>
<thead>
<tr>
<th>Property</th>
<th>Epidermis</th>
<th>Dermis</th>
<th>Subcutaneous Tissue</th>
<th>Bone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal Conductivity, $k$ W/m$\cdot$K (cal/s$\cdot$cm$\cdot$K)</td>
<td>0.6280 (0.0015)</td>
<td>0.5902 (0.00141)</td>
<td>0.2930 (0.0007)</td>
<td>—</td>
</tr>
<tr>
<td>Volumetric Heat Capacity, $\rho C_p$ J/m$^2$$\cdot$K$^2$ (cal/cm$^2$$\cdot$K)</td>
<td>4.40 x 10$^6$ (1.05)</td>
<td>4.186 x 10$^6$ (1.00)</td>
<td>2.60 x 10$^6$ (0.62)</td>
<td>—</td>
</tr>
</tbody>
</table>

Equally spaced depth intervals ($\Delta x$), denoted as nodes or meshes, are recommended for highest accuracy in all numerical models. A value for $\Delta x$ of $15 \times 10^{-6}$ m has been found effective. Sparse or unstructured meshes are not recommended for use in the finite difference method.

Use the following initial and boundary conditions:

1. The initial temperature within the layers shall have a linear increase with depth from 305.65 K (32.5°C) at the surface to 306.65 K (33.5°C) at the back of the subcutaneous layer (adipose). The deep temperature shall be constant for all time at 306.65 K (33.5°C).

2. Pennes measured the temperature distributions in the forearms of volunteers. For the overall thickness of the skin and subcutaneous layers (adipose) listed in Table 8.9.7.2.2.1, the measured rise was 1 K (1°C). The skin surface temperature of the volunteers in the experiments by Stoll and Greene was kept very near to 305.65 K (32.5°C).

3. Due to very thin subcutaneous values for the back of the hand, a layer of bone was needed for the isothermal temperature boundary condition to be applied. A thickness of bone is specified so that these two areas of the hands have back layer tissue thicknesses similar to the subcutaneous layers of the other hand locations.

The absorbed heat flux is applied only at the skin surface and it is assumed that heat conduction is the only mode of heat transfer in the skin and subcutaneous layers (adipose). This calculation excludes any thermal radiation components that could penetrate the skin.

Assuming heat conduction only within the skin and deeper layers ignores enhanced heat transfer due to changing blood flow in the dermis and subcutaneous layers (adipose). The in vivo (living) values listed in 8.9.7.1.1 are back calculated from the experimental results of Stoll and Greene and numerical extensions by Weaver and Stoll (4). The values account to a large degree for the blood flow in the test subjects.

The absorbed heat flux at the skin surface at time $t = 0$ (start of the exposure) is zero (0).

The absorbed heat flux values at the skin surface at all times $t > 0$ are the time dependent absorbed heat flux values determined in 8.9.7.1.1. No corrections are made for radiant heat losses or emissivity/absorptivity differences between the sensors and the skin surface used in the model.
The absorbed heat flux values at the skin surface at all times $t > 0$ are the time dependent absorbed heat flux values determined in 8.9.7.1.1. No corrections are made for radiant heat losses or emissivity/absorptivity differences between the sensors and the skin surface used in the model.

Calculate an associated internal temperature field for the skin model at each sensor sampling time interval for the entire sampling time by applying each of the sensor’s time-dependent heat flux values to individual skin modeled surfaces (a skin model is evaluated for each measurement sensor). These internal temperature fields shall include, as a minimum, the calculation of temperature values at the surface ($\text{depth} = 0.0 \text{ m}$), at the skin model epidermis/dermis interface (used to predict second-degree burn injury), and the skin model dermis/subcutaneous interface (used to predict a third-degree burn injury).

### Determination of the Predicted Skin Burn Injury

#### Table 8.9.7.3 Constants for Calculation of Omega Using Eq 8.9.7.3.1

<table>
<thead>
<tr>
<th>Skin Injury</th>
<th>Temperature Range</th>
<th>$P$</th>
<th>$\Delta E/R$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Second-degree (4)</td>
<td>$317.15 \text{ K} \leq T \leq 323.15 \text{ K}$ (44°C $\leq T \leq 50$°C)</td>
<td>$2.185 \times 10^{124} \text{ s}^{-1}$</td>
<td>$93534.9 \text{ K}$</td>
</tr>
<tr>
<td></td>
<td>$T &gt; 323.15 \text{ K}$ ($T &gt; 50$°C), use:</td>
<td>$1.823 \times 10^{51} \text{ s}^{-1}$</td>
<td>$39109.8 \text{ K}$</td>
</tr>
<tr>
<td>Third-degree (9)</td>
<td>$317.15 \text{ K} \leq T \leq 323.15 \text{ K}$ (44°C $\leq T \leq 50$°C)</td>
<td>$4.322 \times 10^{64} \text{ s}^{-1}$</td>
<td>$50000 \text{ K}$</td>
</tr>
<tr>
<td></td>
<td>$T &gt; 323.15 \text{ K}$ ($T &gt; 50$°C), use:</td>
<td>$9.389 \times 10^{104} \text{ s}^{-1}$</td>
<td>$80000 \text{ K}$</td>
</tr>
</tbody>
</table>

8.9.7.3.1 The Damage Integral Model of Henriques (5), Eq 8.9.7.3.1, is used to predict skin burn injury parameters based on skin temperature values at each measurement time interval at skin model depths of $75 \times 10^{-6}$ m (second-degree burn injury prediction) and $1200 \times 10^{-6}$ m (third-degree burn injury prediction).

$$\Omega = \int Pe^{-\frac{(\Delta E)}{RT}} dt$$  \[8.9.7.3.1\]

where:

- $\Omega = \text{Burn injury parameter; value} \geq 1 \text{ indicates predicted burn injury}$
- $P = \text{Pre-exponential term, dependent on depth and temperature,} \ 1/\text{sec}$
- $\Delta E = \text{Activation energy, dependent on depth and temperature, J/kmol}$
- $R = \text{Universal gas constant,} \ 8314.5 \text{ J/mol} \cdot \text{K}$
- $T = \text{Temperature at specified depth (in kelvin)} \ \text{K}$
- $t = \text{time of exposure and data collection period in sec}$

8.9.7.3.2 Determine the second- and third-degree burn injury parameter values, $\Omega$, by numerically integrating Eq 8.9.7.3.1 using the closed composite, extended trapezoidal rule, or Simpson’s rule, for the total time that data was gathered.

8.9.7.3.3 The integration is performed at each measured time interval for each sensor at the second- and third-degree skin depths (epidermis/dermis interface and dermis/subcutaneous interface depths, respectively) when the temperature, $T$, is $\geq 317.15 \text{ K}$ (44°C). (See Table 8.9.7.2.1.)

8.9.7.3.4 A second-degree burn injury occurs when the value of $\Omega \geq 1.0$ for depths $\geq$ epidermis/dermis interface depth and $< \text{the dermis/subcutaneous interface depth}$ (Table 8.9.7.2.1).

8.9.7.3.5 A third-degree burn injury occurs when the value of $\Omega \geq 1.0$ for depths $> \text{the dermis/subcutaneous interface depth}$ (Table 8.9.7.2.1).

8.9.7.3.6 For the second- and third-degree burn injury predictions, the temperature dependent values for $P$ and $\Delta E/R$ are listed in Table 8.9.7.3.

8.9.7.4 Skin Burn Injury Test Cases.
Table 8.9.7.4 Skin Model Validation Data Set A

<table>
<thead>
<tr>
<th>Absorbed Exposure Heat Flux (constant for the exposure)</th>
<th>Exposure Duration</th>
<th>Required Size of Time Step</th>
</tr>
</thead>
<tbody>
<tr>
<td>W/m²</td>
<td>(cal/s•cm²)</td>
<td>S</td>
</tr>
<tr>
<td>3935</td>
<td>(0.094)</td>
<td>35.9</td>
</tr>
<tr>
<td>5903</td>
<td>(0.141)</td>
<td>21.09</td>
</tr>
<tr>
<td>11805</td>
<td>(0.282)</td>
<td>8.30</td>
</tr>
<tr>
<td>15740</td>
<td>(0.376)</td>
<td>5.55</td>
</tr>
<tr>
<td>23609</td>
<td>(0.564)</td>
<td>3.00</td>
</tr>
<tr>
<td>31479</td>
<td>(0.752)</td>
<td>1.95</td>
</tr>
<tr>
<td>39348</td>
<td>(0.940)</td>
<td>1.41</td>
</tr>
<tr>
<td>47218</td>
<td>(1.128)</td>
<td>1.08</td>
</tr>
<tr>
<td>55088</td>
<td>(1.316)</td>
<td>0.862</td>
</tr>
<tr>
<td>62957</td>
<td>(1.504)</td>
<td>0.713</td>
</tr>
<tr>
<td>70827</td>
<td>(1.692)</td>
<td>0.603</td>
</tr>
<tr>
<td>78697</td>
<td>(1.880)</td>
<td>0.522</td>
</tr>
</tbody>
</table>

8.9.7.4.1 Skin models using the absorbed heat flux and exposure times in Table 8.9.7.4, along with the thickness values specific to ASTM F1930 (75 µm, 1225 µm, and 3885 µm) shall result in values of 1 ± 0.10 for all test cases at the epidermis/dermis interface at the time when the interface temperature has cooled to or below 317.15 K (44ºC). The skin layer properties listed in Table 8.9.7.2.2.1 and the calculation constants in Table 8.9.7.3 shall be used for these calculations. In addition, the time when \( \Omega = 1 \) shall never be less than the exposure duration listed. This latter requirement is to keep the prediction consistent with the observations of Stoll and Greene. Note that the parameter, \( \Omega \), is a cumulative value and having epidermis/dermis interface temperatures lower than 317.15 K (44ºC) does not produce negative values that are subtracted.

8.9.7.4.2 The calculation method used in 8.9.7.2 and 8.9.7.3 shall meet the validation requirements identified in Table 8.9.7.4 when using the skin thickness values specific for ASTM F1930 (75 µm for the epidermis, 1225 µm dermis, and 3885 µm subcutaneous).

8.9.7.4.3 When validating the skin burn injury model, use the layer thickness specific to ASTM F1930 (75 µm, 1225 µm, and 3885 µm), the thermal conductivity and volumetric heat capacity values specified in Table 8.9.7.2.2.1, and the boundary and initial conditions of 8.9.7.2.3 with the exception that the exposure heat fluxes in 8.9.7.2.3.4 become the constant valued ones listed in Table 8.9.7.4. The total calculation time shall be chosen so that the temperatures at the epidermis/dermis and dermis/subcutaneous interfaces both fall below 317.15 K (44ºC) during the cooling phase. For these test cases the skin surface shall be assumed to be adiabatic during the cooling phase, that is, no heat losses from the surface during cooling. Minor changes in the values of thermal conductivity and volumetric heat capacity listed in Table 8.9.7.2.2.1 are permitted providing the validation requirements specified in Table 8.9.7.4 are met with one set of values for all 12 test cases.

8.9.7.4.3.1 Discussion.

The adiabatic boundary condition during cooling is selected because of the lack of detail in the published documents on the orientation of the forearms and the proximity of surrounding equipment used to conduct the experiments. Furthermore, the data gathered from the thermal energy sensors when conducting this test method takes into account convection and radiation heat losses inherently through the calculation of the net energy absorbed by the thermal energy sensors. Therefore, this adiabatic assumption only applies to the model validation data set and not the entire test method.
8.9.7.5 Calculated Results.
For all glove evaluation and specification test reports, include results of the computer program. Base the predicted burn injury on the total area of the head containing sensors and on the total area of the head covered by the test gloves.

1. Total area (percent) of head containing sensors
   (a) Head area of second-degree burn injury (percent).
   (b) Head area of third-degree burn injury (percent).
   (c) Total head area of burn injury (sum of second- and third-degree burn injury) (percent), and associated variation statistic.

2. Total area (percent) of head covered by the test gloves
   (a) Covered area of second-degree burn injury (percent)
   (b) Covered area of third-degree burn injury (percent)

3. Other calculated information used in assessing performance

4. Diagram of the head showing location and burn injury levels as second- and third-degree areas

8.9.8 Report.
State that the specimens were tested as directed in Test Method xxx. Describe the material sampled, the method of sampling used, and any deviations from the method.

8.9.8.1 In the material description, include for each shroud/hood/balaclava: type, size, fabric weight, fiber type, color, and nonstandard or special shroud/hood/balaclava features and design characteristics.

8.9.8.2 Report the information in 8.9.7.3 through 8.9.7.3.6.

8.9.8.3 Type of Test.
Material of construction evaluation, shroud/hood/balaclava design evaluation, or end-use shroud/hood/balaclava evaluation.

8.9.8.4 Exposure Conditions.
The information that describes the exposure conditions includes the following:

1. The average of the exposure heat flux and the standard deviation of the average heat flux from all sensors determined from the nude exposures taken before and after each test series
2. The nominal heat flux, the duration of the exposure, and the duration of the data acquisition time for each test
3. The temperature and relative humidity in the room where the shroud/hood/balaclava were held prior to testing
4. Any other information relating to the exposure conditions shall be included to assist in interpretation of the test specimen results

8.9.9 Interpretation
Pass or fail determinations shall be based on the average total covered area of second- and third-degree burn injury (percent) < 50 percent.

Supplemental Information

<table>
<thead>
<tr>
<th>File Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PyroHead_Rev1.docx</td>
<td>This document was provided by NC State which was derived from ASTM F1930 that is a current work in progress under work item number WK46354.</td>
</tr>
</tbody>
</table>
Committee Statement

Committee Statement: The committee would like to solicit Public Comments on the requirements for the test methods. It is understood that these test methods are currently under development. Data and refinements to the methods will be submitted and considered.

Response Message: 

http://submittals.nfpa.org/TerraViewWeb/ContentFetcher?commentPara...
8.XX Whole Shroud/Hood/Balaclava Thermal Protection Performance Test

8.XX.1 Application

8.XX.1.1 This test method shall apply to protective Shroud/Hood/Balaclava as exposed to short duration thermal exposure resulting from a fire.

8.XX.2. Samples

8.XX.2.1 One set of a Shroud/Hood/Balaclava shall be provided, size TBD

8.XX.3 Specimens  A total of five specimen shall be tested.

8.XX.4 Apparatus

8.XX.4.1 Instrumented Head—One Head with specified dimensions (TBD) shall be used.

8.XX.4.1.1 Size and Shape—The Head dimensions shall correspond to those required for size(TBD) of Shroud/Hood/Balaclava because deviations in fit will affect the results.

8.XX.4.1.2 The Head shall be constructed of flame resistant, thermally stable, nonmetallic materials which will not contribute fuel to the combustion process. A flame resistant thermally stable, glass fiber reinforced vinyl ester resin at least 3 mm (1/8 in.) thick, has proven effective

8.XX.4.2 Apparatus for Burn Injury Assessment:

8.XX.4.2.1 Head Construction—a minimum of 22 thermal energy sensors shall be used per Head. They shall be distributed as uniformly as possible within each area on the Head.

8.XX.4.2.2 Thermal Energy Sensors—each sensor shall have the capacity to measure the incident heat flux over a range from 0.0 to 165 kW/m2 (0.0 to 4.0 cal/cm2•s). This range permits the use of the sensors to set the exposure level by directly exposing the instrumented Head to the controlled flash fire in a test without the Shroud/Hood/Balaclava and also having the capability to measure the heat transfer to the Head when covered with test Shroud/Hood/Balaclava or protective Shroud/Hood/Balaclava ensemble.

8.XX.4.2.3 The sensors shall be constructed of a material with known thermal and physical characteristics that can be used to indicate the time varying heat flux received by the sensors. One type of sensor which has been used successfully is a copper slug calorimeter. The minimum response time for the sensors shall be ≤0.1 s. Coating the sensor with a thin layer of flat black high temperature paint\(^1\) with an absorptivity of at least 0.9\(^16\) has been found effective. The outer surface shall have an emissivity of at least 0.9.

8.XX.4.2.4 The calibration determined for each sensor shall be recorded, and the most recent calibration results used to carry out the burn injury analysis.

---

\(^1\) Krylon # 1618 BBQ and Stove; Krylon #1316 Sandable Primer; Krylon #1614 High Heat and Radiator paint have been found to be effective. See ASTM Study “Evaluation of Black Paint and Calorimeters used for Electric Arc Testing”, ASTM contract #F18-103601, Kinectrics Report:8046-003-RC-0001-R00, August 22, 2000.
8.XX.4.3 Thermal Energy (Heat Flux) Calibration Sensor—use a NIST traceable heat flux measuring device to calibrate the energy source used to calibrate the thermal energy (heat flux) sensors. A permanent record shall be kept of the sensor calibrations during their operating life.

8.XX.4.4 Data Acquisition System—a system shall be provided with the capability of acquiring and storing the results of the measurement from each sensor at least ten times per second for the data acquisition period.

8.XX.4.5 Burn Assessment Program—a computer software program shall be used that has the capability of receiving the output of the thermal sensors, calculating the time dependent surface heat flux, predicting a second degree and third degree burn injury for each sensor utilizing the skin burn injury model and determining the total predicted burn injury area as a result of the simulated flash fire exposure.

8.XX.4.5.1 Incident Heat Calculation—the average heat flux to the surface of the Head shall be determined by exposing the nude Head for 3 seconds. The total and average value of all sensors shall be determined taking into account the sensor calibrations and characteristics. The values calculated for each sensor at each time step shall be placed in a file for future use in estimating the temperature history within human skin for the burn injury calculation.

8.XX.4.5.2 Burn Injury Calculation—the predicted time necessary to cause second-degree and third-degree burn injury for each sensor shall be calculated.

8.XX.4.5.3 Burn Injury Assessment—the sum of the areas represented by the sensors that received sufficient heat to result in a predicted second-degree burn shall be the predicted second-degree percentage burn area assessment. The sum of the area represented by the sensors that received sufficient heat to result in a predicted third-degree burn shall be the predicted third-degree percentage burn area assessment. The sum of these two areas shall be the total predicted percentage of burn injury resulting from the exposure to the flash fire condition. The sum of all sensors shall represent 100% of the Head.

8.XX.4.6 Exposure Chamber—a ventilated, fire-resistant enclosure with viewing windows and access door(s) shall be provided to contain the Head and exposure apparatus.

8.XX.4.6.1 Exposure Chamber Size—The chamber size shall be sufficient to provide a uniform flame exposure over the surface of the test Shroud/Hood/Balaclava s and shall have sufficient space to allow safe movement around the Head for dressing without accidentally jarring and displacing the burners.

8.XX.4.6.2 Burner and Manikin Alignment-apparatus and procedures for checking the alignment of the burners and Head position prior to each test shall be available.

8.XX.4.6.3 Chamber Air Flow—the chamber shall be isolated from air movement other than the natural air flow required for the combustion process so that the pilot flames and exposure flames are not affected before and during the test exposure and data acquisition periods. A forced air exhaust system for rapid removal of combustion gas products after the data acquisition period shall be provided.

8.XX.4.6.5 Chamber Safety Devices—the exposure chamber shall be equipped with sufficient safety devices, detectors and suppression systems to provide safe operation of the test apparatus. These safety devices, detectors and suppression systems include propane gas detectors, motion detectors, door closure detectors, Head held fire extinguishers and any other devices necessary.
8.XX.4.7 Fuel Delivery System—A system of piping, pressure regulators, valves, and pressure sensors including a double block and bleed burner management scheme (see NFPA 58) or similar system consistent with local codes shall be provided to safely deliver gaseous propane to the ignition system and exposure burners. This delivery system shall be sufficient to provide an average heat flux of at least 2.0 cal/s•cm² for an exposure time of at least 3 s. Fuel delivery shall be controlled to provide known exposure duration within ±0.1 seconds of the set exposure time.

8.XX.4.7.1 Fuel—the propane gas used in the system shall be from a liquid propane supply with sufficient purity and constancy to provide a uniform flame from the exposure burners. It is recommended that the fuel meet the HD-5 specifications. (See Specification D1835, CAN/CGSB 3.14 M88, or equivalent)

8.XX.4.7.2 Burner System—the burner system shall consist of one ignition pilot flame for each exposure burner, and sufficient burners to provide the required range of heat fluxes with a flame distribution uniformity to meet the requirements in 10.3.2.

8.XX.4.7.3 Exposure Burners—Large, induced combustion air, industrial style propane burners are positioned around the Head to produce a uniform laboratory simulation of a fire. These burners produce a large fuel rich reddish-yellow flame. If necessary, enlarge the burner gas jet, or remove it, to yield a fuel to air mixture for a long luminous reddish-yellow flame that engulfs the Head. A minimum of four burners has been shown to yield the exposure level and uniformity as described in 8.XX.5.3.5.

8.XX.4.7.3.1 Ignition Pilot Flame—each exposure burner shall be equipped with a pilot flame positioned near the exit of the burner, but not in the direct path of the flames to interfere with the exposure flame pattern. The pilot flame shall be interlocked to the burner gas supply valves to prevent premature or erroneous opening of these valves.

8.XX.4.8 Image Recording System—a system for recording a visual image of the Head before, during, and after the flame exposure shall be provided.

8.XX.4.9 Safety Check List—a check list shall be included in the computer operating program to ensure that all safety features have been satisfied before the flame exposure can occur. This list shall include, but is not limited to, the following: confirm that the Head has been properly dressed in the test garment; confirm that the chamber doors are closed; confirm that no person is in the burn chamber; and all safety requirements are met. The procedural safety checks shall be documented.

8.XX.4.10 Garment Conditioning Area—the area shall be maintained at 21 ± 2°C (70 ± 5°F) and 65 ± 5% relative humidity. It shall be large enough to have good air circulation around the test specimens.

8.XX.5 Preparation and Calibration of Apparatus

8.XX.5.1 Preparation of Apparatus—exposing the instrumented Head to a fire exposure in a safe manner and evaluating the test specimen requires a startup and exposure sequence that is specific to the test apparatus. Some of the steps listed require manual execution, others are initiated by the computer program, depending upon the individual apparatus. Perform the steps as specified in the apparatus operating procedure. Some of the steps that shall be included are:

8.XX.5.1.1 Burn Chamber Purging—ventilate the chamber for a period of time sufficient to remove a volume of air at least ten times the volume of the chamber. The degree of ventilating the chamber shall at a minimum comply with NFPA 86.
8.XX.5.1.2 Gas Line Charging—the following procedure or a comparable procedure shall be used for gas line charging. Close the supply line vent valves and open the valves to the fuel supply to charge the system with propane gas at the operating pressure up to, but not into, the chamber. Charge and initiate the pilots first, before charging the header in the exposure chamber for the torches.

8.XX.5.1.3 Confirmation of Exposure Conditions—using the procedure described below expose the PyroHead® to the test fire for 3 s. Confirm that the calculated heat flux standard deviation is not greater than 0.50 cal/cm²•s and the exposure is within ± 2.5% of the specified test condition. If the calculated heat flux or standard deviation is not within these specifications, determine the cause of the deviations and correct before proceeding with garment testing.

8.XX.5.2 Calibration of Sensor and Data System:

8.XX.5.2.1 Calibration Principles:

8.XX.5.2.1.1 Thermal energy sensors are used to measure the fire exposure intensity and the thermal energy transferred to the manikin during the exposure. Calibrate the individual sensors performance against a suitable NIST (or other recognized standards body) traceable reference. Calibrate to the exposure and heat transfer conditions experienced during test setup and garment testing, typically over a range of 0.07 cal/cm²•s to 3.0 cal/cm²•s.

8.XX.5.2.1.2 Verify the heat fluxes produced by the calibration device to within ±2.5% of the required exposure level with the heat flux calibration sensor.

8.XX.5.2.1.3 Test the thermal energy sensors used in the manikin to ensure that the heat flux response is accurate over the range of heat fluxes produced by the exposure and under the test specimen. If the response is linear but not within 2.5% of the known calibration exposure energy, include a correction factor in the heat flux calculations. If the response is not linear and within 2.5% of the known calibration exposure energy, determine a correction factor curve for each sensor for use in the heat flux calculations.
8.XX.5..3.1 Measure the intensity and uniformity of the fire exposure by exposing the nude Head to the flames. Software capable of converting the measured data into time varying surface heat fluxes at each sensor is required. Calculate the average heat flux over the steady region as shown in Fig. 1 during the exposure for each sensor. Calculate the area weighted average of these values and the standard deviation. The weighted average is the average exposure heat flux level for the test conditions, and the standard deviation is a measure of the exposure uniformity.

**FIG. 1 Average Heat Flux Determination for a Nude Exposure**

(Exposure begins – Burner gas valve opens)

(Exposure ends – Burner gas valve closes)

8.XX.5.3.2 Position the exposure burners and adjust the flames so that the standard deviation of the average exposure heat flux level of all of the Head sensors does not exceed 0.50 cal/cm²•s. Confirm the standard deviation of the average heat flux level to be equal to or less than 0.50 cal/cm²•s for each nude Head exposure, and if necessary, adjust the burners to obtain the exposure uniformity.

8.XX.5.3.3 Expose the nude Head to the flames before testing a set of specimens and repeat the exposure at the conclusion of the testing of the set. If the average exposure heat flux for the test conditions differs by more than 5% between the before and after measurements, report this and give consideration to repeating the sequence of specimen tests. As a minimum, check the Head exposure level at the beginning and at the end of the work day.

8.XX.5.3.4 Use a 3 seconds fire exposure for these calibrations, and monitor the fuel pressure of the supply line close to the burner fuel supply header. The measured absolute fuel pressure at this location shall not fall more than 10% during a single fire exposure. The duration of the fire exposure shall be controlled by the internal clock of the data acquisition system.

8.XX.5.3.5 The average heat flux calculated in 8.XX.5.3.1 shall be 2.0 cal/s•cm² ± 2.5%. If not, adjust the fuel flow rate by modifying the gas pressure or flow at the burner Head. Repeat the calibration run(s) until the specified value is obtained. Repeat nude calibrations shall only be conducted when no single sensor temperature exceeds 38°C (100°F) in order to minimize corrections required for nonlinear temperature dependent sensor response.
8.XX.5.3.6 The computer controlled data acquisition system shall be capable of recording the output from each sensor at least ten times per second during the calibration. The accuracy of the measurement system shall be less than 2% of the reading or ± 1.0°C (± 1.8°F) if a temperature sensor is used. Set the sampling rate during an exposure to provide a minimum of two readings for each sensor every second.

8.XX.5.3.7 Calibration of the fire exposure on the Head shall be done as the first and last test for each test day. Report the results of this exposure as the average absorbed heat flux in cal/cm²•s and exposure duration in seconds. Also report the standard deviation of the Head sensors, the area weighted percent of sensors indicating second-degree and third-degree burns, and the sum of these two values as a total percent burn.

8.XX.5.4 Defective sensor replacement - any defective sensor shall be replaced with a calibrated sensor prior to Shroud/Hood/Balaclava testing.

8.XX.6. Procedure

8.XX.6.1 Sensor Temperatures—Before starting an exposure ensure that the average temperature of all the sensors located under the test specimen are 32 ± 2°C (90 ± 4°F) and no single sensor exceeds 38°C (100°F)

8.XX.6.2 Dress the Head —Dress the Head with the test specimens. Arrange the Shroud/Hood/Balaclava on the Head in the way they are expected to be used by the end-user/wearer or as specified by the test author. Note in the test report how the Head is dressed. Use the same fit and placement of the Shroud/Hood/Balaclava for each test to minimize variability in the test results.

8.XX.6.3 Record the Test Attributes—Record the information that relates to the test, including: Purpose of test, test series, Shroud/Hood/Balaclava identification, layering, fit on the Head, Shroud/Hood/Balaclava style, number or pattern description, test conditions, test remarks, exposure duration, data acquisition time, persons observing the test, and any other information relevant to the test series.

8.XX.6.3 Burner Alignment - verify that burner alignment is correct as established in x.xx.x

8.XX.6.4 Head Alignment - verify that the Head is spatially positioned and aligned in the exposure chamber via a centering or alignment device.

8.XX.6.5 Set Test Parameters – enter into the burner management control system the specified exposure time and data acquisition time.

8.XX.6.5.1 The minimum data acquisition time shall be 60 seconds for all exposures with garments. The data acquisition time shall be long enough to ensure that all of the thermal energy stored in the Shroud/Hood/Balaclava is no longer contributing to burn injury. Confirm that the acquisition time is sufficient by inspecting the calculated burn injury versus time information to determine that the total burn injury of all of the sensors has leveled off and is not continuing to rise at the end of the data acquisition time. If the amount of burn injury is not constant for the last 10 seconds of acquisition time, increase the time of acquisition to achieve this requirement.
8.XX.6.6 Confirm Safe Operation Conditions—follow the operating instructions in the computer program and fill in the fields on the safety screen to ensure that all of the safety requirements have been met and that it is safe to proceed with the garment exposure.

8.XX.6.7 Light Pilot Flames—when all of the safety requirements are met, light the pilot flames and confirm that all of the pilot flames on the burners that will be used in the test exposure are actually lit. Warning: Visually confirm the presence of each pilot flame in addition to the panel light or computer indication. The test exposure shall be initiated only when all of the safety requirements are met, the pilot flames are ignited and visually confirmed, and the final valve in the gas supply line is opened.

8.XX.6.8 Start Image Recording System—start the video or film system used to visually document each test.

8.XX.6.9 Expose the Test Shroud/Hood/Balaclava —initiate the test exposure by pressing the appropriate computer key. The computer program will start the data acquisition, open the burner gas supply solenoid valves for the time of the exposure, and stop the data acquisition at the end of the specified time.

8.XX.6.10 Acquire the Heat Transfer Data—collect the data from all installed thermal energy sensors. Note that data collection after the fire exposure shall be done in a quiescent environment.

8.XX.6.11 Record Garment Response Remarks—record observations of test Shroud/Hood/Balaclava to the exposure. These remarks include but are not limited to the following: occurrence of after-flame (time, intensity and location), ignition, melting, smoke generation, unexpected Shroud/Hood/Balaclava or material failures. material shrinkage, and charring or observed degradation. These remarks become a permanent part of the test record.

8.XX.6.12 Initiate Test Report Preparation—initiate the computer program to perform the calculations to determine the amount of total burn injury and to prepare the test report. Perform these operations immediately or, if warranted delay them for later processing.

8.XX.6.13 Initiate Forced Air Exhaust System—start the forced air exhaust system to remove the combustion products and gasses produced from the fire exposure. Run the system long enough to ensure a safe working environment in the exposure chamber prior to entering.

8.XX.6.14 Prepare for the Next Test Exposure—carefully remove the exposed Shroud/Hood/Balaclava s from the Head. Wipe the Head and sensor surfaces with a damp cloth to remove residue from the test garment exposure. If the sensors are too hot, run the ventilating fan(s) to cool them so that the average temperature of all sensors is 32 ± 2°C (90 ± 4°F) and no single sensor exceeds 38°C (100°F). The Head and sensors shall be inspected to ensure that they are free of any decomposition materials, and if a deposit is present, carefully clean the manikin and sensors with soap and water or a petroleum solvent. Use the gentlest method that is effective in cleaning the sensor. If required, repaint the surface of the sensor and dry the paint. Ensure that the manikin and sensors are dry, and if necessary, dry them, for example with the ventilating fan(s), before conducting the next test. Visually inspect the sensors for damage, e.g. cracks or discontinuities in the sensor surface.

8.XX.6.15 Sensor Replacement—repair or replace damaged or inoperative sensors. Calibrate repaired or replaced sensors before using.

8.XX.6.16 Test Remaining Specimens—test the remaining specimens at the same exposure conditions.
8.XX.7 Calculated Results

8XX.7.1 Skin Burn Injury Prediction and determination of head manikin sensor heat flux values.

8XX.7.1.1 Convert the recorded thermal energy sensor responses at each time step into their respective time-dependent absorbed heat flux values in kW/m\(^2\) (cal/s•cm\(^2\)) using the method appropriate for the sensor.

8XX.7.1.1.1 Discussion—Different laboratories use different sensor technologies in their manikins. Each requires a different method to convert the measured responses into respective absorbed heat flux values.

8XX.7.2 Determination of the predicted skin and subcutaneous fat (adipose) internal temperature field.

8XX.7.2.1 For all head locations assume the thermal exposure is represented as a transient one dimensional heat diffusion problem in which the temperature within the skin and subcutaneous layers (adipose) varies with both position (depth) and time, and is described by the linear parabolic differential equation (Fourier’s Field Equation):

\[
\rho C_p(x) \frac{\partial[T(x,t)]}{\partial t} = \frac{\partial}{\partial x} \left[ k(x) \frac{\partial[T(x,t)]}{\partial x} \right]
\]

where:

\[
\rho C_p(x) = \text{Volumetric heat capacity, J/m}^3\text{•K (cal/cm}^3\text{•K)}
\]

\[t = \text{Time, s}\]

\[x = \text{Depth from skin surface, m [cm]}\]

\[T(x,t) = \text{Temperature at depth x, time t, K}\]

\[k(x) = \text{Thermal Conductivity, W/m\text{•K (cal/s•cm•K)}}\]

8XX.7.2.1.1 Discussion—Use of absolute temperatures is recommended when solving Eq 1 because Eq 2, which is used for the calculation of \(\Omega\), the burn injury parameter, requires absolute temperatures.

8XX.7.2.2. Solve Eq 1 numerically using a sensor location specific skin model that takes into account the depth dependency of the thermal conductivity and volumetric heat capacity values as identified in Tables 8XX.7.2.1 and 8XX.7.2.2. Each of the layers shall be constant thickness, lying parallel to the surface.

### TABLE 8XX.7.2.1 Model Thickness Values for Sensor Locations on Head Manikin (in µm)

<table>
<thead>
<tr>
<th>Sensor Location</th>
<th>Epidermis</th>
<th>Dermis</th>
<th>Subcutaneous Tissue</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cranium</td>
<td>70</td>
<td>1430</td>
<td>3400</td>
</tr>
<tr>
<td>----------</td>
<td>-----</td>
<td>------</td>
<td>------</td>
</tr>
<tr>
<td>Temple</td>
<td>50</td>
<td>1800</td>
<td>3400</td>
</tr>
<tr>
<td>Ears</td>
<td>50</td>
<td>750</td>
<td>600</td>
</tr>
<tr>
<td>Cheek</td>
<td>85</td>
<td>1665</td>
<td>4000</td>
</tr>
<tr>
<td>Neck</td>
<td>85</td>
<td>1765</td>
<td>9900</td>
</tr>
<tr>
<td>Forehead</td>
<td>75</td>
<td>1675</td>
<td>3400</td>
</tr>
<tr>
<td>Eyelids</td>
<td>50</td>
<td>550</td>
<td>600</td>
</tr>
<tr>
<td>Chin</td>
<td>85</td>
<td>1865</td>
<td>1300</td>
</tr>
</tbody>
</table>

Table 8XX.7.2.2 Thermo Physical Properties for each layer of model

<table>
<thead>
<tr>
<th>Property</th>
<th>Epidermis</th>
<th>Dermis</th>
<th>Subcutaneous Tissue</th>
<th>Bone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal Conductivity, $k_W/m\cdot K$</td>
<td>0.6280 (0.0015)</td>
<td>0.5902 (0.00141)</td>
<td>0.2930 (0.0007)</td>
<td>0.3000 ()</td>
</tr>
<tr>
<td>Volumetric Heat Capacity, $\rho C_p \cdot J/m^2 \cdot K$</td>
<td>4.40x10^6 (1.05)</td>
<td>4.186x10^6 (1.00)</td>
<td>2.60x10^6 (0.62)</td>
<td>2.619x10^6 ()</td>
</tr>
</tbody>
</table>

8XX.7.2.2.2 The discretization methods to solve Eq 1 that have been found effective are: the finite differences method (following the “combined method” central differences representation where truncation errors are expected to be second order in both $\Delta t$ and $\Delta x$), finite elements method (for example the Galerkin method), and the finite volume method (sometimes called the control volume method).

(1) Discussion—Equally spaced depth intervals ($\Delta x$), denoted as “nodes” or “meshes”, are recommended for highest accuracy in all numerical models. A value for $\Delta x$ of 15 $\times$ 10^-6 m has been found effective. Sparse or unstructured meshes are not recommended for use in the finite difference method.

8XX.7.2.3 Use the following initial and boundary conditions:

8XX.7.2.3.1 The initial temperature within the layers shall have a linear increase with depth from 305.65 K (32.5ºC) at the surface to 306.65 K (33.5ºC) at the back of the subcutaneous layer (adipose). The deep temperature shall be constant for all time at 306.65 K (33.5ºC).

(1) Discussion—Pennes (3) measured the temperature distributions in the forearms of volunteers. For the overall thickness of the skin and subcutaneous layers (adipose) listed in Table 8XX.7.2.2, the measured rise was 1 K (1ºC). The skin surface temperature of the volunteers in the experiments by Stoll and Greene (2) was kept very near to 305.65 K (32.5ºC).

8XX.7.2.3.2 The absorbed heat flux is applied only at the skin surface and it is assumed that heat conduction is the only mode of heat transfer in the skin and subcutaneous layers (adipose). This calculation excludes any thermal radiation components that could penetrate the skin.

(1) Discussion—Assuming heat conduction only within the skin and deeper layers ignores enhanced heat transfer due to changing blood flow in the dermis and subcutaneous layers (adipose). The in vivo (living) values listed in Table 8XX.7.2.2 are back calculated from the experimental results of Stoll and
Greene (2) and numerical extensions by Weaver and Stoll (4). The values account to a large degree for the blood flow in the test subjects.

8XX.7.2.3.3 The absorbed heat flux at the skin surface at time \( t = 0 \) (start of the exposure) is zero (0).

8XX.7.2.3.4 The absorbed heat flux values at the skin surface at all times \( t > 0 \) are the time dependent absorbed heat flux values determined in 8XX.7.1.1. No corrections are made for radiant heat losses or emissivity/absorptivity differences between the sensors and the skin surface used in the model.

8XX.7.2.4 Calculate an associated internal temperature field for the skin model at each sensor sampling time interval for the entire sampling time by applying each of the sensor’s time-dependent heat flux values to individual skin modeled surfaces (a skin model is evaluated for each measurement sensor). These internal temperature fields shall include, as a minimum, the calculation of temperature values at the surface (depth = 0.0 m), at the skin model epidermis/dermis interface (used to predict second-degree burn injury), and the skin model dermis/subcutaneous interface (used to predict a third-degree burn injury).

8XX.7.3 Determination of the Predicted Skin Burn Injury:

8XX.7.3.1 The Damage Integral Model of Henriques (5), Eq 2, is used to predict skin burn injury parameter based on skin temperature values at each measurement time interval at skin model depths of \( 75 \times 10^{-6} \) m (second-degree burn injury prediction) and \( 1200 \times 10^{-6} \) m (third-degree burn injury prediction).

\[
\Omega = \int P e^{-(\Delta E/RT)} dt
\]  \hspace{1cm} (2)

where:

\( \Omega \) = Burn Injury Parameter; Value, \( \geq 1 \) indicates predicted burn injury

\( t \) = time of exposure and data collection period, s

\( P \) = Pre-exponential term, dependent on depth and temperature, 1/s

\( \Delta E \) = Activation energy, dependent on depth and temperature, J/kmol

\( R \) = Universal gas constant, 8314.5 J/mol • K

\( T \) = Temperature at specified depth (in kelvin) K

8XX.7.3.2 Determine the second-degree and third-degree burn injury parameter values, \( \Omega \)'s, by numerically integrating Eq 2 using the closed composite, extended trapezoidal rule or Simpson’s rule, for the total time that data was gathered.

8XX.7.3.3 The integration is performed at each measured time interval for each sensor at the second-degree and third-degree skin depths (epidermis/dermis interface and dermis/subcutaneous interface depths, respectively) when the temperature, \( T \), is \( \geq 317.15 \) K (44°C). (See Table 8XX.7.2.1)
8XX.7.3.4 A second-degree burn injury occurs when the value of $\Omega \geq 1.0$ for depths $\geq$ epidermis/dermis interface depth and $<\text{the dermis/subcutaneous interface depth}$ (Table 8XX.7.2.1).

8XX.7.3.5 A third-degree burn injury occurs when the value of $\Omega \geq 1.0$ for depths $\geq$ the dermis/subcutaneous interface depth (Table 8XX.7.2.1).

8XX.7.3.6 For the second-degree and third-degree burn injury predictions, the temperature dependent values for $P$ and $\Delta E/R$ are listed in Table 8XX.7.3.

### TABLE 8XX.7.3 Constants for Calculation of Omega Using Eq 2

<table>
<thead>
<tr>
<th>Skin Injury</th>
<th>Temperature Range</th>
<th>$P$</th>
<th>$\Delta E/R$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Second-degree (4)</td>
<td>$317.15 \text{ K} \leq T \leq 323.15 \text{ K}$ ($44^\circ \text{C} \leq T \leq 50^\circ \text{C}$)</td>
<td>$2.185 \times 10^{12}$ s$^{-1}$</td>
<td>93 534.9 K</td>
</tr>
<tr>
<td></td>
<td>$T &gt; 323.15 \text{ K}$ ($T &gt; 50^\circ \text{C}$), use:</td>
<td>$1.823 \times 10^{11}$ s$^{-1}$</td>
<td>39 109.8 K</td>
</tr>
<tr>
<td>Third-degree (9)</td>
<td>$317.15 \text{ K} \leq T \leq 323.15 \text{ K}$ ($44^\circ \text{C} \leq T \leq 50^\circ \text{C}$)</td>
<td>$4.322 \times 10^{64}$ s$^{-1}$</td>
<td>50 000 K</td>
</tr>
<tr>
<td></td>
<td>$T &gt; 323.15 \text{ K}$ ($T &gt; 50^\circ \text{C}$), use:</td>
<td>$9.389 \times 10^{10}$ s$^{-1}$</td>
<td>80 000 K</td>
</tr>
</tbody>
</table>

8XX.7.4 Skin burn injury test cases

8XX.7.4.1 The calculation method used in 8XX.7.2 and 8XX.7.3 shall meet the validation requirements identified in Table 8XX.7.4 when using the skin thickness values specific for the ASTM F1930 (75 µm for the epidermis, 1225 µm dermis, and 3885 µm subcutaneous).

### TABLE 8XX.7.4 Skin Model Validation Data SetA

<table>
<thead>
<tr>
<th>Absorbed Exposure Heat Flux (constant for the exposure)</th>
<th>Exposure Duration</th>
<th>Required Size of Time Step</th>
</tr>
</thead>
<tbody>
<tr>
<td>W/m$^2$</td>
<td>(cal/s•cm$^2$)</td>
<td>s</td>
</tr>
<tr>
<td>-------------------------</td>
<td>------------------</td>
<td>-----</td>
</tr>
<tr>
<td>3935</td>
<td>(0.094)</td>
<td>35.9</td>
</tr>
<tr>
<td>5903</td>
<td>(0.141)</td>
<td>21.09</td>
</tr>
<tr>
<td>11 805</td>
<td>(0.282)</td>
<td>8.30</td>
</tr>
<tr>
<td>15 740</td>
<td>(0.376)</td>
<td>5.55</td>
</tr>
<tr>
<td>23 609</td>
<td>(0.564)</td>
<td>3.00</td>
</tr>
<tr>
<td>31 479</td>
<td>(0.752)</td>
<td>1.96</td>
</tr>
<tr>
<td>39 348</td>
<td>(0.940)</td>
<td>1.41</td>
</tr>
</tbody>
</table>
Skin models using the absorbed heat flux and exposure times in Table 8XX.7.4, along with the thickness values specific to ASTM F1930 (75 µm, 1225 µm, and 3885 µm) shall result in values of 1 ± 0.10 for all test cases at the epidermis/dermis interface at the time when the interface temperature has cooled to or below 317.15 K (44ºC). The skin layer properties listed in Table 8XX.7.2.2 and the calculation constants in Table 8XX.7.3 shall be used for these calculations. In addition, the time when Ω = 1 shall never be less than the exposure duration listed. This latter requirement is to keep the prediction consistent with the observations of Stoll and Greene (2). Note that the parameter, Ω, is a cumulative value and having epidermis/dermis interface temperatures lower than 317.15 K (44ºC) does not produce negative values that are subtracted.

8XX.7.4.2 When validating the skin burn injury model, use the layer thickness specific to ASTM F1930 (75 µm, 1225 µm, and 3885 µm), the thermal conductivity and volumetric heat capacity values specified in Table 8XX.7.2.2, and the boundary and initial conditions of 8XX.7.2.3 with the exception that the exposure heat fluxes in 8XX.7.2.3.4 become the constant valued ones listed in Table 8XX.7.4. The total calculation time shall be chosen so that the temperatures at the epidermis/dermis and dermis/subcutaneous interfaces both fall below 317.15 K (44ºC) during the cooling phase. For these test cases the skin surface shall be assumed to be adiabatic during the cooling phase, that is, no heat losses from the surface during cooling. Minor changes in the values of thermal conductivity and volumetric heat capacity listed in Table 8XX.7.2.2 are permitted providing the validation requirements specified in Table 8XX.7.4 are met with one set of values for all twelve test cases.

8XX.7.4.2.1 Discussion—The adiabatic boundary condition during cooling is selected because of the lack of detail in the published documents on the orientation of the forearms and the proximity of surrounding equipment used to conduct the experiments. Furthermore, the data gathered from the thermal energy sensors when conducting this test method takes into account convection and radiation heat losses inherently through the calculation of the net energy absorbed by the thermal energy sensors. Therefore this adiabatic assumption only applies to the model validation data set and not the entire test method.

8X.7.5 Calculated Results—for all glove evaluation and specification test reports, include results of the computer program. Base the predicted burn injury on the total area of the Head containing sensors and on the total area of the Head covered by the test gloves.

1) Total area (%) of Head containing sensors.
1a) Head area of second-degree burn injury (%).
1b) Head area of third-degree burn injury (%).
1c) Total Head area of burn injury (sum of second- and third-degree burn injury) (%), and associated variation statistic.

2) Total area (%) of Head covered by the test gloves.

2a) Covered area of second-degree burn injury (%).

2b) Covered area of third-degree burn injury (%)

3) Other calculated information used in assessing performance.

3a) Diagram of the Head showing location and burn injury levels as second-degree and third-degree areas.

8.XX.8 Report

8.XX.8.1 State that the specimens were tested as directed in Test Method xxx Describe the material sampled, the method of sampling used, and any deviations from the method.

8.XX.8.1.1 In the material description include for each shroud/hood/balaclava: type, size, fabric weight, fiber type, color, and non-standard or special shroud/hood/balaclava features and design characteristics.

8.XX.8.2 Report the information in 8.XX.7.3–8.XX.7.6

8.XX.8.3 Type of Test—material of construction evaluation, shroud/hood/balaclava design evaluation, or end-use shroud/hood/balaclava evaluation.

8.XX.8.4 Exposure Conditions—the information that describes the exposure conditions, including:

8.XX.8.4.1 The average of the exposure heat flux and the standard deviation of the average heat flux from all sensors determined from the nude exposures taken before and after each test series.

8.XX.8.4.2 The nominal heat flux, the duration of the exposure, and the duration of the data acquisition time for each test.

8.XX.8.4.3 The temperature and relative humidity in the room where the shroud/hood/balaclava were held prior to testing.

8.XX.8.4.4 Any other information relating to the exposure conditions shall be included to assist in interpretation of the test specimen results.

8.XX.9 Interpretation

8.XX.9.1 Pass or fail determinations shall be based on the average total covered area second and third-degree burn injury (%) <50%.
A.5.1.1

Purchasers might wish to include a requirement in the purchase specifications for an additional label that includes certain information such as the date of manufacture, manufacturer's name, and protective garment identification number to be located in a protected location on the protective garment in order to reduce the chance of label degradation and as a backup source of information to aid in protective garment tracking or during an investigation.

Submitter Information Verification

Submitter Full Name: Eric Nette
Organization: [ Not Specified ]
Street Address:
City:
State:
Zip:
Submittal Date: Wed Nov 05 16:20:45 CST 2014

Committee Statement

Committee Statement: Additional clothing items were added to the scope of the document.
Response Message:
A.5.2.1
The garment manufacturer should provide, at a minimum, the following instructions and information with each flame-resistant garment:

Pre-use information
  Safety considerations
  Limitations of use
  Garment marking recommendations and restrictions
  Warranty information

Preparation for use
  Sizing/adjustment
  Recommended storage practices

Inspection frequency and details

Donning and doffing procedures

Proper use consistent with NFPA 2113, Standard on Selection, Care, Use, and Maintenance of Flame-Resistant Garments for Protection of Industrial Personnel Against Flash Fire

Maintenance and cleaning
  Cleaning instructions and precautions
  Maintenance criteria and methods of repair where applicable

Retirement and disposal criteria

The required information can be provided either with the use of a suitable electronic link or with accompanying printed literature packaged with each clothing item.

A.5.2.2
The selection of protective clothing size relates directly to the garment's ability to function properly. In occupations such as the petrochemical industry, proper fit and function relate directly to the wearer's ability to perform assigned jobs. Issues of proper fit are directly associated with the risk of injury. Protective clothing that restricts movement will result in lost efficiency and can promote injury and illness. Proper sizing is a factor in the ability of a person to perform tasks that often involve life or death situations. Protective clothing must fit well to function properly when additional safety equipment or other garments are worn. In addition, the selection of flame-resistant garment size has a direct impact on maintaining appropriate protection in areas where the flame-resistant garment has an interface with safety equipment or other protective garments. ASTM F 1731, Standard Practice for Body Measurements and Sizing of Fire and Rescue Services Uniforms and Other Thermal Hazard Protective Clothing, might be found useful when selecting protective clothing for technical operations. ASTM F 1731 primarily addresses processes for sizing flame-resistant garment; however, the techniques described are useful in the selection of protective clothing addressed in this standard. The required information can be provided either with the use of a suitable electronic link or with accompanying printed literature packaged with each clothing item.

Submitter Information Verification

Submitter Full Name: Eric Nette
Organization: [ Not Specified ]
Street Address: 
City: 
Committee Statement

Committee Statement: Additional clothing items were added to the scope of the document. A5.2.1 was moved out of the annex and made mandatory as the previous information in 5.2.1 was not specific in what information was to be provided and how that information was to be provided.
B.1 Test Properties and Methods.
Table B.1 provides a description of the test properties and methods used for evaluating flame-resistant garments. A number of additional properties can be used in the evaluation of flame-resistant garments that are not required as part of this standard. Table B.1 also lists these additional properties, recommended test methods, and their suggested application.

### Table B.1 Performance Properties and Additional Evaluation Properties for Flame-Resistant Garments

<table>
<thead>
<tr>
<th>Property (Section No.)</th>
<th>Test Method Cited</th>
<th>Description of Test Method</th>
<th>Application of Test Method</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mandatory Tests</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heat transfer</td>
<td>Method appears in Section 8.2.</td>
<td>A 150 mm (6 in.) square fabric specimen is placed on a specimen holder that suspends the specimen horizontally over two Meker burners and a radiant panel. The heat and flame source is adjusted to provide an exposure heat flux of 84 kW/m² (2.0 cal/cm² · sec). A weighted sensor containing a copper calorimeter is placed on top of the specimen and measures the heat transfer through the specimen. A water-cooled shutter between the specimen and heat source is withdrawn to begin the exposure. The test measures the amount of time with continuous heating for heat breakthrough resistance (using an arbitrary criterion of heat through the specimen to cause a second-degree burn). This time is multiplied by the exposure heat flux to provide an HTP rating. HTP ratings are measured with the sensor both in “contact” with the specimen and “spaced” 6 mm (¼ in.) away from the specimen. Note that this test method does not result in a burn injury prediction. The heat remaining in a test sample is not accounted for, which would otherwise contribute to a predicted skin burn injury.</td>
<td>This test is a measure of the unsteady state heat transfer properties of garment materials. The HTP test uses an exposure heat flux that is representative of a JP4 jet fuel pool fire environment. NFPA 2112 requires that specimens have an HTP rating of 12.6 J/cm² (3.0 cal/cm²) or more when measured in “contact,” simulating direct contact with the skin, and 25 J/cm² (6.0 cal/cm²) or more when measured “spaced,” simulating an air gap between the skin and the garment material. Higher HTP ratings indicate better unsteady state heat transfer performance for this test but do not correlate to improved predicted skin burn injury performance.</td>
</tr>
<tr>
<td>Flame resistance</td>
<td>ASTM D6413 D6413 ; washing and drying per commercial laundering procedure or dry cleaning (100 cycles) (Section 8.3)</td>
<td>A 75 mm × 305 mm (3 in. × 12 in.) fabric specimen is placed in a holder that is suspended vertically over a 38 mm (1½ in.) high methane-fueled flame. The specimen is placed 19 mm (¾ in.) into the flame for 12 seconds. After exposure to the flame, the amount of time during which the specimen continues to burn (after-flame) is recorded. The length of the burn or char length is then measured by attaching a weight to the specimen and measuring the length of the tear along the burn line. Observations are recorded if any melting and dripping are observed. Samples are tested in this manner both before and after 100 wash/dry cycles or 100 dry cleaning cycles.</td>
<td>This test is used to determine how easily fabrics ignite and how easily they continue to burn once ignited. In order to pass NFPA 2112, materials cannot have an average after-flame time greater than 2 seconds, a char length greater than 102 mm (4 in.), or any melting with dripping.</td>
</tr>
<tr>
<td>Property (Section No.)</td>
<td>Test Method Cited</td>
<td>Description of Test Method</td>
<td>Application of Test Method</td>
</tr>
<tr>
<td>------------------------</td>
<td>-------------------</td>
<td>----------------------------</td>
<td>---------------------------</td>
</tr>
<tr>
<td><strong>Mandatory Tests</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermal shrinkage resistance (7.1.3)</td>
<td>Method appears in Section 8.4; washing and drying per commercial laundering procedure or dry cleaning (3 cycles)</td>
<td>A 381 mm (15 in.) square fabric specimen is marked for width and length dimensions and is then suspended in a forced air–circulating oven at 260°C (500°F). Following a 5-minute exposure, the specimen dimensions are remeasured and then compared against the original measurements to determine the amount of shrinkage. The specimen is examined for evidence of melting, dripping, separation, or ignition. Specimens that demonstrate such behavior fail the test.</td>
<td>A fabric's resistance to shrinkage of a fabric when exposed to heat is considered important in minimizing the effects of a flash short-duration thermal exposure from fire. NFPA 2112 permits shrinkage in this laboratory-based test of 10 percent or less. Lower reported shrinkage indicates fabric that is more resistant to thermal shrinkage.</td>
</tr>
<tr>
<td>Heat resistance (7.1.4/Section 7.3)</td>
<td>Method appears in Section 8.4; washing and drying per commercial laundering procedure or dry cleaning (3 cycles)</td>
<td>The exposure used for thermal shrinkage is also used for measuring heat resistance. Fabrics or garment components not required to meet thermal shrinkage requirements can be 152 mm (6 in.) square specimens. Following a 5-minute exposure, the specimen is examined for evidence of melting and dripping, separation, or ignition. Specimens that demonstrate such behavior fail the test. The test is also applied to hardware items.</td>
<td>This test measures how garment fabrics and components react to the high heat that could occur during a flash short-duration thermal exposure from fire. The purpose of the test is to prevent materials or components that will easily ignite, melt, drip, or separate during exposure to high heat from being used in garments.</td>
</tr>
<tr>
<td>Manikin testing (7.1.5)</td>
<td>ASTM E 1930; washing and drying per commercial laundering procedure or dry cleaning (1 cycle) (Section 8.5)</td>
<td>The fabric is made into a standardized coverall design and placed on an instrumented manikin that is dressed in cotton underwear. The manikin is subjected to an overall flame and heat exposure averaging 84 kW/m² (2.0 cal/cm² · sec) for 3 seconds. Sensors embedded in the manikin's skin predict whether a second- or third-degree burn will occur at that specific location. A computer program determines the percentage of the body that would sustain second- or third-degree burns.</td>
<td>This test provides an overall evaluation of how the fabric performs in a standardized coverall design. NFPA 2112 requires a body burn prediction of 50 percent or less of the surface area covered by sensors (hands and feet are excluded). Lower percent body burn predictions indicate greater protection provided by the fabric.</td>
</tr>
<tr>
<td>Thread melting resistance (Section 7.2)</td>
<td>FTMS 191A, 1534 (Section 8.6)</td>
<td>A small segment of thread used in the stitching of station/work uniforms is placed in a flask containing an organic solvent and heated. (The solvent extracts substances that would interfere with the test.) Next, the extracted thread segment is put in a device that slowly heats the thread. The temperature at which the thread begins to melt is the melting temperature.</td>
<td>Thread used in flame-resistant garments must withstand temperatures of up to 260°C (500°F). If the melting temperature is less than 260°C (500°F), the thread fails the test. The temperature, 260°C (500°F), is consistent with the heat resistance test.</td>
</tr>
<tr>
<td>Label legibility (Section 7.4)</td>
<td>Method appears in Section 8.7; washing and drying per commercial laundering</td>
<td>Sample labels containing the required product information are subjected to 100 wash/dry or dry cleaning cycles and then examined for legibility.</td>
<td>This requirement checks for label durability. Following this test, the labels must remain legible from a distance of at least 305 mm (12 in.).</td>
</tr>
<tr>
<td>Property (Section No.)</td>
<td>Test Method Cited</td>
<td>Description of Test Method</td>
<td>Application of Test Method</td>
</tr>
<tr>
<td>------------------------</td>
<td>-------------------</td>
<td>-----------------------------</td>
<td>---------------------------</td>
</tr>
<tr>
<td><strong>Mandatory Tests</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>procedure or dry cleaning (100 cycles)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Other Property Evaluations</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fabric weight</td>
<td>ASTM D 3776 D3776</td>
<td>A known, specific area of fabric is weighed using a laboratory balance. The measured fabric weight is divided by the area of the fabric. This yields a fabric weight in ounces per square yard.</td>
<td>Fabric weights are commonly used to reference materials.</td>
</tr>
<tr>
<td>Tensile strength (grab method)</td>
<td>ASTM D 5034 D5034</td>
<td>In this test, a 102 mm × 204 mm (4 in. × 8 in.) fabric specimen is placed between the two grips of a tensile testing machine and pulled in the direction of the specimen's long axis until it breaks. The force measured at the site of the break is reported as the tensile strength. Tensile strength is reported for both the warp (machine) and fill (cross-machine) directions of the fabric.</td>
<td>Tensile strength is a measurement that describes the ease with which a woven material can be pulled apart. Higher tensile strengths indicate greater fabric strength.</td>
</tr>
<tr>
<td>Tear strength (Elmendorf method)</td>
<td>ASTM D 4424 D1424</td>
<td>In this test, a notched 102 mm × 204 mm (4 in. × 8 in.) material specimen is placed into a test device. The test device uses a pendulum that is allowed to fall by its own weight. The force of the falling pendulum tears the material beyond the notch. This test measures the force in pounds that is required to continue a tear in the notched test specimen. Tear resistance is reported for both the warp (machine) and fill (cross-machine) directions of the fabric.</td>
<td>Tear resistance is a measurement of the ease with which a woven fabric can be torn apart. Higher tear strengths indicate fabrics with greater resistance to tearing.</td>
</tr>
<tr>
<td>Material burst strength</td>
<td>ASTM D 3787 D3787</td>
<td>This test measures the force required to burst a knit or stretch woven fabric. A material specimen is clamped over a diaphragm that is inflated until the specimen bursts. The pressure at which the fabric bursts is the burst strength.</td>
<td>Burst strength is a measure of how easily a knit fabric can be penetrated by a hard round object. Higher burst strength indicates fabrics that are more resistant to bursting.</td>
</tr>
<tr>
<td>Laundering shrinkage</td>
<td>AATCC 135; machine cycle 3; wash temp. IV; and drying procedure Aii (number of cycles to be specified)</td>
<td>A fabric specimen, on which dimensions are marked and measured in both its width and length, is subjected to a specified number of separate wash/dry cycles under controlled conditions. Following the washing and drying, the dimensions of the material sample are compared to its original dimensions to determine the amount of shrinkage. Shrinkage is reported in both the warp (machine) and fill (cross-machine) directions of the fabric.</td>
<td>Laundering shrinkage is a measure of the percentage a fabric shrinks after laundering. Shrinkage measured for a fabric is not necessarily representative of shrinkage measured for a garment.</td>
</tr>
<tr>
<td>Laundering colorfastness</td>
<td>AATCC 61; color change procedure</td>
<td>A fabric sample is subjected to controlled washing and drying conditions. Following exposure, the color of the material sample is compared to a color scale chart that</td>
<td>Laundering colorfastness assesses the amount of color change, or fading, that occurs in the fabric following exposure to washing and drying. Fabrics</td>
</tr>
<tr>
<td>Property (Section No.)</td>
<td>Test Method Cited</td>
<td>Description of Test Method</td>
<td>Application of Test Method</td>
</tr>
<tr>
<td>------------------------</td>
<td>-------------------</td>
<td>-----------------------------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td><strong>Mandatory Tests</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>indicates the degree of a color change. Color scale ratings range from Grade 1 (change in color) to Grade 5 (negligible or no change) in 0.5 increments.</td>
<td>with high color scale ratings are more resistant to color changes in laundering.</td>
</tr>
<tr>
<td>Dry cleaning colorfastness</td>
<td>AATCC 132</td>
<td>A fabric sample is subjected to controlled dry cleaning conditions. Following exposure, the color of the material sample is compared to a color scale chart that indicates the degree of a color change. Color scale ratings range from Grade 1 (change in color) to Grade 5 (negligible or no change) in 0.5 increments.</td>
<td>Dry cleaning colorfastness assesses the amount of color change, or fading, that occurs in the fabric following exposure to dry cleaning solvents. Fabrics with high color scale ratings are more resistant to color changes in dry cleaning.</td>
</tr>
<tr>
<td>Crocking colorfastness</td>
<td>AATCC 8</td>
<td>In this test method, a fabric sample is placed in a device against a white transfer cloth. The device rubs the fabric against the transfer cloth. The amount of color that is transferred to the white transfer cloth is assessed by a rating scale of Grade 1 to 5 in 0.5 increments (similar to laundering colorfastness).</td>
<td>Crocking colorfastness is a measure of the amount of color or dye that is transferred from the fabric by rubbing or abrasion. Fabrics with high color scale ratings are more resistant to loss of color through rubbing from wearing.</td>
</tr>
<tr>
<td>Light colorfastness, continuous xenon-arc lamp exposure</td>
<td>AATCC 16, Option e</td>
<td>A fabric specimen is placed in a weatherometer using a water-cooled xenon-arc lamp, which simulates intense exposure to sunlight and humidity. The exposure test is conducted for a total of two weeks. Following the exposure, the fabric is compared to a color scale chart that indicates the degree of color change. Color scale ratings range from Grade 1 to 5 in 0.5 increments (similar to laundering colorfastness).</td>
<td>Light colorfastness is a measure of the amount of color loss in a fabric due to extended exposure to light. Fabrics with high color scale ratings are more resistant to fading when exposed to outdoor light.</td>
</tr>
<tr>
<td>Seam efficiency</td>
<td>ASTM D 1683 D1683</td>
<td>The strength of a seam is measured in the same way as fabric tensile strength. In this test, a garment seam specimen is placed between two grips in a tensile testing machine and pulled in a direction perpendicular to the seam line until it breaks. The force to break the seam can be compared to the force to break the fabric by itself. The location of the break in the specimen can also be reported.</td>
<td>Seam efficiency compares the strength of a seam to the fabric that it joins. Higher seam strength indicates stronger seams; however, seams that break in the fabric, as opposed to at the stitching or seam area, are stronger than the fabric itself.</td>
</tr>
</tbody>
</table>

**Submitter Information Verification**

Submitter Full Name: Eric Nette  
Organization: [ Not Specified ]  
Street Address:  
City:  
State:  
Zip:
Committee Statement

Committee Statement: The standard was changed to maintain consistency with NFPA 2113. This document represents minimum specifications of clothing for egress of workers with the intent of not contributing to the burn injury of the wearer, providing a degree of protection to the wearer, and reducing the severity of burn injuries resulting from short-duration thermal exposures or accidental exposure to flash fires.

Response Message:

Public Input No. 51-NFPA 2112-2014 [Section No. B.1]
Annex C  Informational References

C.1  Referenced Publications.
The documents or portions thereof listed in this annex are referenced within the informational sections of this standard and are not part of the requirements of this document unless also listed in Chapter 2 for other reasons.

C.1.1  NFPA Publications.
National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

C.1.2  Other Publications.
C.1.2.1  AATCC Publications.
American Association of Textile Chemists and Colorists, P.O. Box 12215, Research Triangle Park, NC 27709.
AATCC 132, Colorfastness to Dry Cleaning, 2009 2013.

C.1.2.2  ASTM Publications.
ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959.
C.1.2.3 GSA Publications.
U.S. General Services Administration, 1800 F Street, N.W., Washington, DC 20405.

C.1.2.4 ISO Publications.
International Organization for Standardization, 1, rue de Varembé, Case postale 56, CH-1211, Geneve 20, Switzerland.

C.1.2.5 U.S. Government Publications.
Title 21, Code of Federal Regulations, Part 7, Subpart C.

C.2 Informational References.
The following documents or portions thereof are listed here as informational resources only. They are not a part of the requirements of this document.


C.2.1 ANSI Publications.
American National Standards Institute, Inc., 25 West 43rd Street, 4th Floor, New York, NY 10036.


C.2.1 Other Publications.
C.3 References for Extracts in Informational Sections.
(Reserved)

Submitter Information Verification

Submitter Full Name: Eric Nette
Organization: [ Not Specified ]
Street Address:
City:
State:
Zip:
Submittal Date: Tue Nov 04 10:12:21 CST 2014

Committee Statement

Committee Statement: Referenced current editions and titles. Draft standards will not be referenced at this time.
Response Message:
Public Input No. 28-NFPA 2112-2014 [Chapter C]

http://submittals.nfpa.org/TerraViewWeb/ContentFetcher?commentPara...