Enclosed is the agenda package for the September 6-8, 2016 meeting for the NFPA 2112 Second Draft Meeting. Please ensure that you have reviewed the public comments and the other agenda items in advance to prepare for discussion. The agenda and public input will be posted on the document information pages (www.nfpa.org/2112next).

Some items to have available during the meeting include:

- Agenda package with public comments
- A copy of NFPA 2112 (visit the NFPA 2112 Document information pages for your free committee copy)
- Any previous copies of the technical committees standard
- A laptop

Optional items that are sometimes useful include:


If you have any questions or comments, please feel free to reach me at (617) 984-7434 or by e-mail at enette@nfpa.org. I look forward to our meeting to begin the revision cycle!
1. Meeting opening, introduction and attendance

2. Approval of First Draft Meeting Minutes of November 4-6, 2014 (Attachment A. November 4-6, 2014 Meeting Minutes).

3. Chair's remarks, Steven Corrado

4. Staff Liaison update:
   b. Committee Membership Update (Attachment C. FLG-AAA Membership)

5. Old/New Business – Order of Consideration/Schedule for Task Group Work and Public Comments
   a. Task Group Reports
      i. ASTM F 1930 Task Group Report
      ii. New Garment Task Group Report
   b. Public Comments for NFPA 2112 (Attachment E. NFPA 2112 - A2017 Public Comments)
      i. Categorized (Attachment F. Public Comments Categorization)

6. Other business

7. Date/Location of Next Meeting. TBD, next meeting will be during the next revision cycle

8. Adjournment

Attachments:
A. November 4-6, 2014 Meeting Minutes
B. A2017 – Revision Cycle
C. FLG-AAA Committee Membership
D. NFPA Process – Quick Reference Guide
E. NFPA 2112 - A2017 Public Comments
F. Public Comments Categorization
Attachment A:
November 4-6, 2014
Meeting Minutes
TECHNICAL COMMITTEE ON FLASH FIRE PROTECTIVE GARMENTS

TO: TECHNICAL COMMITTEE ON FLASH FIRE PROTECTIVE GARMENTS
FROM: Eric Nette, Staff Liaison
DATE: November 12, 2014
SUBJ: NFPA 2112 FLG-AAA Minutes of November 4-6, 2014, First Draft Meeting (New Orleans, LA)

I. Attendance:

Members and Alternates:

Steven Corrado, Committee Chair, UL LLC
Terry Clark, Anadarko Petroleum Corporation
Doug Dale, University of Alberta (Phone)
Alec Feldman, JOIFF-International Organization for Industrial Hazard Management
Darren Hewston, Plains Exploration & Production Company
Pamela Kavalesky, Intertek Testing Services (Phone)
Stacy Klausing, Arcwear
Joshua Moody, Milliken & Company/Westex, Inc.
Roger Parry, The DuPont Company, Inc.
Mark Saner, Workrite Uniform Company, Inc.
Brian Shiels, PBI Performance Products, Inc.
Brian Spears, NFPA Industrial Fire Protection Section
Michael Stanhope, TenCate/Southern Mills, Inc.
Denise Statham, VF Imagewear/Bulwark Protective Apparel
David Wedge, Draper Knitting Company, Inc.
Tricia Hock, Safety Equipment Institute (Phone)
Amanda Newsom, Underwriters Laboratories, Inc.
Eric Nette, NFPA, Staff Liaison

Guests:
John Kohler, Springfield LLC
Chris Atkinson, Aitex
Craig Tutterow, Mount Vernon Mills
II. Minutes of Meeting:

1. The Chair opened the meeting at 8:00 a.m., Tuesday November 4, 2014.
2. Attendees introduced themselves and necessary corrections were made to the Technical Committee roster.
3. The Staff Liaison reported on the current committee roster and member status.

<table>
<thead>
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<td>Alternate Members:</td>
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</table>

4. Staff introduced and reviewed NFPA’s standards development process.
5. Previous Meeting Minutes were approved by the Committee.
6. The Committee discussed outstanding issues in regards to updating the standard to accommodate the new edition of ASTM F 1930.
   i. A Committee Input (CI-25) was issued as a placeholder for any necessary Second Revisions pending results from a Task Group that was formed during this meeting
   ii. Task Group Membership consists of the following volunteers, subject to change:
       1. Denise Statham (Chair)
       2. Brian Shiels
       3. Roger Parry
       4. Chris Atkinson
       5. Josh Moody
       6. Doug Dale
       7. Michael Stanhope
       8. Sean Deaton
9. Harry Winer
10. Craig Tutterow
7. Vincent Diaz representing Atlantic Thread gave a presentation introducing his Public Inputs and the reasoning behind them.
8. Jeffrey Stull representing International Personnel Protection, Inc. gave a presentation introducing his Public Inputs and the reasoning behind them.
9. North Carolina State University made a presentation on their test method titled “PyroHands” and “Pyrohead” for possible inclusion in the standard.
10. The Committee responded to 72 Public Inputs and created 72 First Revisions to NFPA 2112. A single Committee Input was made by the committee as noted in item 6.i above.
11. The Committee formed a Task Group to evaluate the changes to NFPA 2112 with the addition of new clothing items (Hood/Balaclava/Shroud, Gloves and Rainwear) to ensure the entire document was changed and addresses the new topic sufficiently.
   i. Task Group Membership consists of the following volunteers, subject to change
      1. Michael Stanhope (Chair)
      2. Jeffrey Stull
      3. Tricia Hock
      4. Stacey Klausing
      5. Dave Wedge
      6. Josh Moody
      7. Amanda Newsom

12. **Next Meeting.** The Committee’s next meeting will be NFPA 2112 Second Draft Meeting. The Committee proposed the next meeting to be around November, 2015. The exact date will be determined later, but it will most likely be in Portland, Oregon.
13. The Chair thanked everyone for their input. The Committee Meeting was adjourned at 4:45 p.m., on Thursday November 6, 2014.

Respectfully submitted,

Eric Nette, NFPA, Staff Liaison
Attachment B:
A2017 Revision Cycle
NFPA 2112 Revision Cycle
KEY DATES
Annual 2017

NFPA 2112 A2017 [FLG-AAA]

Important Dates For the Cycle:

Public Comment Closing May 16, 2016 (DONE)
Posting of Second Draft December 12, 2016
Notice of Intent to Make Motion (NITMAM) February 20, 2017
Issuance of Consent Standard May 12, 2017 (published bit later)
NFPA Annual Meeting with CAMs June 4-7, 2017
Issuance of Standard – with CAMs August 10, 2017 (published bit later)
Attachment C:
FLG-AAA Committee Membership
Attachment D:
NFPA Process – Quick Reference Guide
New Process (Second Draft Stage) – Quick Reference Guide

For additional information on the New Regulations visit: www.nfpa.org/NewRegs

A Technical Committee (TC) can take these actions at the Second Draft (ROC) meeting:
   1. Resolve a Public Comment
      - Accept
      - Reject, But See Related Second Revision
      - Reject
      - Reject But hold
   2. Create a Second Revision

**NOTE:** All actions require a Committee Statement.

Resolve Public Comment (TC needs to act upon all the Public Comments)
- **Accept**
  - The TC takes the text exactly as submitted by the public comment and creates a second revision.
  - Sample Motion: “I move to accept PC#__.”
  - Approval by meeting vote (simple majority) and final approval through ballot.
- **Reject but See**
  - The TC agrees with the concept of the PC in whole or part but wants to edit the text to create a second revision.
  - Sample Motions:
    - “I move to reject PC#__, but create a second revision using it as a basis.”
    - “I move to make a second revision using PC#__ as a basis.”
  - Approval by meeting vote (simple majority) and final approval through ballot.
- **Reject**
  - The TC disagrees with the proposed changes in the public comment.
  - Sample Motion: “I move to reject PC#__.”
  - Approval by meeting vote (simple majority). Not subject to ballot.
- **Reject, but Hold.**
  - The TC may hold any comment until the public input stage of the next revision cycle meeting any of the following criteria:
    - New concept that has not had any public review
    - The changed text would require the technical committee to restudy the change
    - The proposed concept cannot be handled in the second draft timeframe
  - Sample Motion: “I move to hold PC#__.”
  - Approval by meeting vote (simple majority). Not subject to ballot.

Create a Second Revision (change to the document)
- TC must create a Second Revision (SR) for each change they wish to make to the document. The TC can either choose to use a Public Comment for the basis of the change or not.
• Using Public Comment for basis:
  
  i. See above for **ACCEPT** or **REJECT BUT SEE**.

• Without using Public Comment for basis

  i. Sample Motion: “I make a motion to revise section ___ as follows __.”
     Approval by meeting vote (simple majority) and final approval through ballot.
### Comparison to Previous Process:

<table>
<thead>
<tr>
<th>PREVIOUS ACTIONS</th>
<th>NEW PROCESS ACTIONS</th>
<th>Sample Motion</th>
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</thead>
</table>
| Accept           | 1) Committee generates a Second Revision and Substantiation (CS) for change  
                  2) Committee provides response (CS) to each PC. | 1) “I move to accept PC#__.” |
|                  |                     |               |
| Any variation of Accept (APA, APR, APP) on a public comment | 1) Committee rejects the comment, but creates a Second Revision  
                  2) Committee provides response (CS) to each PC that is associated with the revision | 1) “I move to revise section__ using PC#__ as the basis for change.”  
                  2) “I move to reject PC#__, but create a second revision using it as a basis.” |
| Rejected Public Comment | 1) Committee rejects the comment  
                           2) Committee provides response (CS) to PC | “I make a motion to reject PC#__ with the following committee statement__.” |
| Accepted Committee Comment | Committee generates a Second Revision and Substantiation (CS) for change | “I make a motion to revise section__ as follows__.”  
                              Committee generates a statement for reason for change. |

**Notes:**

1) All meeting actions require a favorable vote of a simple majority of the members present.
2) All Second Revisions will be contained in the ballot and will require a 2/3 affirmative vote to confirm the meeting action.
3) Only the Second Revisions will be balloted. PCs will be contained in the report but will not be balloted.
## Term Comparison between Current and Old:

<table>
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<th>OLD TERM</th>
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<td>ROP Stage</td>
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<td>Committee Input</td>
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<td>ROC</td>
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<tr>
<td>Second Draft</td>
<td>ROC Draft</td>
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</tbody>
</table>

Note: The highlighted terms are the ones that will be most applicable at the Second Draft Meeting.
Attachment E:
NFPA 2112 – A2017
Public Comments
Recommendations:
Delete all paragraphs of Section 7.7 with exception of 7.7.8 (label legibility)
Remove other references to rainwear where part of test methods not including label legibility
Add new paragraph to Section 7.7
7.7.1 Rainwear shall be tested to the performance requirements specified in ASTM F2733, Standard Specification for Flame Resistant Rainwear for Protection Against Flame Hazards.
Add new paragraph to Chapter 6
6.4 Rainwear Construction
6.4.1 Rainwear shall be required to meet the construction requirements specified in ASTM F2733, Standard Specification for Flame Resistant Rainwear for Protection Against Flame Hazards.

Statement of Problem and Substantiation for Public Comment

The First Draft Report has not provided sufficient substantiation for incorporating the HTP and other requirements into the standard’s expanded scope that now includes rainwear. Substantiation is needed to determine how these requirements will address relevant FR rainwear performance needs.

The Fire and Emergency Services Protective Clothing and Equipment Correlating Committee has established a set of guidelines for implementing new test methods and performance criteria. These guidelines are certainly relevant when expanding the scope of existing standards to a user group or industry.

In part the guidelines include:
• Showing that tests provide relevant forms of evaluation.
• Establishing requirements that prevent proper testing or consideration of product technologies because the test method or criteria is design restrictive.

The criteria further go on to say that consideration should be given to the impact of test methods on products that have been certified or fielded.

Garments can now be certified to ASTM F2733, an existing rainwear standard for protection against flame hazards. Comparing the requirements of ASTM F2733 to the proposed NFPA 2112 Draft, the HTP and other requirements essentially add additional performance criteria and tests to a particular class of garments. Documentation is needed to show that the additional test methods are relevant to users and represent performance levels required for the application. It is questionable that the other test methods and criteria within the standard that are used for uniform like products be applied to rainwear.

The proposed changes bring rainwear into the NFPA 2112 standard but limit the additional criteria beyond ASTM F2733 to label legibility, a notable improvement. The suggested language also provides for the third party certification of FR rainwear that is currently not required by ASTM F2733.

Related Item
First Revision No. 37-NFPA 2112-2014 [New Section after 7.4]

Submitter Information Verification

Submitter Full Name: William Gorak
Organization: WL Gore & Associates
Public Comment No. 104-NFPA 2112-2016 [Global Input]

See attached for mandatory flame resistance testing of large labels.

Additional Proposed Changes

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<td>Proposed_Changes_to_NFPA_2112_for_FR_Emblems.docx</td>
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</table>

Statement of Problem and Substantiation for Public Comment

Currently labels are excluded from flame resistance testing but some manufacturers may introduce relatively large labels onto the exterior of the garment that pose potential safety hazards to the wearer in the case of accidental contact or flash fire events.

Related Item

Public Input No. 62-NFPA 2112-2014 [New Section after 7.4]

Submitter Information Verification

Submitter Full Name: Jeffrey Stull
Organization: International Personnel Protection, Inc.
Street Address:  
City:  
State:  
Zip:  
Submittal Date:  Mon May 16 16:54:08 EDT 2016
Proposed Changes to NFPA 2112 to Address Flame and Heat Resistance Testing of Emblems

Green highlighted language indicates material address changes specific to emblems
Yellow highlighted language indicates material from NFPA 2112 TIA 12-2

Chapter 2 Referenced Publications

Add reference


Chapter 3 Definitions

Add asterisk to indicate related annex material

3.3.9* Emblem(s). Shields, heraldry, or printing that designates a governmental entity or a specific organization; rank, title, position, or other professional status that is painted, screened, embroidered, sewn, glued, bonded, or otherwise attached in a permanent manner.

Chapter 7 Performance Requirements

Make changes as indicated by underlined or strikeout text

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 afterflame of not more than 2 seconds, and shall not melt and drip.

7.1.2.1 Emblems that are placed on exterior of the garment that are in excess of 25.8 cm² (4.0 in²) in total area shall be tested for flame resistance as specified in Section 8.3 and shall not have an afterflame of not more than 2 seconds, and shall not melt and drip.

7.1.4 Fabric, cold weather insulation material, other textile materials, and reflective striping, emblems placed on the exterior of the garment that are 25.8 cm² (4.0 in²) or less in total area, 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.

7.1.4.1 Labels, and emblems placed on the exterior of the garment that are 25.8 cm² (4.0 in²) or less in total area, shall not be required to be tested for heat resistance.

7.1.4.2 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.

Chapter 8 Test Methods

Make changes as indicated by underlined or strikeout text

8.3 Flame Resistance Test.
8.3.1 Application.
8.3.1.1 This test method shall apply to each flame-resistant garment fabric layer.
8.3.1.2 Modifications to this test method for testing woven textile materials shall be as specified in 8.3.8.
8.3.1.3 Modifications to this test method for testing knit textile materials shall be as specified in 8.3.9.
8.3.1.4 Modifications to this test method for testing nonwoven textile materials shall be as specified in 8.3.10.
8.3.1.5 Modifications to this test method for testing small specimens and emblems, other than transfer films, not meeting the specimen size requirements of 8.3.2 shall be as specified in 8.3.11.
8.3.1.6 Modifications to this test method for testing reflective striping shall be as specified in 8.3.12.
8.3.1.7 Modifications to this test method for testing cold weather insulation materials shall be as specified in 8.3.13.

8.3.2 Specimens.
8.3.2.1 Each specimen shall consist of a 76 mm × 305 mm (3 in. × 12 in.) rectangle with the long dimension parallel to either the warp or filling, the wale or course, or machine or cross-machine direction of the material.
8.3.2.2 Each individual layer of multilayer material systems or composites shall be separately tested.

8.3.3 Sample Preparation.
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 dry cleaning as specified in 8.1.4.

8.3.4 Apparatus. The test apparatus shall be that specified in ASTM D 6413, Test Method for Flame Resistance of Textiles (Vertical Test).

8.3.5 Procedure.
8.3.5.1 Flame resistance testing shall be performed in accordance with ASTM D 6413, Test Method for Flame Resistance of Textiles (Vertical Test).
8.3.5.2 Each specimen shall be examined for evidence of melting and dripping.

8.3.6 Report.
8.3.6.1 After-flame time and char length shall be reported for each specimen.
8.3.6.2 The average after-flame time and char length for each material shall be calculated and reported.
8.3.6.3 The after-flame time shall be reported to the nearest 0.2 second, and the char length to the nearest 3.2 mm (1/8 in.).
8.3.6.4 Observations of melting and dripping for each specimen shall be reported.

8.3.7 Interpretation.
8.3.7.1 Pass/fail performance shall be based on any observed melting and dripping, the average after-flame time, and average char length.
8.3.7.2 Failure in either direction shall constitute failure of the material.

8.3.8 Specific Requirements for Testing Woven Textile Materials.
8.3.8.1 Five specimens from each of the warp and filling directions shall be tested.
8.3.8.2 No two warp specimens shall contain the same warp yarns, and no two filling specimens shall contain the same filling yarns.
8.3.8.3 Testing shall be performed as described in 8.3.2 through 8.3.7.

8.3.9 Specific Requirements for Testing Knit Textile Materials.
8.3.9.1 Five specimens from each of the two directions shall be tested.
8.3.9.2 Samples for conditioning shall include material that is a minimum of 76 mm × 305 mm (3 in. × 12 in.).
8.3.9.3 Testing shall be performed as described in 8.3.2 through 8.3.7.

8.3.10 Specific Requirements for Testing Nonwoven 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.

8.3.11 Specific Requirements for Testing Small Materials and Emblems other than Transfer Films.
8.3.11.1 Five specimens attached to the textile layer as used in the protective garment shall be tested.
8.3.11.1.1 For the purpose of this testing, the textile layer shall be permitted to be of navy 200 g/m² (6.0 oz/yd²), 100 percent aramid material.
8.3.11.1.2 When tested, emblems shall be attached to the textile layer in the same manner as normally used for attaching emblems to garment fabric.
8.3.11.2 The specimens shall be attached to the textile layer such that the bottom (exposure) edge of the item coincides with the bottom (exposure) edge of the textile support layer.
8.3.11.3 Testing shall be performed as described in 8.3.2 through 8.3.7, except char length shall not be measured.

8.3.12 Specific Requirements for Testing Reflective Striping.
8.3.12.1 Five reflective striping specimens for flammability testing shall be prepared by attaching the reflective striping to 76 mm × 305 mm (3 in. × 12 in.) pieces of fabric utilized in the construction of the garment, in the manner that it is normally attached to the fabric.
8.3.12.2 The reflective striping shall be oriented parallel to the long axis and in the center of the fabric.
8.3.12.3 Testing shall be performed as described in 8.3.2 through 8.3.7, except char length shall not be measured.

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/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.
8.3.13.2 Following wash or dry-clean conditioning, 5 specimens measuring 75 mm × 300 mm (3 in. × 12 in.) from each of the warp and filling direction shall be removed from the cold weather insulation material layer of the conditioned panels.
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.

Specific Requirements for Testing Transfer Films.

Transfer films shall be applied to individual specimens of the textile layer as used in the protective garment.

Five specimens from each of the warp and filling directions of the textile layer shall be tested.

Each specimen shall consist of a 76 mm × 306 mm (3 in. × 16 in.) rectangle with the long dimension parallel to the warp or filling direction of the material. The transfer film shall be placed in the center of the specimen with a minimum width of 25 mm (1 in.) and a minimum length of 100 mm (4 in.), oriented with respect to the textile short and long dimension, respectively employing the same technique that is normally used in applying the transfer film on garment fabrics.

Specimens shall be tested in accordance with ASTM D 6413, Test Method for Flame Resistance of Textiles (Vertical Test) with the exception that the folded specimen mounting described in paragraphs 9.3 and 9.3.2 of ASTM F 1358, Standard Test Method for Effects of Flame Impingement on Materials Used in Protective Clothing Not Designated Primarily for Flame Resistance, shall be used.

Char length shall not be measured.

Heat and Thermal Shrinkage Resistance Test.

The heat and thermal shrinkage resistance test method shall be applied to flame-resistant garment fabrics, components, and hardware.

This test method shall apply to flame-resistant garment fabrics, components, hardware, and cold weather insulation materials.

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

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

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

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

Modifications to this test method for testing emblems, including transfer films, shall be as specified in 8.4.12.

Specimens.

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, and cold weather insulation materials not listed in 8.4.2.2 and 8.4.2.3.

Both heat and thermal shrinkage resistance testing shall be conducted on a minimum of three specimens for each flame-resistant garment fabric.

Each separable layer of multilayer material systems or composites shall be tested as an individual layer.

Sample Preparation.
8.4.3.1 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 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 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 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.

8.4.4 Apparatus.

8.4.4.1 The test oven shall be a horizontal flow circulating oven with minimum interior dimensions to permit the specimens to be suspended and be not less than 51mm (2 in.) from any interior oven surface or other test specimens.

8.4.4.2 The test oven shall have an airflow rate of 38 m/min to 76 m/min (125 ft/min to 250 ft/min) at the standard temperature and pressure of 21°C (70°F) at 1 atm, measured at the center point of the oven.

8.4.4.3 A test thermocouple shall be positioned so that it is level with the horizontal centerline of a mounted sample specimen.

8.4.4.3.1 The thermocouple shall be equidistant between the vertical centerline of a mounted specimen placed in the middle of the oven and the oven wall where the airflow enters the test chamber.

8.4.4.3.2 The thermocouple shall be an exposed bead, Type J or Type K, No. 30 AWG thermocouple.

8.4.4.3.3 The test oven shall be heated and the test thermocouple stabilized at 260°C +6/−0°C (500°F +10/−0°F) for a period of not less than 30 minutes.

8.4.5 Procedure.

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

8.4.5.2 The specimen shall be suspended by metal hooks at the top and centered in the oven so that the entire specimen is not less than 51 mm (2 in.) from any oven surface or other specimen and airflow is parallel to the plane of the material.

8.4.5.3 The oven door shall not remain open more than 15 seconds.

8.4.5.3.1 The air circulation shall be shut off while the door is open and turned on when the door is closed.

8.4.5.3.2 The total oven recovery time after the door is closed shall not exceed 30 seconds.

8.4.5.4 The specimen, mounted as specified, shall be exposed in the test oven for 5 minutes +0.15/−0 minutes.

8.4.5.5 The test exposure time shall begin when the test thermocouple recovers to a temperature of 260°C +6/−0°C (500°F +10/−0°F).

8.4.5.6 Immediately after the exposure specified in 8.4.5.4, the specimen shall be removed and examined for evidence of ignition, melting and dripping, or separation.

8.4.5.7 Determination of “pass” or “fail” shall be made within 5 minutes of removal from the oven.
8.4.5.8 Knit fabric shall be pulled to original dimensions and shall be allowed to relax for 1 minute prior to measurement to determine “pass” or “fail.”

8.4.6 Report.
8.4.6.1 Observations of ignition, melting and dripping, or separation shall be reported for each specimen.
8.4.6.2 The percent change in the width and length dimensions of each specimen shall be calculated, and the results shall be reported as the average of all three specimens in each dimension.

8.4.7 Interpretation.
8.4.7.1 Any evidence of ignition, melting and dripping, or separation on any specimen shall constitute failing performance.
8.4.7.2 The average percent change in both dimensions shall be used to determine pass/fail performance.
8.4.7.3 Failure in any one dimension shall constitute failure for the entire sample.

8.4.8 Specific Requirements for Testing Flame-Resistant Garment Textile Materials.
8.4.8.1 Each specimen shall be 381 mm ± 13 mm × 381 mm ± 13 mm (15 in. ± 0.5 in. × 15 in. ± 0.5 in.) and shall be cut from the fabric to be utilized in the construction of the clothing item.
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.
8.4.8.3.4.8.2 Testing shall be performed in accordance with 8.4.2 through 8.4.7.

8.4.9 Specific Requirements for Testing Other Flame-Resistant Garment Materials (Including Reflective Striping).
8.4.9.1 Specimen length shall be 152 mm (6 in.), except for textiles utilized in the clothing item in lengths less than 152 mm (6 in.), where lengths shall be the same as utilized in the clothing item.
8.4.9.2 Specimen width shall be 152 mm (6 in.), except for textiles or reflective striping utilized in the clothing item in widths less than 152 mm (6 in.), where widths shall be the same as utilized in the clothing item.
8.4.9.3 Samples for conditioning shall include material sewn onto a 0.84m² (1 yd²), of navy 200 g/m² (6.0 oz/yd²), 100 percent aramid material no closer than 51 mm (2 in.) apart in parallel strips.
8.4.9.3.1 Specimens, except reflective striping, shall be removed from the ballast material prior to testing.
8.4.9.3.2 Specimens shall be placed in the oven with the long dimension of the specimen parallel to the oven sides.
8.4.9.3.3 Reflective striping specimens shall be placed in the oven with the striping parallel to the oven sides.
8.4.9.4 Testing shall be performed in accordance with 8.4.2 through 8.4.7, and thermal shrinkage shall not be measured.

8.4.10 Specific Requirements for Testing Hardware.
8.4.10.1 A minimum of three complete hardware items shall be tested.
8.4.10.2 Hardware shall not be conditioned.
8.4.10.3 Observations of hardware condition following heat exposure shall be limited to ignition.
8.4.10.4 Hardware shall be evaluated for functionality within 10 minutes following removal from the oven.
8.4.10.5 Testing shall be performed in accordance with 8.4.2 through 8.4.7, and thermal shrinkage shall not be measured.

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, 3 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.

8.4.12 **Specific Requirements for Testing Emblems Including Transfer Films.**

8.4.12.1 Specimens shall consist of emblems or transfer films placed on 0.84m² (1 yd²), of navy 200 g/m² (6.0 oz/yd²), 100 percent aramid material fabric pieces that measure 152 mm ± 6 mm × 152 mm ± 6 mm (65 in. ± 0.25 in. × 6 in. ± 0.25 in.).

8.4.12.2 Representative emblems or transfer films specimens shall measure a minimum of 100 mm (4.0 in.) and 25 (1.0 in.) and shall be attached to individual fabric pieces in the same manner as normally applied for their attachment to garments.

8.4.12.3 Specimens shall be placed in the oven with the long dimension of the specimen parallel to the oven sides.

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

**Annex A Explanatory Material**

Add new annex sections

A.3.3.9 Emblems also include transfer films that are applied as thin films onto fabric through heat.

A.8.3.11.1 This testing is intended to demonstrate the flame resistance of the specific emblem technology. Testing of representative emblems should be applied to demonstrate the efficacy of the specific emblem technology.
1.3.3
Certification of flame-resistant garments, shrouds/hoods/balaclavas, gloves, or rainwear to the requirements of this standard shall not preclude certification to additional appropriate standards where the garment, shrouds/hoods/balaclavas, gloves, or rainwear meet all the applicable requirements of each standard.

Statement of Problem and Substantiation for Public Comment

The proposed change corrects an omission from expanding the scope of the standard in this specific chapter.

Related Item
First Revision No. 30-NFPA 2112-2014 [Chapter 1]

Submitter Information Verification

Submitter Full Name: JEFFREY STULL
Organization: INTERNATIONAL PERSONNEL PROTECTION, INC
Street Address:
City:
State:
Zip:
Submittal Date: Fri May 15 05:20:56 EDT 2015
Chapter 2   Referenced Publications

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

2.2   NFPA Publications.
National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.
NFPA 2113, Standard on Selection, Care, Use, and Maintenance of Flame-Resistant Garments for Protection of Industrial Personnel Against Short-Duration Thermal Exposures from Fire, 2015 edition.

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.
AATCC 158, Dimensional Changes on Dry-Cleaning in Perchloroethylene: Machine Method, 2011.

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

2.3.3   ISO Publications.
International Organization for Standardization, 1 rue de Varembe, ISO Central Secretariat, BIBC II, 8, Chemin de Blandonnet, Case postale 56, CH-1211 Geneva 20, 401, 1214 Vernier, Geneva, Switzerland.

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


**Statement of Problem and Substantiation for Public Comment**

Updated ISO address.

**Related Public Comments for This Document**

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<td>Public Comment No. 16-NFPA 2112-2015 [Chapter C]</td>
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<tr>
<td>First Revision No. 21-NFPA 2112-2014 [Chapter 2]</td>
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**Submitter Information Verification**

**Submitter Full Name:** Aaron Adamczyk

**Organization:** [Not Specified]

**Street Address:**

**City:**

**State:**

**Zip:**

**Submittal Date:** Sat May 09 02:22:31 EDT 2015
## 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 ISO Publications.
International Organization for Standardization, 1, rue de Varembé, Case postale 56, CH-1211 Geneve 20, Switzerland.


#### 2.3.4 Other Publications.


#### 2.3.5 International Safety Equipment Association Standards.
1901 North Moore Street, Arlington, VA 22209-1762, USA.

2.4 References for Extracts in Mandatory Sections.


Statement of Problem and Substantiation for Public Comment

The proposed reference is one of three for supporting manufacturer claims for the level of insulation provided by cold weather insulation garments that are included as part of the scope of this standard.

Related Public Comments for This Document

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<td>Public Comment No. 32-NFPA 2112-2015 [Section No. 7.1]</td>
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First Revision No. 2-NFPA 2112-2014 [Section No. 3.3.6]

Submitter Information Verification

Submitter Full Name: JEFFREY STULL

Organization: INTERNATIONAL PERSONNEL PROTECTION, INC.

Street Address: 

City: 

State: 

Zip: 

Submittal Date: Fri May 15 05:51:57 EDT 2015
Public Comment No. 14-NFPA 2112-2015 [Section No. 2.3.2]

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

Statement of Problem and Substantiation for Public Comment

The majority of the Heat and Thermal Shrinkage Test Method described in this Standard have been incorporated into ASTM F2984, and have been vetted in an Interlaboratory Study by ASTM. Incorporating ASTM F2894, with specific modifications to maintain consistency with previous editions, simplifies this Standard. If incorporated in Chapter 8, as proposed in Public Comment No. 13, it also needs to be included in the Referenced Documents.

Related Public Comments for This Document

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Submitter Information Verification

Submitter Full Name: BRIAN SHIELS
Organization: PBI Performance Products, Inc.
Street Address: 
City: 
State: 
Zip: 
Submittal Date: Fri May 01 08:40:25 EDT 2015
Public Comment No. 22-NFPA 2112-2015 [Section No. 2.3.2]

2.3.2 ASTM Publications.

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


Statement of Problem and Substantiation for Public Comment

The 2015 edition of ASTM F1930 was approved earlier this year and includes a variety of improvements over the 2013 edition. It also includes reference to a standard coverall pattern that is now available from ASTM.

Related Item
First Revision No. 21-NFPA 2112-2014 [Chapter 2]

Submitter Information Verification

Submitter Full Name: BRIAN SHIELS
Organization: PBI PERFORMANCE PRODUCTS INC
Street Address:
City:
State:
Zip:
Submittal Date: Thu May 14 10:38:40 EDT 2015
2.3.2 ASTM Publications.
ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959.

Statement of Problem and Substantiation for Public Comment

The additional references are added to address the provision of cold weather insulation as part of the standard, previously addressed via a tentative interim amendment, that was included in the first revision. The references apply to the manufacturer claims of insulation provided by cold weather insulation garment products.

Related Public Comments for This Document

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Related Item
First Revision No. 2-NFPA 2112-2014 [Section No. 3.3.6]

Submitter Information Verification

Submitter Full Name: JEFFREY STULL
Organization: INTERNATIONAL PERSONNEL PROTECTION, INC.
Street Address: 
City: 
State: 
Zip: 
Submittal Date: Fri May 15 05:38:59 EDT 2015
Public Comment No. 36-NFPA 2112-2015 [Section No. 2.3.2]

2.3.2 ASTM Publications.

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


Statement of Problem and Substantiation for Public Comment

Large emblems or heraldry applied by the manufacturer that are not flame resistant should be either limited in their size or subject to testing commensurate with other fabrics used in the construction of the garment. The proposed series of changes establish clearer definitions, design criteria, performance criteria, and test methods to evaluate large labels when applied by the manufacturer. The proposed new reference adds a new test method for appropriately evaluating transfer films.

Related Item

Public Input No. 61-NFPA 2112-2014 [New Section after 6.3]

Submitter Information Verification

Submitter Full Name: JEFFREY STULL
Organization: INTERNATIONAL PERSONNEL PROTECTION, INC.
Street Address: 
City: 
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Submittal Date: Fri May 15 06:44:01 EDT 2015
Public Comment No. 42-NFPA 2112-2015 [Section No. 2.3.2]

2.3.2 ASTM Publications.

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


Statement of Problem and Substantiation for Public Comment

Rainwear should function to provide protection from getting wet. Current requirements for material and seam water penetration resistance in flame resistance rainwear do not capture the design aspects of the clothing to prevent water penetration. Wetting of materials can change the thermal insulation performance of garment systems adversely and can be a factor for increased burn injuries during a high temperature flame/high heat exposure event. This proposed change provides a test method to evaluate whole garment performance.

Related Item
First Revision No. 37-NFPA 2112-2014 [New Section after 7.4]

Submitter Information Verification

Submitter Full Name: JEFFREY STULL
Organization: INTERNATIONAL PERSONNEL PROTECTION, INC.
Street Address: 
City: 
State: 
Zip: 
Submittal Date: Fri May 15 10:04:48 EDT 2015
Public Comment No. 62-NFPA 2112-2016 [Section No. 2.3.2]

2.3.2 ASTM Publications.

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


Statement of Problem and Substantiation for Public Comment

ASTM D6413 has since been updated to the 2015 edition, so the proposed change reflects the current version of the document.

Related Item

First Revision No. 21-NFPA 2112-2014 [Chapter 2]

Submitter Information Verification

Submitter Full Name: Stacy Klausing
Organization: Arcwear
Street Address:
City:
State:
Zip:
Submittal Date: Mon Apr 04 13:14:03 EDT 2016
Public Comment No. 83-NFPA 2112-2016 [Section No. 2.3.2]

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

Statement of Problem and Substantiation for Public Comment
adding standard to support PC82

Related Public Comments for This Document

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<td>Public Comment No. 82-NFPA 2112-2016 [Sections 8.4.4, 8.4.5]</td>
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Submitter Information Verification

Submitter Full Name: Amanda Newsom
Organization: UL LLC
Street Address:
City:
State:
Zip:
Submittal Date: Wed May 11 08:58:04 EDT 2016
### Statement of Problem and Substantiation for Public Comment

A separate appendix section has been proposed for this definition.

**Related Item**

Public Input No. 61-NFPA 2112-2014 [New Section after 6.3]

### Submitter Information Verification

**Submitter Full Name:** JEFFREY STULL  
**Organization:** INTERNATIONAL PERSONNEL PROTECTION, INC.  
**Street Address:**  
**City:**  
**State:**  
**Zip:**  
**Submittal Date:** Fri May 15 06:35:49 EDT 2015
Public Comment No. 89-NFPA 2112-2016 [Section No. 3.3.27]

3.3.27 Product.
The compliant flame-resistant garment, shrouds/hoods/balaclavas, gloves, or rainwear.

Statement of Problem and Substantiation for Public Comment

The scope expansion of the standard now refers specifically to shrouds/hoods/balaclavas, gloves, and rainwear. The change in the Product definition should also account for this.

Related Item
First Revision No. 30-NFPA 2112-2014 [Chapter 1]

Submitter Information Verification

Submitter Full Name: Roger Parry
Organization: The DuPont Company, Inc.
Street Address:
City:
State:
Zip:
Submittal Date: Thu May 12 10:35:17 EDT 2016
3.3.36 Shroud/Hood/ Balaclava/Hood.
An item of clothing designed to provide protection to the wearer's head or neck or both less the face opening.

Statement of Problem and Substantiation for Public Comment

The heading was changed to match the order of shroud/hood/balaclava in other sections, for consistency.
This change also further describes a shroud/hood/balaclava as "an item of clothing"

Related Item
First Revision No. 83-NFPA 2112-2015 [Section No. 3.3.36]

Submitter Information Verification

Submitter Full Name: BRIAN SHIELS
Organization: PBI PERFORMANCE PRODUCTS INC
Street Address: 
City: 
State: 
Zip: 
Submittal Date: Thu May 14 10:53:11 EDT 2015
Chapter 4  Certification - Conformity Assessment

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 comply with ANSI/ISEA 125, American National Standard for Conformity Assessment of Safety and Personal Protective Equipment, conformity assessment Level 1, 2, or 3 in its entirety, and shall be marked in accordance with Section 9 of ANSI/ISEA 125.

4.1.4  All flame-resistant garments, shrouds/hoods/balaclavas, gloves, and rainwear shall have a product label that 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.

3  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.

4.1.6  The certification organization, Manufacturers shall not certify, label any flame-resistant garments, shrouds/hoods/balaclavas, gloves, and rainwear to the 2012 edition of this standard on or after May 13, 2016.

4.1.7  The certification organization, Manufacturers 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 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 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 to 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 be performed after XX/XX/XXXX.

4.1.6 - Inspection 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.

5.1 - 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.

4.3.1.6 - 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.

6 - Inspection by the certification organization for determining compliance with the design requirements specified in Chapter 6 shall be performed on whole or complete products.
1. 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. 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. Reevaluation or Recertification shall be conducted and documented before labeling the modified products as being compliant with this standard.

4. Certification Program (ANSI/ISEA 125 Level 3).

4.3.2. Product Modifications.

4.3.2.10. 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 be owned or controlled by manufacturers or vendors of the product being certified.

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

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

4.2.4 -
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 and ANSI/ISEA 125 Level 3.

4.2.5 -
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.
4.2.6
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 to 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 is in place.

4.2.7
The certification organization shall have a program for investigating field reports alleging malperformance or failure of listed products.

4.2.8
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.

4.2.9
For the certification of flame-resistant garments, shrouds/hoods/balaclavas, gloves, and rainwear, the certification organization shall conduct inspections of the manufacturing facility.

Additional Proposed Changes

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<th>File Name</th>
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<tr>
<td>ArcWear_Public_Comment_71-</td>
<td>Please see attached for a redline and clean version of the proposed change</td>
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<tr>
<td>_Certification.docx</td>
<td>with easy-to-view formatting.</td>
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Statement of Problem and Substantiation for Public Comment

NFPA 2112 garments are primarily for apparel that may only incidentally be exposed to a flash fire. The restructure of Section 4 as conformity assessment compliant with ANSI/ISEA 125 will allow more competition in testing and manufacturer flexibility in garment design. ANSI/ISEA 125 allows for three levels of conformity assessment: self-declaration, ISO 17025 accredited testing and ISO 9001 certified manufacturing, and ISO 17065 third-party certification.

This change would allow small manufacturers to comply with the self-certification level for new or low-volume products that meet the minimum requirements of NFPA 2112, but offer flexibility for apparel. For example, balaclavas, specialty garments for cold weather insulation, high-vis, and other uses could effectively meet the requirements of the standard if an end user chose to specify such a garment.

The proposed language has been adapted from public comments submitted to NFPA 70E. NFPA 2112 garments are closer in hazard to garments used for the electric arc hazard than they are for firefighter turnout gear, which requires third-party certification.

Related Public Comments for This Document

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<th>Related Comment</th>
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<tr>
<td>Public Comment No. 81-NFPA 2112-2016 [Section No. 5.1.4]</td>
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<td>First Revision No. 39-NFPA 2112-2014 [Chapter 4]</td>
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Submitter Information Verification
Chapter 4 Certification Conformity Assessment

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 to comply with ANSI/ISEA 125, American National Standard for Conformity Assessment of Safety and Personal Protective Equipment, conformity assessment Level 1, 2, or 3 in its entirety, and shall be marked in accordance with Section 9 of ANSI/ISEA 125.

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 that 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 2012 edition of this standard on or after May 13, 2016.

4.2 Certification Program.

4.1.6 Inspection 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.
4.1.7 Inspection 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.

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

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

4.1.10 Testing conducted 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.

4.1.11 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.

4.1.12 Reevaluation or Recertification shall be conducted and documented before labeling the modified products as being compliant with this standard.

4.2 Certification Program (ANSI/ISEA 125 Level 3).

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

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

4.2.3 The certification organization shall be accredited for personal protective equipment in accordance with ISO/IEC 17065, Conformity Assessment — Requirements for Bodies Certifying Products, Processes, and Services.

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 and ANSI/ISEA 125 Level 3.

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* 4.2.5*
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 to 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.

4.3.19
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.
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.

4.4.7.1
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.

Clean Version of Public Comment:

Chapter 4. Conformity Assessment
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 comply with ANSI/ISEA 125, American National Standard for Conformity Assessment of Safety and Personal Protective Equipment, conformity assessment Level 1, 2, or 3 in its entirety, and shall be marked in accordance with Section 9 of ANSI/ISEA 125.

4.1.2
All flame-resistant garments, shrouds/hoods/balaclavas, gloves, and rainwear shall have a product label that shall meet the requirements of Section 5.1.

4.1.3
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 compliant to this standard.

4.1.4
Manufacturers shall not label any flame-resistant garments, shrouds/hoods/balaclavas, gloves, and rainwear to the 2012 edition of this standard on or after XX/XX/XXXX.

4.1.5 Manufactures shall not label any flame-resistant garments, shrouds/hoods/balaclavas, gloves, and rainwear as compliant with the 2007 edition of this standard on or after XX/XX/XXXX.

4.1.6 Inspection 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.

4.1.7 Inspection 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.

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

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

4.1.10 Testing conducted 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.

4.1.11 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.

4.1.12 Reevaluation or Recertification shall be conducted and documented before labeling the modified products as being compliant with this standard.

4.2 Certification Program (ANSI/ISEA 125 Level 3).

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

4.2.4
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 and ANSI/ISEA 125 Level 3.

4.2.5*
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.

4.2.6
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 to 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 is in place.

4.2.7
The certification organization shall have a program for investigating field reports alleging malperformance or failure of listed products.

4.2.8
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.

4.2.9
For the certification of flame-resistant garments, shrouds/hoods/balaclavas, gloves, and rainwear, the certification organization shall conduct inspections of the manufacturing facility.
4.1.7
The certification organization shall not certify any flame-resistant garments, shrouds/hoods/balaclavas, gloves, and rainwear to the 2012 edition of this standard on or after May 13, 2016. 2018.

Statement of Problem and Substantiation for Public Comment

A revised application date is needed as this standard is now in the 2018 cycle (change from 2016 to 2018).

Related Item
First Revision No. 39-NFPA 2112-2014 [Chapter 4]

Submitter Information Verification

Submitter Full Name: Roger Parry
Organization: The DuPont Company, Inc.
Street Address:
City: 
State: 
Zip: 
Submittal Date: Thu May 12 10:22:17 EDT 2016
Public Comment No. 87-NFPA 2112-2016 [Section No. 4.1.8]

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 May 13, 2016.

Statement of Problem and Substantiation for Public Comment

A revised application date is needed as this standard is now in the 2018 cycle (change from 2016 to 2018).

Related Item
First Revision No. 39-NFPA 2112-2014 [Chapter 4]

Submitter Information Verification

Submitter Full Name: Roger Parry
Organization: The DuPont Company, Inc.
Street Address:
City:
State:
Zip:
Submittal Date: Thu May 12 10:28:23 EDT 2016
Public Comment No. 88-NFPA 2112-2016 [Section No. 4.2.7]

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.

Statement of Problem and Substantiation for Public Comment

Editorial correction to correctly identify the intent to have operating procedures in place to do testing.

Related Item
First Revision No. 39-NFPA 2112-2014 [Chapter 4]

Submitter Information Verification

Submitter Full Name: Roger Parry
Organization: The DuPont Company, Inc.
Street Address:
City:
State:
Zip:
Submittal Date: Thu May 12 10:30:52 EDT 2016
5.1.4*

The For ANSI/ISEA 125 Level 3 products, the certification organization's label, symbol, or identifying mark shall be permanently attached to the product label or shall be part of the product label.

Statement of Problem and Substantiation for Public Comment

This comment links with PC 71 on the addition of ANSI 125 for conformity assessment.

Related Public Comments for This Document

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<td>Reference and Conformity Assessment Consistency</td>
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Submitter Information Verification

Submitter Full Name: Stacy Klausing
Organization: Arcwear
Street Address: 
City: 
State: 
Zip: 
Submittal Date: Tue May 10 13:41:59 EDT 2016
Public Comment No. 90-NFPA 2112-2016 [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 CLOTHING ITEM MEETS THE REQUIREMENTS OF NFPA 2112-2016 2018. NFPA 2113 REQUIRES UPPER AND LOWER BODY COVERAGE.

Statement of Problem and Substantiation for Public Comment

A revised application date is needed as this standard is now in the 2018 cycle (change from 2016 to 2018).

Related Item
First Revision No. 42-NFPA 2112-2014 [Section No. 5.1.8]

Submitter Information Verification

Submitter Full Name: Roger Parry
Organization: The DuPont Company, Inc.
Street Address:
City:
State:
Zip:
Submittal Date: Thu May 12 10:44:39 EDT 2016
5.2 User Information.

5.2.1* The manufacturer shall provide 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

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.

5.2.3 Manufacturers shall provide the results of any testing to support additional specific claims being made for the performance of the product beyond the requirements of this standard. These results shall include the identification of the specific standard used and any specific information required by that standard.

Statement of Problem and Substantiation for Public Comment

The proposed section is intended to address the provision of the additional test information that pertains to reporting the insulation performance of cold weather insulation garments.

Related Public Comments for This Document

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<tr>
<td><strong>Submitter Full Name:</strong> JEFFREY STULL</td>
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<tr>
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Public Comment No. 33-NFPA 2112-2015 [Section No. 6.1]

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 shall not come in direct contact with the body.

6.1.3 Slide Fastener Tape Requirements.
All slide fastener tape shall be made of an inherently flame-resistant fiber.

6.1.4 Non-FR heraldry and Emblems.
When non-FR heraldry is attached to the exterior of a garment by the manufacturer, the maximum number of emblems shall be 5 with no individual emblem covering an area greater than 51.6 cm² (8.0 in²).

Statement of Problem and Substantiation for Public Comment

Stating the maximum allowances for the number and size of non-FR emblems would answer the persistent question about the use of heraldry on FR garments. Clearly, there are safety implications when too much area of an FR garment is covered with anything that is non-FR. This new design requirement provides the necessary guidelines to keep wearers safe. This proposed change is based on public input provided by Denise Statham.

Related Item
Public Input No. 61-NFPA 2112-2014 [New Section after 6.3]

Submitter Information Verification

Submitter Full Name: JEFFREY STULL
Organization: INTERNATIONAL PERSONNEL PROTECTION, INC.
Street Address:
City:
State:
Zip:
Submittal Date: Fri May 15 06:24:00 EDT 2015
6.2 - Garment Design.
Shirts and coveralls shall have long sleeves.

Statement of Problem and Substantiation for Public Comment

The addition of this clause is design-restrictive. There are multi-hazard products (NFPA 2112 and NFPA 70E) on the market that would no longer be permitted; for example, t-shirts with long sleeve protectors and gloves. The clause would also eliminate NFPA 2112 compliant undershirts.

Members of the FR Industry have spent years convincing industrial workers to wear FR clothing (and even FR underlayers). NFPA 2112 is commonly viewed by the market as the standard required for Industrial FR compliance. We have concern that removing the allowance of compliant undershirts (t-shirts) from NFPA 2112 would be a step backwards and add confusion for end users when they are looking to spec and purchase FR undergarments. With that being said, we propose to remove this clause as a design restriction, and to consider adding additional requirements appropriate for undergarments in the next revision (for example, a minimum oven test and vertical flame test for under garments).

Related Item
First Revision No. 78-NFPA 2112-2014 [New Section after 6.3]

Submitter Information Verification

Submitter Full Name: Stacy Klausing
Organization: Arcwear
Street Address:
City:
State:
Zip:
Submittal Date: Fri May 13 15:14:11 EDT 2016
Public Comment No. 32-NFPA 2112-2015 [Section No. 7.1]

7.1 Garment and Fabric Requirements.

7.1.1 Fabric utilized in the construction of flame-resistant garments shall be tested for heat transfer performance (HTP) as specified in Section 8.2 and shall have a "spaced" HTP rating of not less than 25 J/cm² (6.0 cal/cm²) and a "contact" HTP rating of not less than 12.6 J/cm² (3.0 cal/cm²).

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.

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, 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.

7.1.4 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.

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

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

7.1.5 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.

7.1.5.1 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.
7.1.5.2
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.

7.1.6
Where flame-resistant garments are represented by the manufacturer for cold weather insulation, the garments shall be evaluated for weather insulation performance using ASTM F1291, Standard Test Method for Measuring the Thermal Insulation of Clothing Using a Heated Manikin, ASTM F2732, Standard Practice for Determining the Temperature Ratings for Cold Weather Protective Clothing, or ANSI/ISEA 201, American National Standard for Classification of Insulating Apparel Used in Cold Work Environments. The results required by these standards shall be reported as part of the user information.

Statement of Problem and Substantiation for Public Comment

The proposed requirement provides a basis for the manufacturer to claim that product provide cold weather insulation performance and establishes information for the end user or purchaser to determine the relative performance of the product using established, recognized standards.

Related Public Comments for This Document

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Submitter Information Verification

Submitter Full Name: JEFFREY STULL
Organization: INTERNATIONAL PERSONNEL PROTECTION, INC.
Street Address:  
City:  
State:  
Zip:  
Submittal Date: Fri May 15 06:06:40 EDT 2015
Public Comment No. 72-NFPA 2112-2016 [Section No. 7.1.1.2]

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 permitted to be tested.

Statement of Problem and Substantiation for Public Comment

where the garment consists of multiple layers, to be worn together the language as currently written mandates testing of the outer layer only. Proposed language will allow the testing to be performed on the entire composite.

Related Item
First Revision No. 10-NFPA 2112-2014 [New Section after 7.1.1]

Submitter Information Verification

Submitter Full Name: Amanda Newsom
Organization: UL LLC
Street Address:
City:
State:
Zip:
Submittal Date: Thu Apr 07 13:46:29 EDT 2016
Public Comment No. 25-NFPA 2112-2015 [New Section after 7.1.2]

7.1.2.1
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 an after-flame of not more than 2 seconds, and shall not melt and drip.

Statement of Problem and Substantiation for Public Comment

Reflective striping is attached to fabric during flame testing and therefore char length is not something that can be measured effectively during testing. Additionally, section 8.3.12.3 removes the requirement for measuring char length. By separating reflective striping to a separate paragraph and removing the char length requirement, I am adding consistency to the requirements.

Related Item
First Revision No. 11-NFPA 2112-2014 [Sections 7.1.2, 7.1.3]

Submitter Information Verification

Submitter Full Name: AMANDA NEWSOM
Organization: UL LLC
Street Address:
City:
State:
Zip:
Submittal Date: Thu May 14 14:28:30 EDT 2015
New 7.1.2.1

7.1.2.1 Emblems that are placed on exterior of the garment that are in excess of 51 cm² (8.0 in²) in total area shall be tested for flame resistance as specified in Section 8.3 and shall not have an afterflame of not more than 2 seconds, and shall not melt and drip.

Statement of Problem and Substantiation for Public Comment

Large emblems or heraldry applied by the manufacturer that are not flame resistant should be either limited in their size or subject to testing commensurate with other fabrics used in the construction of the garment. The proposed series of changes establish clearer definitions, design criteria, performance criteria, and test methods to evaluate large labels when applied by the manufacturer. The proposed change provide criteria for flame resistance of such emblems.

Related Item

Public Input No. 61-NFPA 2112-2014 [New Section after 6.3]

Submitter Information Verification

Submitter Full Name: JEFFREY STULL
Organization: INTERNATIONAL PERSONNEL PROTECTION, INC.
Street Address:
City:
State:
Zip:
Submittal Date: Fri May 15 06:48:27 EDT 2015
Public Comment No. 26-NFPA 2112-2015 [Section No. 7.1.2]

7.1.2
Fabric, cold and 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, 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.

Statement of Problem and Substantiation for Public Comment

Reflective striping is attached to fabric during flame testing and therefore char length is not something that can be measured effectively during testing. Additionally, section 8.3.12.3 removes the requirement for measuring char length. By separating reflective striping to a separate paragraph and removing the char length requirement, I am adding consistency to the requirements.

Related Item
First Revision No. 11-NFPA 2112-2014 [Sections 7.1.2, 7.1.3]

Submitter Information Verification

Submitter Full Name: AMANDA NEWSOM
Organization: UL LLC
Street Address:
City:
State:
Zip:
Submittal Date: Thu May 14 14:28:51 EDT 2015
Public Comment No. 38-NFPA 2112-2015 [Section No. 7.1.4]

7.1.4
Fabric, cold weather insulation materials, other textile materials, and reflective striping, emblems placed on the exterior of the garment that are 51.6 cm $^2$ (8.0 in $^2$) or less in total area, 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.

7.1.4.1
Labels and emblems, placed on the exterior of the garment that are 51.6 cm $^2$ (8.0 in $^2$) or less in total area, shall not be required to be tested for heat resistance.

7.1.4.2
Interlinings, collar stays, elastics, and hook and pile fasteners, when not in direct contact with the skin, shall not be required to be tested for heat resistance.

Statement of Problem and Substantiation for Public Comment

Large emblems or heraldry applied by the manufacturer that are not flame resistant should be either limited in their size or subject to testing commensurate with other fabrics used in the construction of the garment. The proposed series of changes establish clearer definitions, design criteria, performance criteria, and test methods to evaluate large labels when applied by the manufacturer. The proposed change addresses the mandatory testing of large emblems.

Related Item
Public Input No. 61-NFPA 2112-2014 [New Section after 6.3]

Submitter Information Verification

Submitter Full Name: JEFFREY STULL
Organization: INTERNATIONAL PERSONNEL PROTECTION, INC.
Street Address: 
City: 
State: 
Zip: 
Submittal Date: Fri May 15 08:09:37 EDT 2015
7.1.5 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.

7.1.5.1 Where the flame-resistant garment consists of multiple and separable layers intended to be worn separately, both of the following shall apply: Specimen garments consisting of the outer layer only shall be tested. Specimen garments consisting of the inner layer or layers only shall separately. Where each wearable layer has been separately tested, the wearable combinations of these layers is not required to 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 permitted to be tested.

Statement of Problem and Substantiation for Public Comment

The current wording does not consider garments which consist of more than 2 layers. The proposed wording is intended to clarify requirements for all the various garment configurations.

Related Public Comments for This Document

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Submitter Information Verification

Submitter Full Name: Amanda Newsom  
Organization: UL LLC  
Street Address:  
City:  
State:  
Zip:  
Submittal Date: Thu Apr 07 14:26:44 EDT 2016
7.1.5 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.

7.1.5.1 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.

7.1.5.2 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.

Statement of Problem and Substantiation for Public Comment

ASTM F1930, unless further modified to reduce test variation between laboratories, is not adequately specified for use in this NFPA standard and should be eliminated. The thermal manikin test as currently practiced produces predicted body burn values with extreme variance between laboratories. For example, recent round robin testing performed by five participating laboratories at the direction of NFPA 2112 thermal manikin task group produced values for compliant fabrics ranging from 9.2% to 44.4% predicted body burn (Fabric B), 13.8% to 42% predicted body burn (Fabric F), and 13.5% to 29.6% predicted body burn (Fabric D).

The wide range of values between test laboratories could result in a fabric both failing and passing NFPA 2112 certification when tested at different laboratories, resulting in unsafe products for industrial personnel.

Sections to be removed from NFPA 2112:
- Section 2.3.2 ASTM Publications - ASTM F 1930
- Section 7.1.5
- Section 8.5
- Table B.1 - Manikin Testing references
- Annex C.1.2.2
- Index T - Manikin Test references

Related Item
Public Input No. 3-NFPA 2112-2013 [Section No. 7.1.5]

Submitter Information Verification

Submitter Full Name: Michael Stanhope
Organization: TenCate/Southern Mills, Inc.
Street Address: 
City: 
State: 
Zip: 
Submittal Date: Tue May 03 15:37:07 EDT 2016
7.1.5 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.

7.1.5.1 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.

7.1.5.2 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.

Statement of Problem and Substantiation for Public Comment

A recent round robin of this test showed very little correlation between laboratories. One example of this, one lab had a 9.2% body burn and another had 44.4% burn on the same garment. Also on another the spread was 13.8 - 42. Until the test method is improved I feel the test should be eliminated from the standard.

Related Item
First Revision No. 71-NFPA 2112-2014 [Section No. 7.1.5 [Excluding any Sub-Sections]]

Submitter Information Verification

Submitter Full Name: Harry Winer
Organization: HIP Consulting LLC
Street Address: 
City: 
State: 
Zip: 
Submittal Date: Wed May 11 14:46:57 EDT 2016
7.5.5
Sewing thread utilized in the construction of flame-resistant gloves/shrouds/hoods/balaclavas, 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.

Statement of Problem and Substantiation for Public Comment

Section 7.5.5 appears to cite the testing of gloves instead of shrouds/hoods/balaclavas by mistake. Section 7.5 is for the testing of shrouds/hoods/balaclavas and Section 7.6 is designated for gloves in this draft.

Related Item
First Revision No. 35-NFPA 2112-2014 [New Section after 7.4]

Submitter Information Verification

Submitter Full Name: Stacy Klausing
Organization: Arcwear
Street Address:
City:
State:
Zip:
Submittal Date: Mon Apr 04 13:50:42 EDT 2016
Public Comment No. 91-NFPA 2112-2016 [Section No. 7.5.8]

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.

Statement of Problem and Substantiation for Public Comment

The skin burn injury model for the head and face is not the same as that used in ASTM F1930 for the torso, arms, and legs. Currently, there is no established model or agreement in ASTM or ISO on the applicable skin thermo-physical properties (including skin layer thicknesses). Additional work is needed in this area in order to obtain industry consensus on the correct model for evaluating representative predictive burn injury performance. As such, the flame engulfment testing identified here needs to be postponed until a skin burn injury model for the head and face is established.

Related Item
First Revision No. 35-NFPA 2112-2014 [New Section after 7.4]

Submitter Information Verification

Submitter Full Name: Roger Parry
Organization: The DuPont Company, Inc.
Street Address:
City:
State:
Zip:
Submittal Date: Thu May 12 10:51:22 EDT 2016
Fabric utilized in the construction of flame-resistant gloves shall be tested for flame resistance as specified in Section 8.8.10, 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.

Statement of Problem and Substantiation for Public Comment

Editorial: Section reference was updated to 8.10 to reflect Glove Flame Resistance testing instead of 8.8 for Whole Glove Thermal Protection testing, as this requirement is for char length and afterflame time. Whole Glove Thermal Protection testing is covered in Section 7.6.8.

Related Item
First Revision No. 36-NFPA 2112-2014 [New Section after 7.4]

Submitter Information Verification

Submitter Full Name: Stacy Klausing
Organization: Arcwear
Street Address: 
City: 
State: 
Zip: 
Submittal Date: Mon Apr 04 14:27:26 EDT 2016
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.

Statement of Problem and Substantiation for Public Comment

There is essentially an identical standard testing method work item in ASTM F23.80 for a hand “fire engulfment” testing apparatus. Unfortunately, the skin burn injury model for the hands has not been established or agreed upon in ASTM or ISO (including skin layer thicknesses). Additional work is needed in this area in order to obtain industry consensus on the correct model for evaluating representative predictive burn injury performance. As such, the flame engulfment testing identified here needs to be postponed until a consensus skin burn injury model for the hands is established.

Related Item
First Revision No. 36-NFPA 2112-2014 [New Section after 7.4]

Submitter Information Verification

Submitter Full Name: Roger Parry
Organization: The DuPont Company, Inc.
Street Address:
City:
State:
Zip:
Submittal Date: Thu May 12 10:59:20 EDT 2016
Public Comment No. 1-NFPA 2112-2015 [New Section after 7.7.1]

**Consistency with 7.1.1.1 & 7.1.1.2**

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

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

**Statement of Problem and Substantiation for Public Comment**

This change brings the Rainwear requirements in consistency with those of other garment types.

**Related Item**

First Revision No. 37-NFPA 2112-2014 [New Section after 7.4]

**Submitter Information Verification**

- **Submitter Full Name**: BRIAN SHIELS
- **Organization**: PBI PERFORMANCE PRODUCTS INC
- **Street Address**:
- **City**:
- **State**:
- **Zip**:
- **Submittal Date**: Thu Apr 30 14:27:34 EDT 2015
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 and in place.

Statement of Problem and Substantiation for Public Comment

Labels on flame-resistant rainwear that are legible, but not present are no good to the user. Requirement for presence of the label is consistent with label legibility requirements elsewhere in NFPA 2112.

Related Item
First Revision No. 37-NFPA 2112-2014 [New Section after 7.4]

Submitter Information Verification

Submitter Full Name: BRIAN SHIELS
Organization: PBI PERFORMANCE PRODUCTS INC
Street Address:
City:
State:
Zip:
Submittal Date: Thu Apr 30 14:28:27 EDT 2015
NEW 7.7.10

7.7.10 Where manufacturers claim that flame-resistant rainwear is intended to keep the wearer dry, full rainwear shall be tested for overall liquid penetration resistance as specified in Section 8.X, Whole Rainwear Water Penetration Test, and shall allow no water penetration.

Statement of Problem and Substantiation for Public Comment

Rainwear should function to provide protection from getting wet. Current requirements for material and seam water penetration resistance in flame resistance rainwear do not capture the design aspects of the clothing to prevent water penetration. Wetting of materials can change the thermal insulation performance of garment systems adversely and can be a factor for increased burn injuries during a high temperature flame/high heat exposure event. The proposed change provides performance criteria for the demonstration of this capability.

Related Item
First Revision No. 37-NFPA 2112-2014 [New Section after 7.4]

Submitter Information Verification

Submitter Full Name: JEFFREY STULL
Organization: INTERNATIONAL PERSONNEL PROTECTION, INC.
Street Address:
City:
State:
Zip:
Submittal Date: Fri May 15 10:07:09 EDT 2015
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: Specimen garments consisting of the outer layer only shall be tested. Specimen garments consisting of the inner layer or layers only shall be separately. Where each wearable layer has been separately tested, the wearable combinations of these layers is not required to 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 permitted to be tested.

Statement of Problem and Substantiation for Public Comment
See PC73. Aligns requirements with the garment requirements.

Related Public Comments for This Document

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<th>Related Comment</th>
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<td>First Revision No. 1-NFPA 2112-2014 [Section No. 7.1.5.1]</td>
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</table>

Submitter Information Verification

Submitter Full Name: Amanda Newsom
Organization: UL LLC
Street Address: 
City: 
State: 
Zip: 
Submittal Date: Thu Apr 07 14:39:43 EDT 2016
8.1.3* Washing and Drying Procedure.
Where required, specimens shall be subjected to the specified number of cycles of washing and drying in accordance with the following procedure:

(1) Each washing procedure shall be as specified in Table 8.1.3.
(2) * When testing in accordance with 8.3.3.1, the final two cycles shall be run without adding any detergent or chemicals.
(3) No bleach or softener shall be used during any portion of the laundry cycle.
(4) The machine shall be filled with water to the specified level prior to adding chemicals.
(5) The water level shall be determined by measuring inside the washing machine from the bottommost portion of the basket to the water surface.
(6) The water level measurement shall be 12.7 cm (5.0 in.) for the low setting and 25.4 cm (10 in.) for the high setting.
(7) Water hardness shall not exceed 25 ppm.
(8) The extraction cycle shall continue as specified in Table 8.1.3 or until water is no longer flowing to the drain.
(9) The load shall be removed immediately after the extraction cycle concludes.
(10) A full load of 9 kg (20 lb) shall be laundered.
(11) Fabric samples for washing shall be at least 1 m² (1 yd²) of each material.
(12) Whole articles of clothing shall be permitted for conditioning
(13) A dummy load, if needed to make a full load, shall be of similar material as the test material.
(14) The machine type shall be a front-loading, 16 kg (35 lb) capacity, industrial washer capable of performing the operations specified in Table 8.1.3.
(15) Sample specimens shall be tumble dried.
(16) The dryer temperature shall be preset to provide a dryer exhaust temperature of 68°C ± 3°C (155°F ± 5°F) without a load.
(17) Wash water temperature shall be within ±3°C (±5°F) of the value in Table 8.1.3.

Table 8.1.3 Washing Cycle Procedure

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<thead>
<tr>
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<th>Temperature</th>
<th>Quantity per Wash Load</th>
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<td></td>
<td>Time (min)</td>
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<tr>
<td>Break</td>
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<td>66 150</td>
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<tr>
<td>Sodium metasilicate (or equivalent)</td>
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<tr>
<td>Sodium tripolyphosphate</td>
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<tr>
<td>Tergitol 15.S.9 or equivalent</td>
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<td>0.8</td>
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<tr>
<td>Drain</td>
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<td></td>
</tr>
<tr>
<td>Carryover*</td>
<td>5</td>
<td>66 150</td>
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<tr>
<td>Drain</td>
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<tr>
<td>Rinse</td>
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<tr>
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<td>Sour</td>
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<td></td>
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<tr>
<td>Extract</td>
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* Carryover shall be accomplished with agitation.

**Statement of Problem and Substantiation for Public Comment**

This change allows for whole items (such as Shrouds/Hoods/Balaclavas, etc.) to be conditioned in lieu of fabrics, where necessary.

**Related Public Comments for This Document**

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<td>Public Input No. 73-NFPA 2112-2014 [Chapter 8]</td>
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**Submitter Information Verification**

- **Submitter Full Name:** BRIAN SHIELS
- **Organization:** PBI PERFORMANCE PRODUCTS INC
- **Street Address:**
- **City:**
- **State:**
- **Zip:**
- **Submittal Date:** Fri May 15 14:46:18 EDT 2015
Public Comment No. 56-NFPA 2112-2015 [New Section after 8.1.4.2]

8.1.4.3
Whole articles of clothing shall be permitted for conditioning.

Statement of Problem and Substantiation for Public Comment

This change allows for whole articles (e.g. Shrouds/Hoods/Balaclavas) to be conditioned in lieu of fabric, if necessary.

Related Public Comments for This Document

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<td>Public Input No. 73-NFPA 2112-2014 [Chapter 8]</td>
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Submitter Information Verification

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Submittal Date: Fri May 15 14:56:07 EDT 2015
8.3 Flame Resistance Test.

8.3.1 Application.

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

8.3.1.2 Modifications to this test method for testing woven textile materials shall be as specified in 8.3.8.

8.3.1.3 Modifications to this test method for testing knit textile materials shall be as specified in 8.3.9.

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.

8.3.1.5 Modifications to this test method for testing small specimens, and emblems, other than transfer films, not meeting the specimen size requirements of 8.3.2, shall be as specified in 8.3.11.

8.3.1.6 Modifications to this test method for testing reflective striping shall be as specified in 8.3.12.

8.3.1.7 Modifications to this test method for testing cold weather insulation materials shall be as specified in 8.3.13.

8.3.1.8 Modifications to this test method for testing transfer films shall be as specified in 8.3.14.

8.3.2 Specimens.

8.3.2.1 Each specimen shall consist of a 76 mm × 305 mm (3 in. × 12 in.) rectangle with the long dimension parallel to either the warp or filling, the wale or course, or machine or cross-machine direction of the material.

8.3.2.2 Each individual layer of multilayer material systems or composites shall be separately tested.

8.3.3 Sample Preparation.

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.
8.3.3.4
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.

8.3.3.5
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.

8.3.3.6
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.

8.3.3.7
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.

8.3.4 Apparatus.
The test apparatus shall be that specified in ASTM D6413, Standard Test Method for Flame Resistance of Textiles (Vertical Test).

8.3.5 Procedure.
8.3.5.1 Flame resistance testing shall be performed in accordance with ASTM D6413, Standard Test Method for Flame Resistance of Textiles (Vertical Test).

8.3.5.2 Each specimen shall be examined for evidence of melting and dripping.

8.3.6 Report.
8.3.6.1 After-flame time and char length shall be reported for each specimen.

8.3.6.2 The average after-flame time and char length for each material shall be calculated and reported.

8.3.6.3 The after-flame time shall be reported to the nearest 0.2 second, and the char length to the nearest 3.2 mm (⅛ in.).

8.3.6.4 Observations of melting and dripping for each specimen shall be reported.

8.3.7 Interpretation.
8.3.7.1 Pass/fail performance shall be based on any observed melting and dripping, the average after-flame time, and average char length.

8.3.7.2 Failure in either direction shall constitute failure of the material.

8.3.8 Specific Requirements for Testing Woven Textile Materials.
8.3.8.1 Five specimens from each of the warp and filling directions shall be tested.

8.3.8.2 No two warp specimens shall contain the same warp yarns, and no two filling specimens shall contain the same filling yarns.
8.3.8.3
Testing shall be performed as described in 8.3.2 through 8.3.7.

8.3.9  Specific Requirements for Testing Knit Textile Materials.

8.3.9.1
Five specimens from each of the two directions shall be tested.

8.3.9.2
Samples for conditioning shall include material that is a minimum of 76 mm × 305 mm (3 in. × 12 in.).

8.3.9.3
Testing shall be performed as described in 8.3.2 through 8.3.7.

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.

8.3.11  Specific Requirements for Testing Small Materials and Emblems other than Transfer Films.

8.3.11.1
Five specimens attached to the textile layer as used in the protective garment shall be tested.

8.3.11.1.1 For the purpose of this testing, the textile layer shall be permitted to be of navy 200 g/m² (6.0 oz/yd²), 100 percent aramid material.

8.3.11.1.2 When tested, emblems shall be attached to the textile layer in the same manner as normally used for attaching emblems to garment fabric.

8.3.11.2
The specimens shall be attached to the textile layer such that the bottom (exposure) edge of the item coincides with the bottom (exposure) edge of the textile support layer.

8.3.11.3
Testing shall be performed as described in 8.3.2 through 8.3.7, except char length shall not be measured.

8.3.12  Specific Requirements for Testing Reflective Striping.

8.3.12.1
Five reflective striping specimens for flammability testing shall be prepared by attaching the reflective striping to 76 mm × 305 mm (3 in. × 12 in.) pieces of fabric utilized in the construction of the garment, in the manner that it is normally attached to the fabric.

8.3.12.2
The reflective striping shall be oriented parallel to the long axis and in the center of the fabric.

8.3.12.3
Testing shall be performed as described in 8.3.2 through 8.3.7, except char length shall not be measured.

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/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.
8.3.13.2
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.

8.3.14 Specific Requirements for Testing Transfer Films.

8.3.14.1 Transfer films shall be applied to individual specimens of the textile layer as used in the protective garment.

8.3.14.2 Five specimens from each of the warp and filling directions of the textile layer shall be tested.

8.3.14.3 Each specimen shall consist of a 76 mm × 306 mm (3 in. × 16 in.) rectangle with the long dimension parallel to the warp or filling direction of the material. The transfer film shall be placed in the center of the specimen with a minimum width of 25 mm (1 in.) and a minimum length of 100 mm (4 in.), oriented with respect to the textile short and long dimension, respectively employing the same technique that is normally used in applying the transfer film on garment fabrics.

8.3.14.4 Specimens shall be tested in accordance with ASTM D 6413, Test Method for Flame Resistance of Textiles (Vertical Test) with the exception that the folded specimen mounting described in paragraphs 9.3 and 9.3.2 of ASTM F 1358, Standard Test Method for Effects of Flame Impingement on Materials Used in Protective Clothing Not Designated Primarily for Flame Resistance, shall be used.

8.3.14.5 Char length shall not be measured.

Statement of Problem and Substantiation for Public Comment

Large emblems or heraldry applied by the manufacturer that are not flame resistant should be either limited in their size or subject to testing commensurate with other fabrics used in the construction of the garment. The proposed series of changes establish clearer definitions, design criteria, performance criteria, and test methods to evaluate large labels when applied by the manufacturer. The proposed changes address change in the flame resistance test to address emblems and transfer films.

Related Item
Public Input No. 61-NFPA 2112-2014 [New Section after 6.3]

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Submittal Date: Fri May 15 08:20:25 EDT 2015
Public Comment No. 75-NFPA 2112-2016 [Section No. 8.3.3]

8.3.3 Sample Preparation.

8.3.3.1 For fabrics and cold weather insulation materials, and shroud/hood/balaclava materials that are designated on the flame-resistant garment product 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, cold weather insulation materials, and shroud/hood/balaclava materials that are designated on the flame-resistant garment product 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.

8.3.3.4 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.

8.3.3.5 For fabrics, materials 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.

8.3.3.6 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.

8.3.3.7 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.

Statement of Problem and Substantiation for Public Comment

The proposed wording reduces redundancy in the requirements for laundering.

Related Item
First Revision No. 14-NFPA 2112-2014 [Section No. 8.3.3]

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Submittal Date: Thu Apr 07 14:53:23 EDT 2016
Public Comment No. 45-NFPA 2112-2015 [Sections 8.3.3.4, 8.3.3.5, 8.3.3.6]

Sections 8.3.3.4, 8.3.3.5, 8.3.3.6

8.3.3.4
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.

8.3.3.5
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.

8.3.3.6
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.

Statement of Problem and Substantiation for Public Comment

The requirement for flame resistance performance after 100 cycles is excessive; a more reasonable level is 25 cycles.

Related Item
First Revision No. 54-NFPA 2112-2014 [New Section after 8.3.2.2]

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Submittal Date: Fri May 15 10:46:06 EDT 2015
Public Comment No. 24-NFPA 2112-2015 [ Section No. 8.3.13.1 ]

8.3.13.1

Samples for wash or dry-clean conditioning shall be prepared by cutting a 66.75-cm × 66.75-cm (26.30-in. × 26.30-in.) panel of the cold weather insulation material. A similar-sized 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.

Statement of Problem and Substantiation for Public Comment

The increase in sample size allows the testing lab to cut the specimens so that there are no warp or fill yarns being tested in multiple specimens which is required for woven fabrics in 8.3.8.2.

Related Item
First Revision No. 15-NFPA 2112-2014 [New Section after 8.3.12]

Submitter Information Verification

Submitter Full Name: AMANDA NEWSOM
Organization: UL LLC
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Submittal Date: Thu May 14 14:17:12 EDT 2015
8.4 Heat and Thermal Shrinkage Resistance Test.

8.4.1 Application.

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.

8.4.2 Specimens.

8.4.2.1 Only heat resistance testing shall be conducted on not fewer than three specimens for each hardware item, label material, other flame-resistant garment, shroud/hood/balaclava, glove, and rainwear fabrics, and cold weather insulation materials not listed in 8.4.2.2 and 8.4.2.3.

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.

8.4.2.3 Each separable layer of multilayer material systems or composites shall be tested as an individual layer.

8.4.3 Sample Preparation.

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.

8.4.4 Apparatus.

8.4.4.1
The test oven shall be a horizontal flow circulating oven with minimum interior dimensions to permit the specimens to be suspended and be not less than 51 mm (2 in.) from any interior oven surface or other test specimens.

8.4.4.2
The test oven shall have an airflow rate of 38 m/min to 76 m/min (125 ft/min to 250 ft/min) at the standard temperature and pressure of 21°C (70°F) at 1 atm, measured at the center point of the oven.

8.4.4.3
A test thermocouple shall be positioned so that it is level with the horizontal centerline of a mounted sample specimen.

8.4.4.3.1
The thermocouple shall be equidistant between the vertical centerline of a mounted specimen placed in the middle of the oven and the oven wall where the airflow enters the test chamber.

8.4.4.3.2
The thermocouple shall be an exposed bead, Type J or Type K, No. 30 AWG thermocouple.

8.4.4.3.3
The test oven shall be heated and the test thermocouple stabilized at 260°C ±6/-0°C (500°F ±10/-0°F) for a period of not less than 30 minutes.

8.4.
be as specified in ASTM F2894

8.4.5 Procedure.

8.4.5.1
Specimen marking and measurements. The test procedure shall be as specified in accordance with the procedure specified in AATCC 135, Dimensional Changes of Fabrics after Home Laundering, ASTM F2894, with the following modifications:

8.4.5.2
The specimen shall be suspended by metal hooks at the top and centered in the oven so that the entire specimen is not less than 51 mm (2 in.) from any oven surface or other specimen and airflow is parallel to the plane of the material.

8.4.5.3.1.1
The oven door shall not remain open more than 15 seconds.

8.4.5.3.1
The air circulation shall be shut off while the door is open and turned on when the door is closed

8.4.5.3.2
The total oven recovery time after the door is closed shall not exceed 30 seconds.
8.4.5.4
The specimen, mounted as specified, shall be exposed in the test oven for 5 minutes +0.15/-0 minutes.

8.4.5.5
The test exposure time shall begin when the test thermocouple recovers to a temperature of 260°C +6/-0°C (500°F +10/-0°F).

8.4.5.6
Immediately after the exposure specified in 8.4.5.4, the specimen shall be removed and examined for evidence of ignition, melting and dripping, or separation.

8.4.5.7
Determination of “pass” or “fail” shall be made within 5 minutes of removal from the oven.

8.4.5.8
Knit fabric shall be pulled to original dimensions and shall be allowed to relax for 1 minute prior to measurement to determine “pass” or “fail.”

8.4.6
Optional stretching frame shall be used for all knit specimens, where specified by the manufacturer.

8.4.6.1
Observations of ignition, melting and dripping, or separation shall be reported for each specimen.

8.4.6.2
The percent change in the width and length dimensions of each specimen shall be calculated, and the results shall be reported as the average of all three specimens in each dimension.

8.4.7
Interpretation.

8.4.7.1
Any evidence of ignition, melting and dripping, or separation on any specimen shall constitute failing performance.

8.4.7.2
The average percent change in both dimensions shall be used to determine pass/fail performance.

8.4.7.3
Failure in any one dimension shall constitute failure for the entire sample.

8.4.8
Specific Requirements for Testing Flame-Resistant Garment, Shroud/Hood/Balaclava, Glove, and Rainwear Textile Materials.

8.4.8.1
Each specimen shall be 381 mm ± 13 mm × 381 mm ± 13 mm (15 in. ± 0.5 in. × 15 in. ± 0.5 in.) and shall be cut from the fabric to be utilized in the construction of the clothing item.

8.4.8.2
Testing shall be performed in accordance with 8.4.2 through 8.4.7.

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

8.4.9.1
Specimen length shall be 152 mm (6 in.), except for textiles utilized in the clothing item in lengths less than 152 mm (6 in.), where lengths shall be the same as utilized in the clothing item.

8.4.9.2
Specimen width shall be 152 mm (6 in.), except for textiles or reflective striping utilized in the clothing item in widths less than 152 mm (6 in.), where widths shall be the same as utilized in the clothing item.
Samples for conditioning shall include material sewn onto a 0.84 m² (1 yd²), of navy 200 g/m² (6.0 oz/yd²), 100 percent aramid material no closer than 51 mm (2 in.) apart in parallel strips.

8.4.9.3.1
Specimens, except reflective striping, shall be removed from the ballast material prior to testing.

8.4.9.3.2
Specimens shall be placed in the oven with the long dimension of the specimen parallel to the oven sides.

8.4.9.3.3
Reflective striping specimens shall be placed in the oven with the striping parallel to the oven sides.

8.4.9.4
Testing shall be performed in accordance with 8.4.2 through 8.4.7, and thermal shrinkage shall not be measured.

8.4.10 Specific Requirements for Testing Hardware.

8.4.10.1
A minimum of three complete hardware items shall be tested.

8.4.10.2
Hardware shall not be conditioned.

8.4.10.3
Observations of hardware condition following heat exposure shall be limited to ignition.

8.4.10.4
Hardware shall be evaluated for functionality within 10 minutes following removal from the oven.

8.4.10.5
Testing shall be performed in accordance with 8.4.2 through 8.4.7, and thermal shrinkage shall not be measured.

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.

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 (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.

Statement of Problem and Substantiation for Public Comment

The majority of the content in this section has been incorporated into ASTM F2894, and has been vetted by an Interlaboratory Study by ASTM. Incorporating that Test Method, with specific modifications to maintain consistency with previous versions, simplifies this document.

Related Public Comments for This Document

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<th>Related Comment</th>
<th>Relationship</th>
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<tr>
<td>First Revision No. 16-NFPA 2112-2014 [Section No. 8.4.1]</td>
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8.4 Heat and Thermal Shrinkage Resistance Test.

8.4.1 Application.

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.

8.4.1.10 Modifications to this test method for testing emblems, including transfer films, shall be as specified in 8.4.13.

8.4.2 Specimens.

8.4.2.1 Only heat resistance testing shall be conducted on not fewer than three specimens for each hardware item, label material, other flame-resistant garment, shroud/hood/balaclava, glove, and rainwear fabrics, and cold weather insulation materials not listed in 8.4.2.2 and 8.4.2.3.

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.

8.4.2.3 Each separable layer of multilayer material systems or composites shall be tested as an individual layer.

8.4.3 Sample Preparation.
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.

8.4.4 Apparatus.
8.4.4.1
The test oven shall be a horizontal flow circulating oven with minimum interior dimensions to permit the specimens to be suspended and be not less than 51 mm (2 in.) from any interior oven surface or other test specimens.

8.4.4.2
The test oven shall have an airflow rate of 38 m/min to 76 m/min (125 ft/min to 250 ft/min) at the standard temperature and pressure of 21°C (70°F) at 1 atm, measured at the center point of the oven.

8.4.4.3
A test thermocouple shall be positioned so that it is level with the horizontal centerline of a mounted sample specimen.

8.4.4.3.1
The thermocouple shall be equidistant between the vertical centerline of a mounted specimen placed in the middle of the oven and the oven wall where the airflow enters the test chamber.

8.4.4.3.2
The thermocouple shall be an exposed bead, Type J or Type K, No. 30 AWG thermocouple.

8.4.4.3.3
The test oven shall be heated and the test thermocouple stabilized at 260°C ± 6/-0°C (500°F ± 10/-0°F) for a period of not less than 30 minutes.

8.4.5 Procedure.
8.4.5.1
Specimen marking and measurements shall be in accordance with the procedure specified in AATCC 135, *Dimensional Changes of Fabrics after Home Laundering*.

8.4.5.2
The specimen shall be suspended by metal hooks at the top and centered in the oven so that the entire specimen is not less than 51 mm (2 in.) from any oven surface or other specimen and airflow is parallel to the plane of the material.

8.4.5.3
The oven door shall not remain open more than 15 seconds.

8.4.5.3.1
The air circulation shall be shut off while the door is open and turned on when the door is closed.

8.4.5.3.2
The total oven recovery time after the door is closed shall not exceed 30 seconds.
8.4.5.4
The specimen, mounted as specified, shall be exposed in the test oven for 5 minutes ± 0.15/-0 minutes.

8.4.5.5
The test exposure time shall begin when the test thermocouple recovers to a temperature of 260°C ± 6/-0°C (500°F ± 10/-0°F).

8.4.5.6
Immediately after the exposure specified in 8.4.5.4, the specimen shall be removed and examined for evidence of ignition, melting and dripping, or separation.

8.4.5.7
Determination of “pass” or “fail” shall be made within 5 minutes of removal from the oven.

8.4.5.8
Knit fabric shall be pulled to original dimensions and shall be allowed to relax for 1 minute prior to measurement to determine “pass” or “fail.”

8.4.6 Report.
8.4.6.1
Observations of ignition, melting and dripping, or separation shall be reported for each specimen.

8.4.6.2
The percent change in the width and length dimensions of each specimen shall be calculated, and the results shall be reported as the average of all three specimens in each dimension.

8.4.7 Interpretation.
8.4.7.1
Any evidence of ignition, melting and dripping, or separation on any specimen shall constitute failing performance.

8.4.7.2
The average percent change in both dimensions shall be used to determine pass/fail performance.

8.4.7.3
Failure in any one dimension shall constitute failure for the entire sample.

8.4.8 Specific Requirements for Testing Flame-Resistant Garment, Shroud/Hood/Balaclava, Glove, and Rainwear Textile Materials.
8.4.8.1
Each specimen shall be 381 mm ± 13 mm × 381 mm ± 13 mm (15 in. ± 0.5 in. × 15 in. ± 0.5 in.) and shall be cut from the fabric to be utilized in the construction of the clothing item.

8.4.8.2
Testing shall be performed in accordance with 8.4.2 through 8.4.7.

8.4.9 Specific Requirements for Testing Other Flame-Resistant Garment, Shroud/Hood/Balaclava, Glove, and Rainwear Materials (Including Reflective Striping).
8.4.9.1
Specimen length shall be 152 mm (6 in.), except for textiles utilized in the clothing item in lengths less than 152 mm (6 in.), where lengths shall be the same as utilized in the clothing item.

8.4.9.2
Specimen width shall be 152 mm (6 in.), except for textiles or reflective striping utilized in the clothing item in widths less than 152 mm (6 in.), where widths shall be the same as utilized in the clothing item.

8.4.9.3
Samples for conditioning shall include material sewn onto a 0.84 m² (1 yd²), of navy 200 g/m² (6.0 oz/yd²), 100 percent aramid material no closer than 51 mm (2 in.) apart in parallel strips.
8.4.9.3.1 Specimens, except reflective striping, shall be removed from the ballast material prior to testing.

8.4.9.3.2 Specimens shall be placed in the oven with the long dimension of the specimen parallel to the oven sides.

8.4.9.3.3 Reflective striping specimens shall be placed in the oven with the striping parallel to the oven sides.

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

8.4.10 Specific Requirements for Testing Hardware.

8.4.10.1 A minimum of three complete hardware items shall be tested.

8.4.10.2 Hardware shall not be conditioned.

8.4.10.3 Observations of hardware condition following heat exposure shall be limited to ignition.

8.4.10.4 Hardware shall be evaluated for functionality within 10 minutes following removal from the oven.

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

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.

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 (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.

8.4.13 Specific Requirements for Testing Emblems Including Transfer Films.

8.4.13.1 Specimens shall consist of emblems or transfer films placed on 0.84m² (1 yd²), of navy 200 g/m² (6.0 oz/yd²), 100 percent aramid material fabric pieces that measure 152 mm ± 6 mm × 152 mm ± 6 mm (6 in. ± 0.25 in. × 6 in. ± 0.25 in.).

8.4.13.2 Representative emblems or transfer films specimens shall measure a minimum of 100 mm (4.0 in.) and 25 (1.0 in.) and shall be attached to individual fabric pieces in the same manner as normally applied for their attachment to garments.

8.4.13.3 Specimens shall be placed in the oven with the long dimension of the specimen parallel to the oven sides.

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

Statement of Problem and Substantiation for Public Comment

Large emblems or heraldry applied by the manufacturer that are not flame resistant should be either limited in their size or subject to testing commensurate with other fabrics used in the construction of the garment. The proposed series of changes establish clearer definitions, design criteria, performance criteria, and test methods to evaluate large labels when applied by the manufacturer. The proposed changes address the heat resistance testing of emblems and transfer films.
Related Item
Public Input No. 61-NFPA 2112-2014 [New Section after 6.3]

Submitter Information Verification

Submitter Full Name: JEFFREY STULL
Organization: INTERNATIONAL PERSONNEL PROTECTION, INC.
Street Address:
City:
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Zip:
Submittal Date: Fri May 15 09:01:06 EDT 2015
8.4.2.1

Only heat resistance testing shall be conducted on not fewer than at least three specimens for each hardware item, label material, other flame-resistant garment, shroud/hood/balaclava, glove, and rainwear fabrics, and cold weather insulation materials; and other flame-resistant garment materials, not listed in 8.4.2.2 and 8.4.2.3.

Statement of Problem and Substantiation for Public Comment

removed the requirement for testing labels since this is not consistent with chapter 7. Reorganized for clarity.

Related Item

First Revision No. 19-NFPA 2112-2014 [Sections 8.4.8.2, 8.4.8.3]

Submitter Information Verification

Submitter Full Name: Amanda Newsom
Organization: UL LLC
Street Address:
City:
State:
Zip:
Submittal Date: Thu Apr 07 15:19:55 EDT 2016
Public Comment No. 82-NFPA 2112-2016 [Sections 8.4.4, 8.4.5]

Sections 8.4.4, 8.4.5

8.4.4 Apparatus.

8.4.4.1 The test oven shall be a horizontal flow circulating oven with minimum interior dimensions to permit the specimens to be suspended and be not less than 51 mm (2 in.) from any interior oven surface or other test specimens.

8.4.4.2 The test oven shall have an airflow rate of 38 m/min to 76 m/min (125 ft/min to 250 ft/min) at the standard temperature and pressure of 21°C (70°F) at 1 atm, measured at the center point of the oven.

8.4.4.3 A test thermocouple shall be positioned so that it is level with the horizontal centerline of a mounted sample specimen.

8.4.4.3.1 The thermocouple shall be equidistant between the vertical centerline of a mounted specimen placed in the middle of the oven and the oven wall where the airflow enters the test chamber.

8.4.4.3.2 The thermocouple shall be an exposed bead, Type J or Type K, No. 30 AWG thermocouple.

8.4.4.3.3 The test oven shall be heated and the test thermocouple stabilized at 260°C ±6/-0°C (500°F ±10/-0°F) for a period of not less than 30 minutes as specified in ASTM F2894, Standard Test Method for Evaluation of Materials, Protective Clothing and Equipment for Heat Resistance Using a Hot Air Circulating Oven.

8.4.5 Procedure.

8.4.5.1 Specimen marking and measurements

Testing shall be performed in accordance with the procedure specified in AATCC 135, Dimensional Changes of Fabrics after Home Laundering.

8.4.5.2 The specimen shall be suspended by metal hooks at the top and centered in the oven so that the entire specimen is not less than 51 mm (2 in.) from any oven surface or other specimen and airflow is parallel to the plane of the material.

8.4.5.3 The oven door shall not remain open more than 15 seconds.

8.4.5.3.1 The air circulation shall be shut off while the door is open and turned on when the door is closed.

8.4.5.3.2 The total oven recovery time after the door is closed shall not exceed 30 seconds.

8.4.5.4 The specimen, mounted as specified, shall be exposed in the test oven for 5 minutes ±0.15/-0 minutes.
8.4.5.5 -
The test exposure time shall begin when the test thermocouple recovers to a temperature of 260°C ± 5°C (500°F ± 9°F).

8.4.5.6 -
Immediately after the exposure specified in 8.4.5.4, the specimen shall be removed and examined for evidence of ignition, melting and dripping, or separation.

8.4.5.7 -
Determination of "pass" or "fail" shall be made within 5 minutes of removal from the oven.

8.4.5.8 -
Knit fabric shall be pulled to original dimensions and shall be allowed to relax for 1 minute prior to measurement to determine "pass" or "fail."

(2) The optional stretching frame shall be used to evaluate knit materials when specified by the manufacturer.

Statement of Problem and Substantiation for Public Comment

Test method is being updated to include the ASTM test method for heat resistance to align the procedure and apparatus with other similar standards. The stretching frame was left optional to match requirements with those outlined in NFPA 1975, which contains similar products.

Related Public Comments for This Document

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<td>Public Comment No. 83-NFPA 2112-2016 [Section No. 2.3.2]</td>
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First Revision No. 18-NFPA 2112-2014 [Sections 8.4.3.1, 8.4.3.2, 8.4.3.3]

Submitter Information Verification

Submitter Full Name: Amanda Newsom
Organization: UL LLC
Street Address:
City:
State:
Zip:
Submittal Date: Wed May 11 08:16:35 EDT 2016
Public Comment No. 57-NFPA 2112-2015 [Section No. 8.4.8.1]

8.4.8.1
Each specimen shall be 381 mm ± 13 mm × 381 mm ± 13 mm (15 in. ± 0.5 in. × 15 in. ± 0.5 in.), with 250 mm ± 6 mm x 250 mm ± 6 mm (10 in. ± 0.25 in. x 10 in. ± 0.25 in.) benchmarks, and shall be cut from the fabric to be utilized in the construction of the clothing item.

Statement of Problem and Substantiation for Public Comment

Only specimen size was specified; benchmark size should also be specified.

Related Item
First Revision No. 56-NFPA 2112-2014 [Global Input]

Submitter Information Verification

Submitter Full Name: BRIAN SHIELS
Organization: PBI PERFORMANCE PRODUCTS INC
Street Address:
City:
State:
Zip:
Submittal Date: Fri May 15 15:22:44 EDT 2015
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°C/0°C (120°F, 5°F/0°F).

Statement of Problem and Substantiation for Public Comment

While preconditioning for 4 hours at 49°C/120°F may be appropriate in NFPA 1977, we disagree that it is necessary for NFPA 2112 products that will have short, incidental exposure. This 4 hour preconditioning was not suggested for any other product in the first revision.

Related Item
First Revision No. 58-NFPA 2112-2014 [New Section after 8.4.10.5]

Submitter Information Verification

Submitter Full Name: Stacy Klausing
Organization: Arcwear
Street Address: City:
State: Zip:
Submittal Date: Tue May 10 09:42:48 EDT 2016
Add in the following section

8.5.X Apparatus

8.5.X.1 Verify the system response at a minimum annually by performing the In-situ testing specified in section 10.3 within ASTM F1930 Standard Test Method for Evaluation of Flame Resistant Clothing for Protection Against Flash Fire Simulations Using an Instrumented Manikin, with the following specifications. If it is not possible to expose the sensor on the manikin itself with a handheld radiant heat source, an appropriate extension wire can be used to extend the wiring from the manikin to a benchtop radiant heat source.

(1) A minimum of one sensor from each data acquisition card shall be tested
(2) A radiant heating source shall be used to conduct verification
(3) 6000, 8000, and 12000 W/m² (±5%) shall be used as the exposures levels as verified with the appropriate NIST (or equivalent) traceable reference heat flux sensor
(4) Use the following tables to verify the system is predicting burns within in the ranges specified in the table below.

(a) Table 8.5.X.4a shall be used for the 6000 W/m² (±5%) exposure.
(b) Table 8.5.X.4b shall be used for the 8000 W/m² (±5%) exposure.
(c) Table 8.5.X.4c shall be used for the 12000 W/m² (±5%) exposure.

Table 8.5.X.1.4a Table of acceptable heat flux exposures and allowable time to 2nd degree burn predictions

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<th>Exposure (W/m²)</th>
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Table 8.5.X.1.4b Table of acceptable heat flux exposures and allowable time to 2nd degree burn predictions

Table 8.5.X.1.4c Table of acceptable heat flux exposures and allowable time to 2nd degree burn predictions
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Replace 8.5.4.1 with

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*, with the following specifications:

1. All testing shall be conducted with a 3 second exposure.
2. The average incident heat flux shall be 84 kW/m² (± 5%).
3. Heat flux data from one second to three seconds shall be used to calculate the incident heat flux.
4. A numerical fitting function shall not be used to calculate the incident heat flux.
5. Verify that the system response is sufficient such that the average incident heat flux is greater than or equal to 79 kW/m² during a nude calibration exposure at the 1 second mark.

**Statement of Problem and Substantiation for Public Comment**

This public comment is being submitted on behalf of the NFPA 2112 Thermal Manikin Task Group and proposes changes which garnered consensus, although not unanimous, agreement among task group members.

Supplementing ASTM F1930 with language that more specifically describes the apparatus and test procedure will reduce variability in predicted body burn results generated among the many labs that perform this test. Additionally, greater consistency in results will reduce confusion among end users who rely on predicted body burn data to properly select FR clothing.

**Related Item**

Committee Input No. 25-NFPA 2112-2014 [Section No. 8.5.4]

**Submitter Information Verification**

Submitter Full Name: Denise Statham
<table>
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<tr>
<th>Organization:</th>
<th>Bulwark Protective Apparel</th>
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<td>Fri May 13 10:28:10 EDT 2016</td>
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8.5 Manikin Test

8.5.1 Application

The manikin test shall apply to flame-resistant garment fabrics.

8.5.2 Specimens

Three specimens shall be tested.

8.5.2.1 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 Fire Simulations Using an Instrumented Manikin."

8.5.3 Sample Preparation

8.5.3.1 For garments that are designated on the flame-resistant garment label to be washed, specimens shall be tested after one cycle of washing and drying as specified in 8.1.3.

8.5.3.2 For garments that are designated on the flame-resistant garment label to be dry-cleaned, specimens shall be tested after one cycle of dry cleaning as specified in 8.1.4.

8.5.3.3 For garments that are designated on the flame-resistant garment label to be either washed or dry-cleaned, specimens shall be tested after one cycle of washing and drying as specified in 8.1.3, or after one cycle of dry cleaning as specified in 8.1.4.

8.5.3.4 Samples for conditioning shall be full garments.

8.5.4 Procedure

8.5.4.1 Specimens shall be tested in accordance with ASTM F1930, "Standard Test Method for Evaluation of Flame Resistant Clothing for Protection Against 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.

8.5.4.2 The manikin shall be dressed in 170 g/m² (5.0 oz/yd²) (+5 percent), jersey knit, 100 percent cotton underwear briefs and 140 g/m² (4.2 oz/yd²) (+5 percent) jersey knit, 100 percent cotton short-sleeve crew-neck T-shirts before the garment specimen is placed on the manikin.

8.5.5 Report

8.5.5.1 The predicted percent body burn based on the total surface area covered by sensors, excluding hands and feet, for each specimen shall be reported.

8.5.5.2 The average predicted body burn of all specimens shall be calculated and reported.

8.5.6 Interpretation

The average predicted body burn shall be used to determine pass/fail performance for garment fabrics.
Statement of Problem and Substantiation for Public Comment

I feel the test should be eliminated from the standard since a recent round robin test showed very little correlation between laboratories.

Related Item
First Revision No. 23-NFPA 2112-2014 [Section No. 8.5.2.2]

Submitter Information Verification

Submitter Full Name: Harry Winer
Organization: HIP Consulting LLC
Street Address:
City: 
State: 
Zip: 
Submittal Date: Wed May 11 14:53:53 EDT 2016
8.5.1 Application.
The manikin test shall apply to flame-resistant garment and rainwear fabrics.

Statement of Problem and Substantiation for Public Comment
The manikin test is now applicable to rainwear fabrics, and should be indicated as such in this section.

Related Item
First Revision No. 37-NFPA 2112-2014 [New Section after 7.4]

Submitter Information Verification
Submitter Full Name: BRIAN SHIELS
Organization: PBI PERFORMANCE PRODUCTS INC
Street Address:
City:
State:
Zip:
Submittal Date: Thu Apr 30 14:43:04 EDT 2015
Public Comment No. 4-NFPA 2112-2015 [Sections 8.5.3.1, 8.5.3.2, 8.5.3.3, 8.5.3.4]

Sections 8.5.3.1, 8.5.3.2, 8.5.3.3, 8.5.3.4

8.5.3.1
For garments or rainwear that are designated on the flame-resistant garment or rainwear label to be washed, specimens shall be tested after one cycle of washing and drying as specified in 8.1.3.

8.5.3.2
For garments or rainwear that are designated on the flame-resistant garment or rainwear label to be dry-cleaned, specimens shall be tested after one cycle of dry cleaning as specified in 8.1.4.

8.5.3.3
For garments or rainwear that are designated on the flame-resistant garment or rainwear label to be either washed or dry-cleaned, specimens shall be tested after one cycle of washing and drying as specified in 8.1.3, or after one cycle of dry cleaning as specified in 8.1.4.

8.5.3.4
Samples for conditioning shall be full garments as described in 8.5.2.2.

Statement of Problem and Substantiation for Public Comment

The manikin test is now applicable to flame-resistant rainwear materials, and therefore the specimen preparation should also apply.

Related Item
First Revision No. 37-NFPA 2112-2014 [New Section after 7.4]

Submitter Information Verification

Submitter Full Name: BRIAN SHIELS
Organization: PBI PERFORMANCE PRODUCTS INC
Street Address:
City:
State:
Zip:
Submittal Date: Thu Apr 30 14:44:38 EDT 2015
8.5.X Apparatus

8.5.X.1 Verify the system response at least once every four months by performing the In-situ testing specified in section 10.3 within ASTM F1930, Standard Test Method for Evaluation of Flame Resistant Clothing for Protection Against Flash Fire Simulations Using an Instrumented Manikin, with the following specifications:

(1) A minimum of six sensors shall be verified. One sensor from the right arm, left arm, left leg, right leg, chest, and back shall be tested.

(2) A radiant heating source shall be used to conduct verification.

(3) 4000, 8000, and 12000 W/m² (±5%) shall be used as the exposures levels.

(4) Use the following tables to verify the system is predicting burns within the ranges specified in the table below.

(a) Table 8.5.X.4a shall be used for the 4000 W/m² (±5%) exposure.

(b) Table 8.5.X.4b shall be used for the 8000 W/m² (±5%) exposure.

(c) Table 8.5.X.4c shall be used for the 12000 W/m² (±5%) exposure.

Table 8.5.X.1.4a Table of acceptable heat flux exposures and allowable time to 2nd degree burn predictions

<table>
<thead>
<tr>
<th>Exposure (W/m²)</th>
<th>Predicted Time to 2nd Deg Burn</th>
<th>Acceptable Range for Time to 2nd Deg. Burn</th>
</tr>
</thead>
<tbody>
<tr>
<td>3800</td>
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<td>37.3-41.3</td>
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<td>3850</td>
<td>38.6</td>
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Table 8.5.X.1.4b Table of acceptable heat flux exposures and allowable time to 2nd degree burn predictions

<table>
<thead>
<tr>
<th>Exposure (W/m²)</th>
<th>Predicted Time to 2nd Deg Burn</th>
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</tr>
</thead>
<tbody>
<tr>
<td>7600</td>
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### Table 8.5.X.1.4c Table of acceptable heat flux exposures and allowable time to 2nd degree burn predictions

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<tr>
<td>8400</td>
<td>13.8</td>
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</tr>
</tbody>
</table>

**Statement of Problem and Substantiation for Public Comment**

Verifying that laboratories can perform Section 10.3 of ASTM F1930, is critical to the calculation of burn injury.
predictions. At this time, ASTM F1930 only requires this test to be performed once. Adding this section will confirm that a laboratory has performed this section at least every four months and at levels seen under a garment. If a system doesn't capture the majority of the energy, it could result in lower burn injury predictions.

**Related Item**

Public Input No. 1-NFPA 2112-2013 [Chapter 1 [Title Only]]

**Submitter Information Verification**

Submitter Full Name: JOHN MORTON-ASLANIS
Organization: North Carolina State University
Affiliation: Textile Protection and Comfort Center
Street Address:
City:
State:
Zip:
Submittal Date: Fri May 15 12:48:03 EDT 2015
8.5.4.3 The accredited laboratory shall evaluate standard reference garments made from both 4.5 osy and 6 osy Nomex, according to section 8.5.4, at a frequency of every six months or less.

8.5.4.3.1 4.5 osy reference garments shall be 4.5 osy /- 0.2 osy Type 462 Nomex piece dyed royal blue. Fabric used to make garments shall be made from 38/2 /- 5% cotton count yarn and have construction of 66 ends /- 2 ends x 42 picks /- 2 picks.

8.5.4.3.1.1 6.0 osy reference garments shall be 6.0 osy /- 0.3 osy Type 462 Nomex piece dyed royal blue. Fabric used to make garments shall be made from 30/2 /- 5% cotton count yarn and have construction of 67 ends /- 2 ends x 46 picks /- 2 picks.

8.5.4.3.2 When tested in accordance with section 8.5.4, results for 4.5 osy garment shall fall within range of 30 – 42% predicted body burn, and results for 6 osy garment shall fall within range of 16 – 24% predicted body burn in order for test laboratory to certify garments to this standard.

8.5.4.3.3 The accredited laboratory shall maintain consistent test methodology for certification garment testing and for both standard reference garments.

Statement of Problem and Substantiation for Public Comment

ASTM F1930, unless further modified to reduce test variation between laboratories, is not adequately specified for use in this NFPA standard. Therefore, a standardization test using specific reference garments should be added to the manikin test to assure agreement of results between accredited laboratories.

The thermal manikin test as currently practiced produces predicted body burn values with extreme variance between laboratories. For example, recent round robin testing performed by five participating laboratories at the direction of NFPA 2112 thermal manikin task group produced values for compliant fabrics ranging from 9.2% to 44.4% predicted body burn (Fabric B), 13.8% to 42% predicted body burn (Fabric F), and 13.5% to 29.6% predicted body burn (Fabric D).

The wide range of values between test laboratories could result in a fabric both failing and passing NFPA 2112 certification when tested at different laboratories, resulting in unsafe products for industrial personnel.

Related Item

Public Input No. 3-NFPA 2112-2013 [Section No. 7.1.5]

Submitter Information Verification

Submitter Full Name: Michael Stanhope
Organization: TenCate/Southern Mills, Inc.
Street Address:
City:
State:
Zip:
Submittal Date: Mon May 16 14:07:19 EDT 2016
8.5.4.1
Specimens shall be tested in accordance with ASTM F1930, Standard Test Method for Evaluation of Flame Resistant Clothing for Protection Against 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.

Replace 8.5.4.1 with
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, with the following specifications

(1) All testing shall be conducted with a 3 second exposure
(2) Verify that the system response is sufficient such that the average incident heat flux is greater than or equal to 79 kW/m² during a nude calibration exposure at the 1 second mark after the initiation of the test.
(3) The average incident heat flux shall be 84 kW/m² (± 5%)
(4) Heat flux data from one second to three seconds shall be used to calculate the incident heat flux
(5) A numerical curve fitting function shall not be used to calculate the incident heat flux.

Additional Proposed Changes

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</tbody>
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Statement of Problem and Substantiation for Public Comment

ASTM F1930 does not provide a minimum system response time for the test. Because the manikin test is a 3 second duration high intensity flame exposure (84kW/m²± 5%), the overall system must reach that level or above within 1 second. If a system cannot reach this level within 1 second the overall energy exposed to the fabric will be significantly reduced.

The incident heat flux as specified in Section 10.4.2 of ASTM F1930-15 does not provide time values where to calculate the steady region during a nude exposure (see attached). This ensures that all laboratories are calculating and setting the incident heat flux over the same time period.

Related Item
First Revision No. 24-NFPA 2112-2014 [Section No. 8.5.4.1]

Submitter Information Verification

Submitter Full Name: JOHN MORTON-ASLANIS
Organization: North Carolina State University
Affiliation: Textile Protection and Comfort Center
Street Address: 
City: 
State: 
Zip: 
Submittal Date: Fri May 15 11:09:30 EDT 2015
8.5.4.1
Specimens shall be tested in accordance with ASTM F1930, Standard Test Method for Evaluation of Flame Resistant Clothing for Protection Against Fire Simulations Using an Instrumented Manikin, using an exposure heat flux of 84 kW/m² (2.020 cal/cm²·sec) ± 5% with an exposure time of 3.0 ± 0.1 seconds.

Statement of Problem and Substantiation for Public Comment

Tolerances are needed on required heat flux and timing as exact numbers are not practical (the provided additions are consistent with ASTM F1930).

Related Item
First Revision No. 24-NFPA 2112-2014 [Section No. 8.5.4.1]

Submitter Information Verification

Submitter Full Name: Roger Parry
Organization: The DuPont Company, Inc.
Street Address:
City:
State:
Zip:
Submittal Date: Thu May 12 11:14:27 EDT 2016
Public Comment No. 27-NFPA 2112-2015 [New Section after 8.5.6]

Additional Proposed Changes

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Statement of Problem and Substantiation for Public Comment

This public comment is being submitted on behalf of the NFPA 2112 Thermal Manikin Task Group.

Supplementing ASTM F1930 with language that more specifically describes the apparatus and test procedure will reduce variability in predicted body burn results generated among the many labs that perform this test. Additionally, greater consistency in results will reduce confusion among end users who rely on predicted body burn data to properly select FR clothing.

Related Item

Committee Input No. 25-NFPA 2112-2014 [Section No. 8.5.4]

Submitter Information Verification

Submitter Full Name: DENISE STATHAM
Organization: BULWARK PROTECTIVE APPAREL
Street Address:
City:
State:
Zip:
Submittal Date: Thu May 14 16:33:46 EDT 2015
Add in the following section

8.5.X Apparatus

8.5.X.1 Verify the system response at least once every four months by performing the In-situ testing specified in section 10.3 within ASTM F1930 Standard Test Method for Evaluation of Flame Resistant Clothing for Protection Against Flash Fire Simulations Using an Instrumented Manikin, with the following specifications

(1) A minimum of six sensors shall be verified. One sensor from the right arm, left arm, left leg, right leg, chest, and back shall be tested.

(2) A radiant heating source shall be used to conduct verification

(3) 4000, 8000, and 12000 W/m² (+/-5%) shall be used as the exposures levels

(4) Use the following tables to verify the system is predicting burns within the ranges specified in the table below.

(a) Table 8.5.X.4a shall be used for the 4000 W/m² (+/-5%) exposure.

(b) Table 8.5.X.4b shall be used for the 8000 W/m² (+/-5%) exposure

(c) Table 8.5.X.4c shall be used for the 12000 W/m² (+/-5%) exposure

Table 8.5.X.1.4a Table of acceptable heat flux exposures and allowable time to 2nd degree burn predictions

<table>
<thead>
<tr>
<th>Exposure (W/m²)</th>
<th>Predicted Time to 2nd Deg Burn</th>
<th>Acceptable Range for Time to 2nd Deg. Burn</th>
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<tbody>
<tr>
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<tr>
<td>3850</td>
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<tr>
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<td>35.4-39.2</td>
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</tr>
<tr>
<td>4200</td>
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<td>32.8-36.2</td>
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</table>

Table 8.5.X.1.4b Table of acceptable heat flux exposures and allowable time to 2nd degree burn predictions

<table>
<thead>
<tr>
<th>Exposure (W/m²)</th>
<th>Predicted Time to 2nd Deg Burn</th>
<th>Acceptable Range for Time to 2nd Deg. Burn</th>
</tr>
</thead>
<tbody>
<tr>
<td>7600</td>
<td>15.8</td>
<td>15-16.6</td>
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</table>
Table 8.5.X.1.4c Table of acceptable heat flux exposures and allowable time to 2nd degree burn predictions

<table>
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<tr>
<th>Exposure (W/m²)</th>
<th>Predicted Time to 2nd Deg Burn</th>
<th>Acceptable Range for Time to 2nd Deg Burn</th>
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<tbody>
<tr>
<td>8300</td>
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<td>13.3-14.7</td>
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<tr>
<td>8400</td>
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Replace 8.5.4.1 with

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, with the following specifications

(1) All testing shall be conducted with a 3 second exposure.
(2) The average incident heat flux shall be 84 kW/m² (+/- 5%).
   a. Heat flux data from one second to three seconds shall be used to calculate the incident heat flux.
   b. A numerical fitting function shall not be used to calculate the incident heat flux.
(3) Verify that the system response is sufficient such that the average incident heat flux is greater than or equal to 79 kW/m² during a nude calibration exposure at the 1 second mark.
8.5.6 Interpretation.
The average predicted body burn shall be used to determine pass/fail performance for garment and rainwear fabrics.

Statement of Problem and Substantiation for Public Comment

The manikin test is now applicable to flame-resistant rainwear. Therefore, the Interpretation of those test results should also apply.

Related Item
First Revision No. 37-NFPA 2112-2014 [New Section after 7.4]

Submitter Information Verification

Submitter Full Name: BRIAN SHIELS
Organization: PBI PERFORMANCE PRODUCTS INC
Street Address: 
City: 
State: 
Zip: 
Submittal Date: Thu Apr 30 14:48:52 EDT 2015
Public Comment No. 6-NFPA 2112-2015 [Section No. 8.6.1]

8.6.1 Application.
The thread heat resistance test method shall apply to each type of thread used in the construction of the flame-resistant garment, shroud/hood/balaclava, glove, and rainwear, other than embroidery.

Statement of Problem and Substantiation for Public Comment
The thread heat resistance performance is now a requirement of all garment types. As such, the associated Test Method should also apply to all garment types.

Related Item
First Revision No. 35-NFPA 2112-2014 [New Section after 7.4]
First Revision No. 36-NFPA 2112-2014 [New Section after 7.4]
First Revision No. 37-NFPA 2112-2014 [New Section after 7.4]

Submitter Information Verification
Submitter Full Name: BRIAN SHIELS
Organization: PBI PERFORMANCE PRODUCTS INC
Street Address:
City:
State:
Zip:
Submittal Date: Thu Apr 30 14:49:57 EDT 2015
8.6.4 Procedure.
Specimens shall be tested to a temperature of 260°C (500°F) in accordance with ASTM D7138, Standard Test Method to Determine Melting Temperature of Synthetic Fibers, Method 2.

Statement of Problem and Substantiation for Public Comment

Either method specified in ASTM D7138 is appropriate as inherently flame resistant fiber is required in 7.2.

Related Item
First Revision No. 26-NFPA 2112-2014 (Section No. 8.6.4)

Submitter Information Verification

Submitter Full Name: Amanda Newsom
Organization: UL LLC
Street Address: 
City: 
State: 
Zip: 
Submittal Date: Thu Apr 07 15:40:26 EDT 2016
Public Comment No. 7-NFPA 2112-2015 [Section No. 8.7.1]

8.7.1 Application.
This test method shall apply to flame-resistant garment, shroud/hood/balaclava, glove, and rainwear product labels.

Statement of Problem and Substantiation for Public Comment

Label durability is now required of all garment types. Therefore, the Test Method should apply to all garment types.

Related Item
First Revision No. 35-NFPA 2112-2014 [New Section after 7.4]
First Revision No. 36-NFPA 2112-2014 [New Section after 7.4]
First Revision No. 37-NFPA 2112-2014 [New Section after 7.4]

Submitter Information Verification

Submitter Full Name: BRIAN SHIELS
Organization: PBI PERFORMANCE PRODUCTS INC
Street Address:
City:
State:
Zip:
Submittal Date: Thu Apr 30 14:52:03 EDT 2015
Public Comment No. 9-NFPA 2112-2015 [Sections 8.7.3.1, 8.7.3.2]

Sections 8.7.3.1, 8.7.3.2

8.7.3.1
For fabrics that are designated on the flame-resistant garment label to be washed only, 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 only, specimens shall be tested before and after 100 cycles of dry cleaning as specified in 8.1.4.

Statement of Problem and Substantiation for Public Comment

As written, a garment that is designated for both washing and dry-cleaning, could be interpreted to be subjected to BOTH requirements. This amendment would clarify this issue.

Related Item
First Revision No. 73-NFPA 2112-2014 [Section No. 8.7]

Submitter Information Verification

Submitter Full Name: BRIAN SHIELS
Organization: PBI PERFORMANCE PRODUCTS INC
Street Address: City:
State: Zip:
Submittal Date: Thu Apr 30 15:02:24 EDT 2015
Public Comment No. 10-NFPA 2112-2015 [Sections 8.7.3.4, 8.7.3.5]

Sections 8.7.3.4, 8.7.3.5

8.7.3.4
For fabrics that are designated on the flame-resistant shroud/hood/balaclava label to be washed only, 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 only, specimens shall be tested before and after 100 cycles of dry cleaning as specified in 8.1.4.

Statement of Problem and Substantiation for Public Comment

As written, this section could require shrouds/hoods/balaclavas designated for laundry and dry-cleaning to be subjected to BOTH. This amendment resolves this issue.

Related Item
First Revision No. 73-NFPA 2112-2014 [Section No. 8.7]

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Submittal Date: Thu Apr 30 15:03:07 EDT 2015
Public Comment No. 11-NFPA 2112-2015 [ New Section after 8.7.3.6 ]

Adding options for Only washing or Only dry cleaning

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

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

Statement of Problem and Substantiation for Public Comment

The First Draft only included instructions for when flame-resistant rainwear was designated for both laundry and dry-cleaning. The addition of these two new sections will allow for testing of flame-resistant rainwear designated for ONLY laundry or ONLY dry-cleaning.

Related Item
First Revision No. 73-NFPA 2112-2014 [Section No. 8.7]

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Public Comment No. 8-NFPA 2112-2015 [ Section No. 8.7.3.7 ]

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 100 cycles of washing and drying as specified in 8.1.3, or after three 100 cycles of dry cleaning as specified in 8.1.4.

Statement of Problem and Substantiation for Public Comment
Flame-resistant rainwear is tested for flame resistance after 100 washing or dry-cleaning cycles. The same requirement should be placed on flame-resistant rainwear for label durability.

Related Item
First Revision No. 52-NFPA 2112-2014 [Section No. 8.3.1.1]
First Revision No. 73-NFPA 2112-2014 [Section No. 8.7]

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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.

8.8.4.2 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/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 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 \(^4\) with an absorptivity of at least 0.9 \(^4\) has been found effective. The outer surface shall have an emissivity of at least 0.9.

8.8.4.2.2.2 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.
8.8.4.2.3 - 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.

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.

8.8.5.2.2 -

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.

8.8.5.2.3 -

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/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.

8.8.5.4 – 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.

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.

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 ± 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 – 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):

$$\rho C_p(x) \frac{dT(x,t)}{dt} = \frac{\partial}{\partial x} \left[ k(x) \frac{\partial T(x,t)}{\partial x} \right]$$

where:
- $\rho C_p(x)$ = Volumetric heat capacity, J/m$^3$•K (cal/cm$^3$•K)
- $t$ = 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 8.8.7.2.1 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>2800</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>2840</td>
</tr>
</tbody>
</table>

8.8.7.2.1.1 – Discussion.
Use of absolute temperatures is recommended when solving Equation 8.8.7.2.1 because Equation 8.8.7.3.1, which is used for the calculation of $\Omega$, 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</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>0.3000</td>
</tr>
<tr>
<td>Volumetric Heat Capacity, $\rho C_p$ J/m$^3$•K (cal/cm$^3$•K)</td>
<td>4.40 x 10$^6$</td>
<td>4.186 x 10$^6$</td>
<td>2.481 x 10$^6$</td>
</tr>
</tbody>
</table>
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.

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 \(\Delta t\) and \(\Delta x\)), finite elements method (for example, the Galerkin method), and the finite volume method (sometimes called the control volume method).

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 (32.5ºC) 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.

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 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.

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).
8.8.7.3 - Determination of the Predicted Skin Burn Injury.

Table 8.8.7.3 Constants for Calculation of Omega Using Eq 8.8.7.3.1

Skin Injury Temperature

Range P ΔE/R Second-degree (4) 317.15 K ≤ T ≤ 323.15 K (44°C ≤ T ≤ 50°C) 2.185 × 10124 s⁻¹ 93634.9 K T > 323.15 K (T > 50°C), use: 1.823 × 1051 s⁻¹ 39109.8 K Third-degree (9) 317.15 K ≤ T ≤ 323.15 K (44°C ≤ T ≤ 50°C) 4.322 × 1064 s⁻¹ 50000 K T > 323.15 K (T > 50°C), use: 9.389 × 10104 s⁻¹ 80000 K

8.8.7.4 -

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 × 10⁻⁶ m (second-degree burn injury prediction) and 1200 × 10⁻⁶ m (third-degree burn injury prediction).

\[ \Omega = \int P e^{-(\Delta E / RT)} dt \]  - [8.8.7.3.1]

where:

\[ \Omega = \text{Burn injury parameter; value } \geq 1 \text{ indicates predicted burn injury} \]
\[ P = \text{Pre-exponential term, dependent on depth and temperature, } 1/\text{sec} \]
\[ \Delta E = \text{Activation energy, dependent on depth and temperature, J/kmol} \]
\[ R = \text{Universal gas constant, } 8314.5 \text{ J/mol} \cdot \text{K} \]
\[ t = \text{time of exposure and data collection period in sec} \]

8.8.7.3.2 -

Determine the second- and third-degree burn injury parameter values, Ωs, 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.

8.8.7.3.3 -

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 8.8.7.2.1.)

8.8.7.3.4 -

A second-degree burn injury occurs when the value of Ω \( \geq 1.0 \) for depths ≥ epidermis/dermis interface depth and < the dermis/subcutaneous interface depth (Table 8.8.7.2.1).

8.8.7.3.5 -

A third-degree burn injury occurs when the value of Ω \( \geq 1.0 \) for depths ≥ the dermis/subcutaneous interface depth (Table 8.8.7.2.1).

8.8.7.3.6 -

For the second- and third-degree burn injury predictions, the temperature dependent values for P and ΔE/R are listed in Table 8.8.7.3.

8.8.7.4 - 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) Exposure</th>
<th>Time Step W/m² (cal/sec·cm²)</th>
<th>S</th>
<th>S</th>
</tr>
</thead>
<tbody>
<tr>
<td>(0.028) 8.30 0.01 16740 (0.376) 6.55 0.01 23609 (0.564) 3.00 0.01 31479 (0.752) 1.95 0.01 39348</td>
<td>(0.040) 1.41 0.01 47218 (1.128) 1.08 0.01 55088 (1.316) 0.862 0.001 62957 (1.504) 0.713 0.001 70827</td>
<td>(1.692) 0.603 0.001 78697 (1.880) 0.522 0.001</td>
<td></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 8.8.7.2.4 (75 µm, 1225 µm, and 3085 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
(2) Hands area of second-degree burn injury (percent)
(3) Hands area of third-degree burn injury (percent)
(4) Total hands area of burn injury (sum of second- and third-degree burn injury) (percent) and associated variation statistic.
(5) Total area (percent) of hands covered by the test gloves
(6) Covered area of second-degree burn injury (percent)
(7) Covered area of third-degree burn injury (percent)
(8) Other calculated information used in assessing performance
(9) 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.

Statement of Problem and Substantiation for Public Comment
There is essentially an identical standard testing method work item in ASTM F23.80 for a hand "fire engulfment" testing apparatus. Unfortunately, the skin burn injury model for the hands has not been established or agreed upon in ASTM or ISO (including skin layer thicknesses). Additional work is needed in this area in order to obtain industry consensus on the correct model for evaluating representative predictive burn injury performance. As such, the flame engulfment testing identified here needs to be postponed until a consensus skin burn injury model for the hands is established.

Related Item
First Revision No. 67-NFPA 2112-2014 [New Section after 8.7.6]

Submitter Information Verification
Submitter Full Name: Roger Parry
Organization: The DuPont Company, Inc.
Street Address:
City:
State:
Zip:
Submittal Date: Thu May 12 11:22:47 EDT 2016
Public Comment No. 52-NFPA 2112-2015 [ New Section after 8.8.5.1 ]

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, with the following specifications:

1. All testing shall be conducted with a 3 second exposure.
2. The average incident heat flux shall be 84 kW/m$^2$ ($\pm$ 5%)
3. Heat flux data from one second to three seconds shall be used to calculate the incident heat flux.
4. A numerical curve fitting function shall not be used to calculate the incident heat flux.
5. Verify that the system response is sufficient such that the average incident heat flux is greater than or equal to 79 kW/m$^2$ during a nude calibration exposure at the 1 second mark after the initiation of the test.

Additional Proposed Changes

File Name: Proposed_Steady_Region_for_Incident_Heat_Flux.png

Statement of Problem and Substantiation for Public Comment

ASTM F1930 does not provide a minimum system response time for the test. Because the manikin test is a 3 second duration high intensity flame exposure (84 kW/m$^2$ $\pm$ 5%), the overall system must reach that level or above within 1 second. If a system cannot reach this level within 1 second the overall energy exposed to the fabric will be significantly reduced.

The incident heat flux as specified in Section 10.4.2 of ASTM F1930-15 does not provide time values where to calculate the steady region during a nude exposure (see attached). This ensures that all laboratories are calculating and setting the incident heat flux over the same time period.

Related Item
First Revision No. 67-NFPA 2112-2014 [New Section after 8.7.6]

Submitter Information Verification

Submitter Full Name: JOHN MORTON-ASLANIS
Organization: North Carolina State University
Affiliation: Textile Protection and Comfort Center
Street Address:
City:
State:
Zip:
Submittal Date: Fri May 15 14:31:45 EDT 2015
Heat Flux vs. Time

- **Exposure Begins**
- **Exposure Ends**

**Steady Region**

**Average Measured Heat Flux**

Heat Flux in kW/m² vs. Time (seconds)
Verify the system response at least once every four months by performing the In-situ testing specified in section 10.3 within ASTM F1930, Standard Test Method for Evaluation of Flame Resistant Clothing for Protection Against Flash Fire Simulations Using an Instrumented Manikin, with the following specifications:

1. A minimum of six sensors shall be verified. One sensor from the right arm, left arm, left leg, right leg, chest, and back shall be tested.

2. A radiant heating source shall be used to conduct verification.

3. 4000, 8000, and 12000 W/m² (±5%) shall be used as the exposures levels.

4. Use the following tables to verify the system is predicting burns within the ranges specified in the table below:

   (a) Table 8.5.X.4a shall be used for the 4000 W/m² (±5%) exposure.

   (b) Table 8.5.X.4b shall be used for the 8000 W/m² (±5%) exposure.

   (c) Table 8.5.X.4c shall be used for the 12000 W/m² (±5%) exposure.

**Table 8.5.X.4a Table of acceptable heat flux exposures and allowable time to 2nd degree burn predictions**

<table>
<thead>
<tr>
<th>Exposure (W/m²)</th>
<th>Predicted Time to 2nd Deg Burn</th>
<th>Acceptable Range for Time to 2nd Deg. Burn</th>
</tr>
</thead>
<tbody>
<tr>
<td>3800</td>
<td>39.3</td>
<td>37.3-41.3</td>
</tr>
<tr>
<td>3850</td>
<td>38.6</td>
<td>36.7-40.5</td>
</tr>
<tr>
<td>3900</td>
<td>38.0</td>
<td>36.4-39.9</td>
</tr>
<tr>
<td>3950</td>
<td>37.3</td>
<td>35.4-39.2</td>
</tr>
<tr>
<td>4000</td>
<td>36.7</td>
<td>34.9-38.5</td>
</tr>
<tr>
<td>4050</td>
<td>36.1</td>
<td>34.3-37.9</td>
</tr>
<tr>
<td>4100</td>
<td>35.6</td>
<td>33.8-37.4</td>
</tr>
<tr>
<td>4150</td>
<td>35.0</td>
<td>33.3-36.8</td>
</tr>
<tr>
<td>4200</td>
<td>34.5</td>
<td>32.8-36.2</td>
</tr>
</tbody>
</table>

**Table 8.5.X.4b Table of acceptable heat flux exposures and allowable time to 2nd degree burn predictions**

<table>
<thead>
<tr>
<th>Exposure (W/m²)</th>
<th>Predicted Time to 2nd Deg Burn</th>
<th>Acceptable Range for Time to 2nd Deg. Burn</th>
</tr>
</thead>
<tbody>
<tr>
<td>7600</td>
<td>15.8</td>
<td>15-16.6</td>
</tr>
<tr>
<td>7650</td>
<td>15.6</td>
<td>14.8-16.4</td>
</tr>
<tr>
<td>7700</td>
<td>15.5</td>
<td>14.7-16.3</td>
</tr>
</tbody>
</table>
### Table 8.5.X.1.4c Table of acceptable heat flux exposures and allowable time to 2nd degree burn predictions

<table>
<thead>
<tr>
<th>Exposure (W/m²)</th>
<th>Predicted Time to 2nd Deg Burn</th>
<th>Acceptable Range for Time to 2nd Deg. Burn</th>
</tr>
</thead>
<tbody>
<tr>
<td>7750</td>
<td>15.4</td>
<td>14.6-16.2</td>
</tr>
<tr>
<td>7800</td>
<td>15.2</td>
<td>14.4-16</td>
</tr>
<tr>
<td>7850</td>
<td>15.1</td>
<td>14.3-15.9</td>
</tr>
<tr>
<td>7900</td>
<td>15.0</td>
<td>14.3-15.8</td>
</tr>
<tr>
<td>7950</td>
<td>14.8</td>
<td>14.1-15.5</td>
</tr>
<tr>
<td>8000</td>
<td>14.7</td>
<td>14-15.4</td>
</tr>
<tr>
<td>8050</td>
<td>14.6</td>
<td>13.9-15.3</td>
</tr>
<tr>
<td>8100</td>
<td>14.5</td>
<td>13.8-15.2</td>
</tr>
<tr>
<td>8150</td>
<td>14.4</td>
<td>13.7-15.1</td>
</tr>
<tr>
<td>8200</td>
<td>14.2</td>
<td>13.5-14.9</td>
</tr>
<tr>
<td>8250</td>
<td>14.1</td>
<td>13.4-14.8</td>
</tr>
<tr>
<td>8300</td>
<td>14.0</td>
<td>13.3-14.7</td>
</tr>
<tr>
<td>8350</td>
<td>13.9</td>
<td>13.2-14.6</td>
</tr>
<tr>
<td>8400</td>
<td>13.8</td>
<td>13.1-14.5</td>
</tr>
</tbody>
</table>

**Statement of Problem and Substantiation for Public Comment**

Verifying that laboratories can perform Section 10.3 of ASTM F1930, is critical to the calculation of burn injury predictions. At this time, ASTM F1930 only requires this test to be performed once. Adding this section will confirm that a laboratory has performed this section at least every four months and at levels seen under a garment. If a
system doesn't capture the majority of the energy, it could result in lower burn injury predictions.

**Related Item**
First Revision No. 67-NFPA 2112-2014 [New Section after 8.7.6]

**Submitter Information Verification**
- **Submitter Full Name:** JOHN MORTON-ASLANIS
- **Organization:** North Carolina State University
- **Affiliation:** Textile Protection and Comfort Center
- **Street Address:**
- **City:**
- **State:**
- **Zip:**
- **Submittal Date:** Fri May 15 14:34:24 EDT 2015
### 8.8.7.1

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.

#### 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):

\[
p C_p(x) \frac{∂[T(x,t)]}{∂t} = ∂[k(x)\frac{∂[T(x,t)]}{∂x}]/∂x \tag{8.8.7.2.1}
\]

where:

- \( p C_p(x) \) = Volumetric heat capacity, J/m³•K (cal/cm³•K)
- \( t \) = 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 8.8.7.2.1.1 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 Palm</th>
<th>Back of hand</th>
<th>Wrist/forearm</th>
<th>Wrist/forearm</th>
<th>Wrist/forearm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Epidermis</td>
<td>75</td>
<td></td>
<td>1125</td>
<td>585</td>
<td>75</td>
<td>1100</td>
<td>3885</td>
<td></td>
</tr>
<tr>
<td>Dermis</td>
<td>1100</td>
<td>1800</td>
<td>3200</td>
<td>600</td>
<td>1100</td>
<td>3800</td>
<td>3885</td>
<td>600</td>
</tr>
<tr>
<td>Subcutaneous Tissue</td>
<td>3800</td>
<td>3885</td>
<td>3885</td>
<td>3200</td>
<td>3800</td>
<td>3885</td>
<td>3885</td>
<td>3885</td>
</tr>
<tr>
<td>Bone Palm</td>
<td>550</td>
<td>1100</td>
<td>3800</td>
<td>550</td>
<td>550</td>
<td>550</td>
<td>550</td>
<td>550</td>
</tr>
<tr>
<td>Back of hand</td>
<td>85</td>
<td>965</td>
<td>600</td>
<td>85</td>
<td>85</td>
<td>85</td>
<td>85</td>
<td>85</td>
</tr>
<tr>
<td>Wrist/forearm</td>
<td>75</td>
<td>1125</td>
<td>3885</td>
<td>75</td>
<td>75</td>
<td>75</td>
<td>75</td>
<td>75</td>
</tr>
</tbody>
</table>

#### Discussion

Use of absolute temperatures is recommended when solving Equation 8.8.7.2.1 because Equation 8.8.7.3.1, which is used for the calculation of \( \Omega \), the burn injury parameter, requires absolute temperatures.

#### Table 8.8.7.2.1.2 Thermo Physical Properties for Each Layer of Model

<table>
<thead>
<tr>
<th>Property Epidermis Dermis Subcutaneous</th>
<th>Tissue Bone Thermal Conductivity, k W/m•K (cal/s•cm•K)</th>
<th>0.6280</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(0.00146) 0.6092</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.00141) 0.2930</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.0007) 0.3000</td>
<td></td>
</tr>
</tbody>
</table>
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.

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 $\Delta t$ and $\Delta x$), finite elements method (for example, the Galerkin method), and the finite volume method (sometimes called the control volume method).

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 x 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 (32.5ºC) 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.

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 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.

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.
8.8.7.2.2.4 - 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).

8.8.7.3 - 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>∆E/R</th>
</tr>
</thead>
<tbody>
<tr>
<td>Second-degree (4)</td>
<td>317.15 K ≤ T ≤ 323.15 K (44°C ≤ T ≤ 50°C)</td>
<td>2.185 × 10^{12} s^{-1}</td>
<td>39109.8 K</td>
</tr>
<tr>
<td>Third-degree (9)</td>
<td>317.15 K ≤ T ≤ 323.15 K (44°C ≤ T ≤ 50°C)</td>
<td>4.322 × 10^{16} s^{-1}</td>
<td>50000 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 × 10^{-6} m (second-degree burn injury prediction) and 1200 × 10^{-6} m (third-degree burn injury prediction).

\[ \Omega = \int P e^{-(\Delta E/R)} dt \]  

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 • K
- \( t \) = time of exposure and data collection period in sec

8.8.7.3.2 - Determine the second- and third-degree burn injury parameter values, \( \Omega \), 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.

8.8.7.3.3 - 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 \( \geq 317.15 \) K (44°C). (See Table 8.8.7.2.1.)

8.8.7.3.4 - 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 8.8.7.2.1).

8.8.7.3.5 - A third-degree burn injury occurs when the value of \( \Omega \geq 1.0 \) for depths \( \geq \) the dermis/subcutaneous interface depth (Table 8.8.7.2.1).

8.8.7.3.6 - For the second- and third-degree burn injury predictions, the temperature dependent values for \( P \) and \( \Delta E/R \) are listed in Table 8.8.7.3.

8.8.7.4 - 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 Required Size of Time Step W/m^2 (cal/scm^2)</th>
<th>S</th>
<th>S</th>
</tr>
</thead>
<tbody>
<tr>
<td>3935.0(0.094)</td>
<td>35.9</td>
<td>0.01</td>
<td>5900</td>
</tr>
<tr>
<td>0.282</td>
<td>8.30</td>
<td>0.01</td>
<td>15740</td>
</tr>
<tr>
<td>0.940</td>
<td>1.44</td>
<td>0.01</td>
<td>47248</td>
</tr>
</tbody>
</table>

NFPA 2112 Technical Committee Second Draft Meeting Agenda (A2017)
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).

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 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.

<table>
<thead>
<tr>
<th>Total</th>
<th>Total area (percent) of hands containing sensors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hands</td>
<td></td>
</tr>
<tr>
<td>(a)</td>
<td>Hands area of second-degree burn injury (percent)</td>
</tr>
<tr>
<td>Hands</td>
<td></td>
</tr>
<tr>
<td>(b)</td>
<td>Hands area of third-degree burn injury (percent)</td>
</tr>
<tr>
<td>Total</td>
<td></td>
</tr>
<tr>
<td>(c)</td>
<td>Total hands area of burn injury (sum of second- and third-degree burn injury) (percent), and associated variation statistic.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Total</th>
<th>Total area (percent) of hands covered by the test gloves</th>
</tr>
</thead>
<tbody>
<tr>
<td>Covered</td>
<td></td>
</tr>
<tr>
<td>(a)</td>
<td>Covered area of second-degree burn injury (percent)</td>
</tr>
<tr>
<td>Covered</td>
<td></td>
</tr>
<tr>
<td>(b)</td>
<td>Covered area of third-degree burn injury (percent)</td>
</tr>
</tbody>
</table>
Other calculated information used in assessing performance

Diagram of the hands showing location and burn injury levels as second- and third-degree areas

Statement of Problem and Substantiation for Public Comment

ASTM F1930 already calls out how to calculate skin burn injury prediction results

Related Item
First Revision No. 67-NFPA 2112-2014 [New Section after 8.7.6]

Submitter Information Verification

Submitter Full Name: JOHN MORTON-ASLANIS
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Street Address:
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Submittal Date: Fri May 15 14:40:47 EDT 2015
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 (0.12 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/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. 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 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.

8.9.4.5.1 - 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 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 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 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.

8.9.5.2.1.2  
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.

8.9.5.2.2  
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.

8.9.5.3  
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.

8.9.5.3.3  
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/cm² ± 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/cm² 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 specimen. 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.
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.

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.

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.

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

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.

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.

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.

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.

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.

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.

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/m$^2$ (cal/s•cm$^2$) 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):

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

- [8.9.7.2.1]

where:
\[ \rho C_p(x) = \text{volumetric heat capacity, J/m}^3 \cdot \text{K (cal/cm}^3 \cdot \text{K)} \]
\[ t = \text{Time in sec} \]
\[ x = \text{Depth from skin surface, m [cm]} \]
\[ T(x,t) = \text{Temperature at depth x, time t, K} \]
\[ k(x) = \text{Thermal conductivity, W/mK (cal/s•cm•K)} \]

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>
<th>Bone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cranium</td>
<td>70</td>
<td>1430</td>
<td>3400</td>
<td></td>
</tr>
<tr>
<td>Temple</td>
<td>50</td>
<td>1800</td>
<td>3400</td>
<td></td>
</tr>
<tr>
<td>Ears</td>
<td>50</td>
<td>750</td>
<td>600</td>
<td></td>
</tr>
<tr>
<td>Cheek</td>
<td>85</td>
<td>1665</td>
<td>4000</td>
<td></td>
</tr>
<tr>
<td>Neck</td>
<td>85</td>
<td>1765</td>
<td>9900</td>
<td></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.

8.9.7.2.2 –
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.

8.9.7.2.2.1 –
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</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tissue</td>
<td>Bone</td>
<td>Thermal Conductivity, kW/mK (cal/s•cm•K)</td>
<td>0.6280</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(0.0015) 0.5902</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(0.0014) 0.2930</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(0.0007) 0.3000</td>
</tr>
</tbody>
</table>
8.9.7.2.2

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 × 10⁻⁶ m has been found effective. Sparse or unstructured meshes are not recommended for use in the finite difference method.

8.9.7.2.3

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 8.9.7.2.2.1, 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.

8.9.7.2.3.1

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.

8.9.7.2.3.2

The absorbed heat flux at the skin surface at time t = 0 (start of the exposure) is zero (0).

8.9.7.2.3.3

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.

8.9.7.2.3.4

The absorbed heat flux values at the skin surface at all times t > 0 are the time dependent absorbed heat flux values determined in 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.

8.9.7.2.4

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).

8.9.7.3

Determination of the Predicted Skin Burn Injury.
Table 8.9.7.3 Constants for Calculation of Omega Using Eq 8.9.7.3.1

Skin Injury Temperature

<table>
<thead>
<tr>
<th>Range of $P$</th>
<th>$T$</th>
<th>$\Delta E/R$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$317.15 K \leq T \leq 323.15 K$</td>
<td>$2.185 \times 10^{124}$</td>
<td>$93534.9$</td>
</tr>
<tr>
<td>$323.15 K \leq T \leq 50^oC$</td>
<td>$1.823 \times 10^{64}$</td>
<td>$50000$</td>
</tr>
<tr>
<td>$T &gt; 323.15 K$</td>
<td>$9.389 \times 10^{104}$</td>
<td>$80000$</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).

\[
\Omega = \int P e^{-\frac{\Delta E}{RT}} dt
\]

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
- $T$ = Temperature at specified depth (in kelvin) K
- $t$ = Time of exposure and data collection period in sec

8.9.7.3.2

Determine the second- and third-degree burn injury parameter values, $\Omega_s$, 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 $\geq 317.15 K$ ($44^oC$). (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 $< \$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 $\geq$ 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 $W/m^2$ (cal/cm²)</th>
<th>Exposure Duration $S$</th>
<th>Required Size of Time Step $W/m^2$ (cal/cm²) $S$</th>
<th>$\Delta E/R$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.094</td>
<td></td>
<td>3935</td>
<td>0.004</td>
</tr>
<tr>
<td>0.141</td>
<td></td>
<td>5903</td>
<td>0.01</td>
</tr>
<tr>
<td>0.282</td>
<td></td>
<td>21.09</td>
<td>0.01</td>
</tr>
<tr>
<td>0.359</td>
<td></td>
<td>0.01</td>
<td>39350</td>
</tr>
<tr>
<td>0.500</td>
<td></td>
<td>8.30</td>
<td>0.01</td>
</tr>
<tr>
<td>0.692</td>
<td></td>
<td>15740</td>
<td>0.01</td>
</tr>
<tr>
<td>0.940</td>
<td></td>
<td>0.01</td>
<td>1.95</td>
</tr>
<tr>
<td>1.283</td>
<td></td>
<td>23609</td>
<td>0.01</td>
</tr>
<tr>
<td>1.504</td>
<td></td>
<td>31479</td>
<td>0.01</td>
</tr>
<tr>
<td>1.880</td>
<td></td>
<td>39348</td>
<td>0.01</td>
</tr>
<tr>
<td>2.128</td>
<td></td>
<td>47218</td>
<td>0.01</td>
</tr>
<tr>
<td>2.412</td>
<td></td>
<td>62957</td>
<td>0.01</td>
</tr>
<tr>
<td>2.692</td>
<td></td>
<td>70827</td>
<td>0.01</td>
</tr>
<tr>
<td>3.000</td>
<td></td>
<td>78697</td>
<td>0.01</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
2. Head area of second-degree burn injury (percent).
3. Head area of third-degree burn injury (percent).
4. Total head area of burn injury (sum of second- and third-degree burn injury) (percent), and associated variation statistic.

5. Total area (percent) of head covered by the test gloves
6. Covered area of second-degree burn injury (percent)
7. Covered area of third-degree burn injury (percent)

8. Other calculated information used in assessing performance
9. 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.

Statement of Problem and Substantiation for Public Comment

There is essentially an identical standard testing method work item in ASTM F23.80 for a head “fire engulfment” testing apparatus. Unfortunately, the skin burn injury model for the head has not been established or agreed upon in ASTM or ISO (including skin layer thicknesses). Additional work is needed in this area in order to obtain industry consensus on the correct model for evaluating representative predictive burn injury performance. As such, the flame engulfment testing identified here needs to be postponed until a consensus skin burn injury model for the head is established.

Related Item
First Revision No. 68-NFPA 2112-2014 [New Section after 8.7.6]

Submitter Information Verification

Submitter Full Name: Roger Parry
Organization: The DuPont Company, Inc.
Street Address: City: State: Zip: Submittal Date: Thu May 12 11:33:03 EDT 2016
8.9.4.1

Instrumented Head

One instrumented head with specified dimensions (TBD)
dimensions specified in Table 8.9.4.1 shall be used.

Table 8.9.4.1

<table>
<thead>
<tr>
<th>Measurement Location</th>
<th>Centimetres</th>
<th>Inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head girth</td>
<td>57</td>
<td></td>
</tr>
</tbody>
</table>

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.

8.9.4.1.1 Size and Shape

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 (1/8 in.) thick has proven effective.

Statement of Problem and Substantiation for Public Comment

This provides dimensions for the instrumented head.

Related Item

First Revision No. 67-NFPA 2112-2014 [New Section after 8.7.6]

Submitter Information Verification

Submitter Full Name: JOHN MORTON-ASLANIS
Organizations: North Carolina State University
Affiliation: Textile Protection and Comfort Center
Street Address: 
City: 
State: 
Zip: 
Submittal Date: Fri May 15 14:26:05 EDT 2015
Public Comment No. 48-NFPA 2112-2015 [New Section after 8.9.5.1.4]

8.9.5.1.5

(1) All testing shall be conducted with a 3 second exposure.

(2) The average incident heat flux shall be 84 kW/m\(^2\) (\(\pm\) 5%).

(3) Heat flux data from one second to three seconds shall be used to calculate the incident heat flux.

(4) A numerical curve fitting function shall not be used to calculate the incident heat flux.

(5) Verify that the system response is sufficient such that the average incident heat flux is greater than or equal to 79 kW/m\(^2\) during a nude calibration exposure at the 1 second mark after the initiation of the test.

Additional Proposed Changes

<table>
<thead>
<tr>
<th>File Name</th>
<th>Description Approved</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proposed_Steady_Region_for_Incident_Heat_Flux.png</td>
<td></td>
</tr>
</tbody>
</table>

Statement of Problem and Substantiation for Public Comment

ASTM F1930 does not provide a minimum system response time for the test. Because the manikin test is a 3 second duration high intensity flame exposure (84 kW/m\(^2\) \(\pm\) 5%), the overall system must reach that level or above within 1 second. If a system cannot reach this level within 1 second the overall energy exposed to the fabric will be significantly reduced.

The incident heat flux as specified in Section 10.4.2 of ASTM F1930-15 does not provide time values where to calculate the steady region during a nude exposure (see attached). This ensures that all laboratories are calculating and setting the incident heat flux over the same time period.

Related Item

First Revision No. 67-NFPA 2112-2014 [New Section after 8.7.6]

Submitter Information Verification

Submitter Full Name: JOHN MORTON-ASLANIS
Organization: North Carolina State University
Affiliation: Textile Protection and Comfort Center
Street Address:
City:
State:
Zip:
Submittal Date: Fri May 15 14:10:52 EDT 2015
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.

Verify the system response at least once every four months by performing the In-situ testing specified in section 10.3 within ASTM F1930, Standard Test Method for Evaluation of Flame Resistant Clothing for Protection Against Flash Fire Simulations Using an Instrumented Manikin, with the following specifications:

1. A minimum of six sensors shall be verified. One sensor from the right arm, left arm, left leg, right leg, chest, and back shall be tested.

2. A radiant heating source shall be used to conduct verification.

3. 4000, 8000, and 12000 W/m² (±5%) shall be used as the exposures levels.

4. Use the following tables to verify the system is predicting burns within the ranges specified in the table below:

   (a) Table 8.5.X.4a shall be used for the 4000 W/m² (±5%) exposure.

   (b) Table 8.5.X.4b shall be used for the 8000 W/m² (±5%) exposure.

   (c) Table 8.5.X.4c shall be used for the 12000 W/m² (±5%) exposure.

<table>
<thead>
<tr>
<th>Exposure (W/m²)</th>
<th>Predicted Time to 2nd Deg Burn</th>
<th>Acceptable Range for Time to 2nd Deg. Burn</th>
</tr>
</thead>
<tbody>
<tr>
<td>3800</td>
<td>39.3</td>
<td>37.3-41.3</td>
</tr>
<tr>
<td>3850</td>
<td>38.6</td>
<td>36.7-40.5</td>
</tr>
<tr>
<td>3900</td>
<td>38.0</td>
<td>36.4-39.9</td>
</tr>
<tr>
<td>3950</td>
<td>37.3</td>
<td>35.4-39.2</td>
</tr>
<tr>
<td>4000</td>
<td>36.7</td>
<td>34.9-38.5</td>
</tr>
<tr>
<td>4050</td>
<td>36.1</td>
<td>34.3-37.9</td>
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<tr>
<td>4100</td>
<td>35.6</td>
<td>33.8-37.4</td>
</tr>
<tr>
<td>4150</td>
<td>35.0</td>
<td>33.3-36.8</td>
</tr>
<tr>
<td>4200</td>
<td>34.5</td>
<td>32.8-36.2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Exposure (W/m²)</th>
<th>Predicted Time to 2nd Deg Burn</th>
<th>Acceptable Range for Time to 2nd Deg. Burn</th>
</tr>
</thead>
<tbody>
<tr>
<td>7600</td>
<td>15.8</td>
<td>15-16.6</td>
</tr>
<tr>
<td>7650</td>
<td>15.6</td>
<td>14.8-16.4</td>
</tr>
</tbody>
</table>
Table 8.5.X.1.4c Table of acceptable heat flux exposures and allowable time to 2\textsuperscript{nd} degree burn predictions

<table>
<thead>
<tr>
<th>Exposure (W/m(^2))</th>
<th>Predicted Time to 2\textsuperscript{nd} Deg Burn</th>
<th>Acceptable Range for Time to 2\textsuperscript{nd} Deg. Burn</th>
</tr>
</thead>
<tbody>
<tr>
<td>7700</td>
<td>15.5</td>
<td>14.7-16.3</td>
</tr>
<tr>
<td>7750</td>
<td>15.4</td>
<td>14.6-16.2</td>
</tr>
<tr>
<td>7800</td>
<td>15.2</td>
<td>14.4-16</td>
</tr>
<tr>
<td>7850</td>
<td>15.1</td>
<td>14.3-15.9</td>
</tr>
<tr>
<td>7900</td>
<td>15.0</td>
<td>14.3-15.8</td>
</tr>
<tr>
<td>7950</td>
<td>14.8</td>
<td>14.1-15.5</td>
</tr>
<tr>
<td>8000</td>
<td>14.7</td>
<td>14-15.4</td>
</tr>
<tr>
<td>8050</td>
<td>14.6</td>
<td>13.9-15.3</td>
</tr>
<tr>
<td>8100</td>
<td>14.5</td>
<td>13.8-15.2</td>
</tr>
<tr>
<td>8150</td>
<td>14.4</td>
<td>13.7-15.1</td>
</tr>
<tr>
<td>8200</td>
<td>14.2</td>
<td>13.5-14.9</td>
</tr>
<tr>
<td>8250</td>
<td>14.1</td>
<td>13.4-14.8</td>
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<td>8300</td>
<td>14.0</td>
<td>13.3-14.7</td>
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<td>8350</td>
<td>13.9</td>
<td>13.2-14.6</td>
</tr>
<tr>
<td>8400</td>
<td>13.8</td>
<td>13.1-14.5</td>
</tr>
</tbody>
</table>

Verifying that laboratories can perform Section 10.3 of ASTM F1930, is critical to the calculation of burn injury.
predictions. At this time, ASTM F1930 only requires this test to performed once. Adding this section will confirm that a laboratory has performed this section at least every four months and at levels seen under a garment. If a system doesn't capture the majority of the energy, it could result in lower burn injury predictions.

**Related Item**
First Revision No. 67-NFPA 2112-2014 [New Section after 8.7.6]

**Submitter Information Verification**

**Submitter Full Name:** JOHN MORTON-ASLANIS  
**Organization:** North Carolina State University  
**Affiliation:** Textile Protection and Comfort Center  
**Street Address:**  
**City:**  
**State:**  
**Zip:**  
**Submittal Date:** Fri May 15 14:16:21 EDT 2015
8.9.7 Calculated Results.

8.9.7.1

Calculated Results.

8.9.7.1.1

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

8.9.7.1.1.1

8.9.7.1.1.1

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):

\[ \rho C_p(x) \frac{\partial [T(x,t)]}{\partial t} = \frac{\partial [k(x) \frac{\partial [T(x,t)]}{\partial x}]}{\partial x} \]  \hspace{1cm} - [8.9.7.2.1]

where:

- \(\rho C_p(x)\) = Volumetric heat capacity, J/m³•K (cal/cm³•K)
- \(t\) = 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>Tissue</th>
<th>Cranium 70</th>
<th>1430</th>
<th>3400</th>
<th>Temple 50</th>
<th>1800</th>
<th>3400</th>
<th>Ears 50</th>
<th>750</th>
<th>600</th>
<th>Cheek 85</th>
<th>1665</th>
<th>4000</th>
<th>Neck 85</th>
<th>1765</th>
<th>9900</th>
</tr>
</thead>
<tbody>
<tr>
<td>Epidermis</td>
<td>70</td>
<td>1430</td>
<td>3400</td>
<td>50</td>
<td>1800</td>
<td>3400</td>
<td>50</td>
<td>750</td>
<td>600</td>
<td>50</td>
<td>1665</td>
<td>4000</td>
<td>85</td>
<td>1765</td>
<td>9900</td>
<td></td>
</tr>
<tr>
<td>Dermis</td>
<td>1430</td>
<td>3400</td>
<td>50</td>
<td>750</td>
<td>600</td>
<td>4000</td>
<td>50</td>
<td>750</td>
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<td>50</td>
<td>1665</td>
<td>4000</td>
<td>85</td>
<td>1765</td>
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<tr>
<td>Subcutaneous</td>
<td>3400</td>
<td>50</td>
<td>750</td>
<td>600</td>
<td>4000</td>
<td>50</td>
<td>750</td>
<td>600</td>
<td>50</td>
<td>50</td>
<td>1665</td>
<td>4000</td>
<td>85</td>
<td>1765</td>
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<tr>
<td>Cranial</td>
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<td>600</td>
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<td>1665</td>
<td>4000</td>
<td>85</td>
<td>1765</td>
<td>9900</td>
<td></td>
</tr>
<tr>
<td>Auricular</td>
<td>70</td>
<td>1430</td>
<td>3400</td>
<td>50</td>
<td>1800</td>
<td>3400</td>
<td>50</td>
<td>750</td>
<td>600</td>
<td>50</td>
<td>1665</td>
<td>4000</td>
<td>85</td>
<td>1765</td>
<td>9900</td>
<td></td>
</tr>
</tbody>
</table>

Table 8.9.7.2.1 Model Thickness Values for Sensor Locations on Head Manikin (in µm)

8.9.7.2.1 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.

8.9.7.2.2

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.

8.9.7.2.2.1

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).
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 (32.5ºC) 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 8.9.7.2.2.1, 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.

8.9.7.2.3.1

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.

8.9.7.2.3.2

The absorbed heat flux at the skin surface at time $t = 0$ (start of the exposure) is zero (0).

8.9.7.2.3.3

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.

8.9.7.2.3.4

The absorbed heat flux values at the skin surface at all times $t > 0$ are the time dependent absorbed heat flux values determined in 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.
8.9.7.2.4 -
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).

8.9.7.3 - 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 Value</th>
<th>ΔE/R Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Second-degree</td>
<td>317.15 K ≤ T ≤ 323.15 K (44°C ≤ T ≤ 50°C)</td>
<td>2.185 × 10^124 s^-1</td>
<td>93534.9 K</td>
</tr>
<tr>
<td>Third-degree</td>
<td>317.15 K ≤ T ≤ 323.15 K (T &gt; 50°C)</td>
<td>1.823 × 10^51 s^-1</td>
<td>39109.8 K</td>
</tr>
<tr>
<td></td>
<td>317.15 K ≤ T ≤ 323.15 K (44°C ≤ T ≤ 50°C)</td>
<td>4.322 × 10^64 s^-1</td>
<td>50000 K</td>
</tr>
<tr>
<td></td>
<td>T &gt; 323.15 K (T &gt; 50°C)</td>
<td>9.389 × 10^104 s^-1</td>
<td>80000 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 × 10^-6 m (second-degree burn injury prediction) and 1200 × 10^-6 m (third-degree burn injury prediction).

\[ \Omega = \int P e^{-\left(\frac{\Delta E}{RT}\right)} dt \]  

where:
\[ \Omega = \text{Burn injury parameter; value} \geq 1 \text{ indicates predicted burn injury} \]
\[ P = \text{Pre-exponential term, dependent on depth and temperature, 1/sec} \]
\[ \Delta E = \text{Activation energy, dependent on depth and temperature, J/kmol} \]
\[ R = \text{Universal gas constant, 8314.5 J/mol} \cdot \text{K} \]
\[ T = \text{Temperature at specified depth (in kelvin) K} \]
\[ t = \text{time of exposure and data collection period in sec} \]

8.9.7.3.2 -
Determine the second- and third-degree burn injury parameter values, \( \Omega_s \), 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 \( < \) 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 \( \geq \) 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) Exposure</th>
<th>Duration Required Size of Time Step W/m²( cal/s•cm²) S·S</th>
<th>S·S</th>
</tr>
</thead>
<tbody>
<tr>
<td>3935 (0.094) 35.9 0.04 5903 (0.141) 21.09 0.04 11805</td>
<td>S·S</td>
<td></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, 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 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

Calculate the results according to Section 12 of ASTM F1930-15. For all balaclava/shroud/hood 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:

- Total
  (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).
  Total
  (c) Total head area of burn injury (sum of second- and third-degree burn injury) (percent), and associated variation statistic.
- Total area (percent) of head covered by the test gloves
  (1) Covered area of second-degree burn injury (percent)
Statement of Problem and Substantiation for Public Comment

Referencing ASTM F1930 will simplify how to calculate the burn injury prediction results.

**Related Item**
First Revision No. 67-NFPA 2112-2014 [New Section after 8.7.6]

Submitter Information Verification

<table>
<thead>
<tr>
<th>Submitter Full Name:</th>
<th>JOHN MORTON-ASLANIS</th>
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<tbody>
<tr>
<td>Organization:</td>
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<td>Affiliation:</td>
<td>Textile Protection and Comfort Center</td>
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<td>Submittal Date:</td>
<td>Fri May 15 14:19:10 EDT 2015</td>
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NEW TEST METHOD, SECTION 8.11

8.11 Whole Rainwear Water Penetration Test.

8.11.1 Application. This test method shall apply to rainwear where the manufacturer represents the rainwear as keeping the wearer dry.

8.11.2 Samples.

8.11.2.1 Samples shall be complete rainwear garments.

8.11.2.2 Samples shall be conditioned as specified in 8.1.13.

8.11.3 Specimens. A minimum of three specimens shall be tested.

8.11.4 Apparatus. The apparatus and supplies for testing shall be those specified in ASTM F 1359, Standard Test Method for Liquid Penetration Resistance of Protective Clothing or Protective Ensembles Under a Shower Spray While on a Mannequin, with the following modifications:

1. No surfactant shall be used. Water shall be used as the challenge liquid.

2. The mannequin used in testing shall be fully upright and shall have straight arms and legs with the arms positioned at the mannequin’s side.

3. Only the overhead and two upper side nozzles of the test apparatus shall be used.

8.11.5 Procedure. Liquid penetration testing of garments shall be conducted in accordance with ASTM F 1359, Standard Test Method for Liquid Penetration Resistance of Protective Clothing or Protective Ensembles Under a Shower Spray While on a Mannequin, with the following modifications:

1. No provision for partial garments shall be permitted.

2. Blocking of the specimen shall be performed at the collar and sleeve ends to isolate the testing only for the rainwear.

3. The method used for mounting of the mannequin in the spray chamber shall not interfere with the water spray.

4. The normal outer surface of the material shall be exposed to the liquid as oriented in the clothing item.

5. Fluorescent or visible dyes shall not be used in the water for spraying the suited mannequin.

6. The suited mannequin shall be exposed to the liquid spray 1 minutes in each of the four mannequin orientations for a total of 4 minutes.

7. At the end of the liquid spray exposure period, excess liquid shall be removed from the surface of the specimen.

8. The specimen shall be inspected within 5 minutes of the end of the liquid spray exposure period for evidence of water penetration.

8.11.6 Report. A diagram shall be prepared for each test that identifies the locations of any liquid leakage as detected on the liquid-absorptive garment.

8.11.7 Interpretation. Any evidence of liquid on the liquid absorptive garment, as determined by visual, tactile, or absorbent toweling, shall constitute failure of the specimen.

Statement of Problem and Substantiation for Public Comment

Rainwear should function to provide protection from getting wet. Current requirements for material and seam water penetration resistance in flame resistance rainwear do not capture the design aspects of the clothing to prevent water penetration. Wetting of materials can change the thermal insulation performance of garment systems adversely and can be a factor for increased burn injuries during a high temperature flame/high heat exposure event. This proposed change provides a test method for the evaluation of the full rainwear.

Related Item

First Revision No. 37-NFPA 2112-2014 [New Section after 7.4]
### Submitter Information Verification

<table>
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<th>Submitter Full Name</th>
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<td>INTERNATIONAL PERSONNEL PROTECTION, INC.</td>
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<tr>
<td>Street Address</td>
<td></td>
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<td>Fri May 15 10:13:45 EDT 2015</td>
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### Public Comment No. 35-NFPA 2112-2015 [New Section after A.3.3.6]

<table>
<thead>
<tr>
<th>New A.3.3.9</th>
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</thead>
<tbody>
<tr>
<td>Emblems also include transfer films that are applied as thin films onto fabric through heat.</td>
</tr>
</tbody>
</table>

#### Statement of Problem and Substantiation for Public Comment

Large emblems or heraldry applied by the manufacturer that are not flame resistant should be either limited in their size or subject to testing commensurate with other fabrics used in the construction of the garment. The proposed series of changes establish clearer definitions, design criteria, performance criteria, and test methods to evaluate large labels when applied by the manufacturer.

**Related Item**

Public Input No. 61-NFPA 2112-2014 [New Section after 6.3]

#### Submitter Information Verification

<table>
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<td>Submittal Date: Fri May 15 06:38:08 EDT 2015</td>
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</table>
PROPOSED NEW A.8.3.11.1

A.8.3.11.1 This testing is intended to demonstrate the flame resistance of the specific emblem technology. Testing of representative emblems should be applied to demonstrate the efficacy of the specific emblem technology.

Statement of Problem and Substantiation for Public Comment

Large emblems or heraldry applied by the manufacturer that are not flame resistant should be either limited in their size or subject to testing commensurate with other fabrics used in the construction of the garment. The proposed series of changes establish clearer definitions, design criteria, performance criteria, and test methods to evaluate large labels when applied by the manufacturer. The proposed change provided clarification for the testing of emblem flame resistance.

Related Item

Public Input No. 61-NFPA 2112-2014 [New Section after 6.3]

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Annex B  Properties for Evaluating Flame-Resistant Garments, Shouds/Hoods/Balaclavas, Gloves, and Rainwear

This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.
B.1 Test Properties and Methods.
Table B.1 provides a description of the test properties and methods used for evaluating flame-resistant garments, shrouds/hoods/balaclavas, gloves, and rainwear. A number of additional properties can be used in the evaluation of flame-resistant garments, shrouds/hoods/balaclavas, gloves, and rainwear 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>
<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>Mandatory Tests</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heat transfer</td>
<td></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></td>
</tr>
<tr>
<td>resistance (HTP) (7.1.1)</td>
<td>Method appears in Section 8.2.</td>
<td>This test is a measure of the unsteady state heat transfer properties of garment, shroud/hood/balaclava, glove, and rainwear 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>
<td></td>
</tr>
<tr>
<td>Flame resistance</td>
<td></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 (1 ½ 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></td>
</tr>
<tr>
<td>(7.1.2)</td>
<td>ASTM D6413; washing and drying per commercial laundering procedure or dry cleaning (100 cycles) (Section 8.3)</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>
<td></td>
</tr>
<tr>
<td><strong>Property (Section No.)</strong></td>
<td><strong>Test Method Cited</strong></td>
<td><strong>Description of Test Method</strong></td>
<td><strong>Application of Test Method</strong></td>
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</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><strong>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.</strong></td>
<td><strong>A fabric's resistance to shrinkage of a fabric when exposed to heat is considered important in minimizing the effects of a 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.</strong></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><strong>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.</strong></td>
<td><strong>This test measures how garment fabrics and , shroud/hood/balaclava, glove, and rainwear fabrics and components react to the high heat that could occur during a short-duration thermal exposure from fire. The purpose of the test is to prevent materials or components that will easily ignite, melt, and drip, or separate during exposure to high heat from being used in garments, shrouds/hoods/balaclavas, gloves, and rainwear.</strong></td>
</tr>
<tr>
<td>Manikin testing (7.1.5)</td>
<td>ASTM F1930; washing and drying per commercial laundering procedure or dry cleaning (1 cycle) (Section 8.5)</td>
<td><strong>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.</strong></td>
<td><strong>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.</strong></td>
</tr>
<tr>
<td>Thread melting resistance (Section 7.2)</td>
<td>FTMS 191A, 1534 (Section 8.6)</td>
<td><strong>A small segment of thread used in the stitching of station/work uniforms is flame-resistant garments, shrouds/hoods/balaclavas, gloves, or rainwear 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.</strong></td>
<td><strong>Thread used in flame-resistant garments must, shrouds/hoods/balaclavas, gloves, and rainwear 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.</strong></td>
</tr>
<tr>
<td>Label legibility (Section 7.4)</td>
<td>Method appears in Section 8.7;</td>
<td><strong>Sample labels containing the required product information are subjected to 100 wash/dry or dry cleaning cycles and then</strong></td>
<td><strong>This requirement checks for label durability. Following this test, the labels must remain legible from a</strong></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>
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<td><strong>Mandatory Tests</strong></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>washed and drying per</td>
<td>distance of at least 305 mm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>commercial laundering</td>
<td>(12 in.).</td>
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<tr>
<td></td>
<td></td>
<td>procedure or dry cleaning</td>
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<td>examined for legibility.</td>
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<td><strong>Other Property Evaluations</strong></td>
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<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>
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<td>Fabric weight</td>
<td>ASTM D3776</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>
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<td>Tensile strength (grab method)</td>
<td>ASTM D5034</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>
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<td>Tear strength (Elmendorf method)</td>
<td>ASTM D1424</td>
<td>In this test, 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>
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<td>Material burst strength</td>
<td>ASTM D3787</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>
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<td>Laundering shrinkage</td>
<td>AATCC 135; machine cycle 3; wash temp. IV; and drying procedure Aiii (number of cycles to be specified)</td>
<td>A fabric sample is subjected to controlled washing and drying conditions. Following</td>
<td>Laundering colorfastness is a measure of the percentage a fabric shrinks after laundering.</td>
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<td>Laundering colorfastness</td>
<td>AATCC 61; color change</td>
<td>A fabric sample is subjected to controlled washing and drying conditions. Following</td>
<td>Laundering colorfastness is a measure of the percentage a fabric shrinks after laundering.</td>
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<td>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>change, or fading, that occurs in the fabric following exposure to washing and drying. Fabrics with high color scale ratings are more resistant to color changes in laundering.</td>
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<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>
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<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>
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<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>
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<td>Seam efficiency</td>
<td>ASTM 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>
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**Statement of Problem and Substantiation for Public Comment**

Various new garment types have been added throughout the document. Changes made to Annex B reflect those areas where the various new garment types apply.

**Related Item**

- First Revision No. 35-NFPA 2112-2014 [New Section after 7.4]
- First Revision No. 36-NFPA 2112-2014 [New Section after 7.4]
- First Revision No. 37-NFPA 2112-2014 [New Section after 7.4]
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<td><strong>Submitter Full Name:</strong> BRIAN SHIELS</td>
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<tr>
<td><strong>Organization:</strong> PBI PERFORMANCE PRODUCTS INC</td>
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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.


NFPA 2113, Standard on Selection, Care, Use, and Maintenance of Flame-Resistant Garments for Protection of Industrial Personnel Against Flash Fire, 2015 edition.

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 61, Colorfastness to Laundering: Accelerated, 2013.

AATCC 132, Colorfastness to Dry Cleaning, 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.3 References for Extracts in Informational Sections.
(Reserved)

Statement of Problem and Substantiation for Public Comment
Updated ISO 9001 to latest edition.

Related Public Comments for This Document

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Related Item
First Revision No. 22-NFPA 2112-2014 [Chapter C]

Submitter Information Verification

Submitter Full Name: Aaron Adamczyk
Organization: [ Not Specified ]
Street Address:
City:
State:
Zip:
Submittal Date: Sat May 09 02:28:32 EDT 2015
Committee Input No. 25-NFPA 2112-2014 [ Section No. 8.5.4 ]

8.5.4 Procedure.

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.

8.5.4.2 The manikin shall be dressed in 170 g/m² (5.0 oz/yd²) (± 5 percent), jersey knit, 100 percent cotton underwear briefs and 140 g/m² (4.2 oz/yd²) (±5 percent) jersey knit, 100 percent cotton short-sleeve crew-neck T-shirts before the garment specimen is placed on the manikin.

Submitter Information Verification

Submitter Full Name: Eric Nette
Organization: [ Not Specified ]
Street Address:
City:
State:
Zip:
Submittal Date: Tue Nov 04 11:39:10 CST 2014

Committee Statement and Meeting Notes

Committee Statement: The committee anticipates modifying this section, and any other pertinent sections, in the future depending on additional data pertaining to variability in the ASTM F1930 test results. The modifications will likely focus on, but not be limited to, verification of the test computer code, the test garment, and the calibration. A task group will be formed to address this.

Response Message:

Ballot Results

This item has not been balloted
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