

**NFPA®**

**2112**

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**Standard on**  
**Flame-Resistant Clothing for**  
**Protection of Industrial Personnel**  
**Against Short-Duration Thermal**  
**Exposures from Fire**

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**2018**



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**NFPA® 2112**

**Standard on**

**Flame-Resistant Clothing for Protection of Industrial Personnel Against Short-Duration Thermal Exposures from Fire**

**2018 Edition**

This edition of NFPA 2112, *Standard on Flame-Resistant Clothing for Protection of Industrial Personnel Against Short-Duration Thermal Exposures from Fire*, was prepared by the Technical Committee on Flash Fire Protective Garments and acted on by NFPA at its June Association Technical Meeting held June 4–7, 2017, in Boston, MA. It was issued by the Standards Council on August 17, 2017, with an effective date of September 6, 2017, and supersedes all previous editions.

This document has been amended by one or more Tentative Interim Amendments (TIAs) and/or Errata. See “Codes & Standards” at [www.nfpa.org](http://www.nfpa.org) for more information.

This edition of NFPA 2112 was approved as an American National Standard on September 6, 2017.

**Origin and Development of NFPA 2112**

The NFPA Standards Council established the Technical Committee on Flash Fire Protective Garments in 1998. Between February and August of 1999, the technical committee developed two draft standards: NFPA 2112 and NFPA 2113, *Standard on Selection, Care, Use, and Maintenance of Flame-Resistant Garments for Protection of Industrial Personnel Against Flash Fire*, which were then released for public proposals and comments. NFPA 2112 specifies the minimum design, performance, certification requirements, and test methods for flame-resistant garments for use in areas at risk from flash fires. The first editions of NFPA 2112 and NFPA 2113 were approved by the NFPA membership at the May 2001 NFPA World Fire Safety Congress and were issued by the Standards Council in July 2001.

The 2007 edition revised the scope to clarify that the standard applies to the performance of fabrics and components of garments and not the garment itself. The scope was also modified to indicate that NFPA 2112 does not apply to single-use or limited-use garments. The committee pursued the development of separate documents to address the design, testing, certification, selection, and use of those garments. This revision also incorporated updates to reference test methods and the method for calculating total heat flux.

The 2012 edition updated the term *thermal protective performance* to *heat transfer performance* and incorporated ASTM F2700, *Standard Test Method for Unsteady-State Heat Transfer Evaluation of Flame Resistant Materials for Clothing with Continuous Heating*, as the test method. The test method previously shown in the standard was removed, because it duplicated the ASTM F2700 method. A definition for *cold weather insulation material* and testing requirements were added to ensure that garments incorporating such insulation material are properly tested and certified. The 2012 edition clarified certain aspects of the laundering requirements to prevent the presence of residual detergent during testing.

For the 2018 edition, the technical committee has refined the term *flash fire* to *short duration thermal exposure from fire*, which is a more descriptive term for the hazard that the standards address. Revisions have been made to change the terms. The term *inherent flame resistance* also has been added to the standard from NFPA 1971, *Standard on Protective Ensembles for Structural Fire Fighting and Proximity Fire Fighting*.

New garments have been added to the standard, including shrouds/hoods/balaclavas as one item, and gloves. Shrouds/hoods/balaclavas have been defined to cover those items intended to protect the head and/or neck. Gloves have been defined as garments designed to protect the hands and wrist. For now, the technical committee has decided to include only performance and

construction requirements for these garments without an ASTM F1930, *Standard Test Method for Evaluation of Flame Resistant Clothing for Protection Against Fire Simulations Using an Instrumented Manikin*, style test. These requirements include, but are not limited to, construction, thermal shrinkage, heat transfer protective performance, flame resistance, thread, hardware, and interlinings.

TIA 12-2 was issued to address cold weather insulation and interlining for the 2012 edition. Prior to the issuance of the TIA, testing for afterflame, fire resistance, and thermal shrinkage had been performed on materials in a configuration not representative of that seen in application. Typically, these materials serve as internal insulation when used in garments in the field, and therefore not directly exposed to fire. However, during testing, the materials had been directly exposed to fire, which resulted in restricted use of cold weather gear without adding additional safety to the garments.

The TIA incorporated modifications to the testing requirements for cold weather and interlining materials for the 2012 edition to allow the use of these materials in NFPA 2112 gear. For the 2018 edition, the technical committee has incorporated these allowances for the performance and testing requirements.

New requirements have been added for emblems that are represented as flame resistant. Separate testing requirements have been added to confirm that the fire-resistant emblems provide the desired performance. Reflective striping also now needs to be tested for flame resistance.

Finally, due to a concern about variability in the ASTM F1930 testing standard, the technical committee has added two requirements to the testing apparatus to address variability. First, the lab must verify the response from the sensors to a heat flux before being mounted on the manikin. Second, the TC has added a requirement for two standard reference garments which are constructed of known materials with known results. Before a lab can certify results for the manikin test, the lab must test the reference garments and attain results within a predisposed range.

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

**Committee Scope:** This Committee shall have primary responsibility for documents on the manufacture, selection, care, and use of garments and equipment used for protection of industrial personnel where there is potential for flash fire. Industrial personnel include workers who are potentially or may accidentally be exposed to hydrocarbon or combustible dust flash fires, and not electrical flashes. These documents do not cover fire fighters and other emergency services personnel.

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**NFPA 2112****Standard on****Flame-Resistant Clothing for Protection of  
Industrial Personnel Against Short-Duration  
Thermal Exposures from Fire****2018 Edition**

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**NOTICE:** An asterisk (\*) following the number or letter designating a paragraph indicates that explanatory material on the paragraph can be found in Annex A.

A reference in brackets [ ] following a section or paragraph indicates material that has been extracted from another NFPA document. As an aid to the user, the complete title and edition of the source documents for extracts in mandatory sections of the document are given in Chapter 2 and those for extracts in informational sections are given in Annex C. Extracted text may be edited for consistency and style and may include the revision of internal paragraph references and other references as appropriate. Requests for interpretations or revisions of extracted text shall be sent to the technical committee responsible for the source document.

Information on referenced publications can be found in Chapter 2 and Annex C.

**Chapter 1 Administration**

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

**1.2 Purpose.**

**1.2.1\*** This standard shall provide minimum requirements for the design, construction, evaluation, and certification of flame-

resistant garments, shrouds/hoods/balaclavas, gloves, and cloth face coverings for use by industrial personnel, with the intent of not contributing to the burn injury of the wearer, providing a degree of protection to the wearer, and reducing the severity of burn injuries resulting during egress from or accidental exposure to short-duration thermal exposure from fire.

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

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

**1.3 Application.**

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

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

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

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

**1.3.5** The minimum requirements identified in this standard are not intended to meet all the protection needs of a user in areas at risk from short-duration thermal exposure from fire. Users shall refer to NFPA 2113 for conducting the appropriate hazard assessment to identify the in-use area's minimum protection requirements.

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

**1.5 Equivalency.** Nothing herein shall restrict any jurisdiction or manufacturer from exceeding these minimum requirements.

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

## 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 135, *Dimensional Changes of Fabrics After Home Laundering*, 2012.

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.

ASTM D6413/D6413M, *Standard Test Method for Flame Resistance of Textiles (Vertical Test)*, 2015.

ASTM D7138, *Standard Test Method to Determine Melting Temperature of Synthetic Fibers*, 2016.

ASTM F1358, *Standard Test Method for Effects of Flame Impingement on Materials Used in Protective Clothing Not Designated Primarily for Flame Resistance*, 2016.

ASTM F1930, *Standard Test Method for Evaluation of Flame Resistant Clothing for Protection Against Fire Simulations Using an Instrumented Manikin*, 2015.

ASTM F2700, *Standard Test Method for Unsteady-State Heat Transfer Evaluation of Flame Resistant Materials for Clothing with Continuous Heating*, 2008 (2013).

ASTM F2733, *Standard Specification for Flame Resistant Rainwear for Protection Against Flame Hazards*, 2009.

ASTM F2894, *Standard Test Method for Evaluation of Materials, Protective Clothing and Equipment for Heat Resistance Using a Hot Air Circulating Oven*, 2014.

**N 2.3.3 ISEA Publications.** International Safety Equipment Association, 1901 North Moore Street, Suite #808, Arlington, VA 22209-1762.

ANSI/ISEA 125, *American National Standard for Conformity Assessment of Safety and Personal Protective Equipment*, 2014.

**2.3.3 ISO Publications.** International Organization for Standardization, ISO Central Secretariat, BIBC 11, 8, Chemin de Blandonnet, Case Postale 401, 1214 Vernier, Geneva, Switzerland.

ISO 9001, *Quality Management Systems — Requirements*, 2008.

ISO 9001, *Quality Management Systems — Requirements*, 2015.

ISO/IEC 17025, *General Requirements for the Competence of Testing and Calibration Laboratories*, 2005.

ISO/IEC 17065, *Conformity Assessment — Requirements for Bodies Certifying Products, Processes, and Services*, 1st edition, 2012.

### 2.3.4 Other Publications.

Merriam-Webster's *Collegiate Dictionary*, 11th edition, Merriam-Webster, Inc., Springfield, MA, 2003.

### 2.4 References for Extracts in Mandatory Sections.

NFPA 270, *Standard Test Method for Measurement of Smoke Obscuration Using a Conical Radiant Source in a Single Closed Chamber*, 2013 edition.

NFPA 921, *Guide for Fire and Explosion Investigations*, 2017 edition.

NFPA 1971, *Standard on Protective Ensembles for Structural Fire Fighting and Proximity Fire Fighting*, 2018 edition.

NFPA 1975, *Standard on Emergency Services Work Clothing Elements*, 2014 edition.

NFPA 1977, *Standard on Protective Clothing and Equipment for Wildland Fire Fighting*, 2016 edition.

NFPA 1983, *Standard on Life Safety Rope and Equipment for Emergency Services*, 2017 edition.

NFPA 1991, *Standard on Vapor-Protective Ensembles for Hazardous Materials Emergencies and CBRN Terrorism Incidents*, 2016 edition.

## Chapter 3 Definitions

**3.1 General.** The definitions contained in this chapter shall apply to the terms used in this standard. Where terms are not defined in this chapter or within another chapter, they shall be defined using their ordinarily accepted meanings within the context in which they are used. *Merriam-Webster's Collegiate Dictionary*, 11th edition, shall be the source for the ordinarily accepted meaning.

### 3.2 NFPA Official Definitions.

**3.2.1\* Approved.** Acceptable to the authority having jurisdiction.

**3.2.2\* Authority Having Jurisdiction (AHJ).** An organization, office, or individual responsible for enforcing the requirements of a code or standard, or for approving equipment, materials, an installation, or a procedure.

**3.2.3 Labeled.** Equipment or materials to which has been attached a label, symbol, or other identifying mark of an organization that is acceptable to the authority having jurisdiction and concerned with product evaluation, that maintains periodic inspection of production of labeled equipment or materials, and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.

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

**3.2.5 Shall.** Indicates a mandatory requirement.

**3.2.6 Should.** Indicates a recommendation or that which is advised but not required.

**3.2.7 Standard.** An NFPA Standard, the main text of which contains only mandatory provisions using the word "shall" to indicate requirements and that is in a form generally suitable for mandatory reference by another standard or code or for adoption into law. Nonmandatory provisions are not to be considered a part of the requirements of a standard and shall be located in an appendix, annex, footnote, informational note, or other means as permitted in the NFPA Manuals of Style. When used in a generic sense, such as in the phrase "standards development process" or "standards development activities," the term "standards" includes all NFPA Standards, including Codes, Standards, Recommended Practices, and Guides.

### 3.3 General Definitions.

**3.3.1 Accreditation/Accredited.** A system whereby a certification organization determines that a laboratory has demonstrated the ability to conduct tests in an accurate and precise manner consistent with the requirements of this standard, accepts the laboratory's test data, and continues to monitor laboratory practices to ensure accurate and precise testing consistent with the requirements of this standard.

### 3.3.2 Agents.

**3.3.2.1 Biological Agents.** Biological materials that are capable of causing an acute disease or long-term damage to the human body. [1991, 2016]

**3.3.2.2 Radiological Agents.** Radiation associated with x-rays, alpha, beta, and gamma emissions from radioactive isotopes, or other materials in excess of normal background radiation levels.

### 3.3.3 Body.

**3.3.3.1 Lower Body.** The area of the body below the waist including the legs but excluding the ankles and feet.

**3.3.3.2 Upper Body.** The area of body above the waist and extending to the shoulders, including the arms and wrists but excluding the hands.

**3.3.4 Certification/Certified.** A system whereby a certification organization determines that a manufacturer has demonstrated the ability to produce a product that complies with the requirements of this standard, authorizes the manufacturer to use a label on listed products that comply with the requirements of this standard, and establishes a follow-up program conducted by the certification organization as a check on the methods the manufacturer uses to determine continued compliance with the requirements of this standard. [1971, 2018]

**3.3.5 Certification Organization.** An independent, third-party organization that determines product compliance with the requirements of this standard with a labeling/listing/follow-up program. [1971, 2018]

**N 3.3.6\* Cloth Face Covering.** An item of clothing, primarily covering the nose and mouth, designed to reduce the community spread of bioaerosols.

**3.3.7\* Cold Weather Insulation Material.** Fabric that consists of one or more nonseparable layers that is used for protection in a low-temperature environment.

**3.3.8 Compliance/Compliant.** Meeting or exceeding all applicable requirements of this standard. [1971, 2018]

**3.3.9 Component(s).** Any material, part, or subassembly used in the construction of the compliant product. [1971, 2018]

**3.3.10 Drip.** A flow of liquid that lacks sufficient quantity or pressure to form a continuous stream and runs or falls in drops.

**3.3.11\* 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.

**3.3.12\* Fabric.** The one or more layers of textile material(s) used in the primary construction of protective garments.

**3.3.12.1 Textile Fabric.** A planar structure consisting of yarns or fibers. [1977, 2016]

**N 3.3.13\* Fire.** A rapid oxidation process, which is a chemical reaction resulting in the evolution of light and heat in varying intensities. [921, 2017]

**3.3.14\* Flame Resistance.** The property of a material whereby combustion is prevented, terminated, or inhibited following the application of a flaming or nonflaming source of ignition, with or without subsequent removal of the ignition source. Flame resistance can be an inherent property of a material, or it can be imparted by specific treatment. [1971, 2018] (See 3.3.13.1, *Inherent Flame Resistance*.)

**N 3.3.14.1 Inherent Flame Resistance.** Flame resistance that is derived from the essential characteristic of the fiber or polymer. [1971, 2018]

**Δ 3.3.15 Flash Fire.** A type of short-duration fire that spreads by means of a flame front rapidly through a diffuse fuel, such as dust, gas, or the vapors of an ignitable liquid, without the production of damaging pressure.

**3.3.16 Follow-Up Program.** The sampling, inspections, tests, or other measures conducted by the certification organization on a periodic basis to determine the continued compliance of labeled and listed products that are being produced by the manufacturer to the requirements of this standard. [1977, 2016]

**N 3.3.17 Functional.** The ability of an item to continue to be utilized for its intended purpose.

**3.3.18 Garments.** Clothing including, but not limited to, coveralls, trousers, shirts, and outerwear.

**3.3.18.1 Limited-Use Garment.** A garment whose service life is limited by the manufacturer to a specified number of wear cycles and does not meet the testing requirements of this standard.

**3.3.18.2\* Single-Use Garment.** A garment that is designed to be used one time and then disposed of.

**N 3.3.19 Glove.** An item designed to provide protection to the wearer's hand and wrist.

**3.3.20 Hardware.** Nonfabric components of the protective garment including, but not limited to, those made of metal or plastic.

**3.3.21 Hazardous Material.** Any solid, liquid, gas, or mixture thereof that can potentially cause harm to the human body through respiration, ingestion, skin absorption, or contact.

**3.3.22 Hazardous Materials Emergencies.** Incidents involving the release or potential release of hazardous materials. [1971, 2018]

**3.3.23 Industrial Personnel.** Workers who might be at risk of burn injuries resulting during egress from or accidental exposure to short-duration thermal exposure from fire.

**3.3.24\* Interlining.** Any textile that is incorporated into any garment as a layer between outer and inner layers that covers only a small portion of the overall garment.

**3.3.25 Lining.** Any material that is attached and used to cover or partially cover the inside surface of a flame-resistant garment.

**3.3.26 Melt.** A response to heat by a material resulting in evidence of flowing or dripping. [1983, 2017]

**3.3.27 Model.** The collective term used to identify a group of elements or items of the same basic design and components from a single manufacturer produced by the same manufacturing and quality assurance procedures that are covered by the same certification. [1971, 2018]

**3.3.28\* Product.** The compliant flame-resistant garment, shrouds/hoods/balaclavas, or gloves.

**3.3.29\* Product Label.** A label or marking affixed to a product by the manufacturer containing compliant statements, certification statements, manufacturer or model information, or similar dates. [1971, 2018]

**3.3.30 Reflective Striping.** Material added to the exterior of the garment to enhance nighttime or daytime visibility.

**3.3.31 Reinforcement.** An additional layer of a textile material applied to a specific area of the protective garment to make that portion of the protective garment more resistant to wear.

**3.3.32 Sample.** An amount of the material, product, or assembly to be tested that is representative of the item as a whole. [270, 2013]

**3.3.33 Seam.** Any permanent attachment of two or more protective garment fabrics in a line formed by joining the separate material pieces.

**3.3.33.1 Sewn Seam.** A series of stitches joining two or more separate plies of material(s) of planar structure, such as textiles. [1975, 2014]

**3.3.34 Separate.** A material response evidenced by splitting or delaminating. [1971, 2018]

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

**N 3.3.36\* Shroud/Hood/Balaclava.** An item of clothing designed to provide protection to the wearer's head or neck, or both, less the face opening.

**3.3.37 Specimen.** The item that undergoes testing; in some cases, the specimen is also the sample. [1971, 2018]

**N 3.3.38 Transfer Film.** A type of emblem characterized as a thin nontextile polymeric material thermally bonded to the exterior surface of a garment, excluding reflective striping.

**3.3.39 Trouser.** A garment that is designed to provide minimum protection to the lower torso and legs, excluding the ankles and feet.

## Chapter 4 Certification

### 4.1 General.

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

**N 4.1.1.1** All flame-resistant cloth face coverings that are labeled as compliant with this standard shall be constructed of compliant components that meet or exceed all applicable requirements specified in this standard and in Chapter 4 with the following exceptions:

- (1) Certification program requirements in Section 4.2 shall not apply to flame-resistant cloth face coverings.
- (2) Inspection and testing requirements in Section 4.3 shall not apply to flame-resistant cloth face coverings.
- (3) Manufacturer quality assurance program requirements for third-party audits shall not apply to flame-resistant cloth face coverings.

**N 4.1.1.2\*** All flame-resistant cloth face coverings that are labeled as compliant with this standard shall be constructed of compliant components that meet the Level 2 conformity assessment requirements specified in Chapter 7 of ANSI/ISEA 125, *American National Standard for Conformity Assessment of Safety and Personal Protective Equipment*, with the exception of paragraph 7.1.

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

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

**N 4.1.3.1** All flame-resistant cloth face coverings shall be labeled.

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

**N 4.1.4.1** All flame-resistant cloth face coverings shall have a label that meets 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, or gloves to the 2012 edition of this standard on or after August 10, 2017.

**4.1.8** The certification organization shall not permit any manufacturer to label any flame-resistant garments, shrouds/hoods/balaclavas, or gloves as compliant with the 2012 edition of this standard on or after August 10, 2018.

## 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 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, and gloves conform to the requirements of this standard.
- (2) The manufacturer has documentation that the fabric and components used in the garment, shroud/hood/balaclava, and glove 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, and gloves, the certification organization shall conduct inspections of the manufacturing facility and the accredited laboratory, as specified in 4.3.2 through 4.3.9.

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

**4.3.3** All inspections, evaluations, conditioning, or testing conducted by a product manufacturer shall not be used in the

certification or recertification process unless the facility for inspections, evaluations, conditioning, or testing has been accredited in accordance with all requirements pertaining to testing laboratories in ISO 17025, *General Requirements for the Competence of Testing and Calibration Laboratories*.

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

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

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

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

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

#### **4.3.9 Recertification.**

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

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

#### **4.3.10 Product Modifications.**

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

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

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

#### **4.4 Manufacturer's Quality Assurance Program.**

##### **4.4.1 General.**

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

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

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

##### **4.4.2 Instructions.**

**4.4.2.1** The manufacturer shall maintain written inspection and testing instructions.

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

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

##### **4.4.3 Records.**

**4.4.3.1** The manufacturer shall maintain records of all "pass" and "fail" tests.

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

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

##### **4.4.5 Calibration Program.**

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

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

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

##### **4.4.7 Nonconforming Materials.**

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

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

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

## Chapter 5 Labeling and Information

### 5.1 Product Label Requirements.

**5.1.1\*** All flame-resistant clothing shall have a product label or labels permanently and conspicuously attached to each flame-resistant garment, shroud/hood/balaclava, and glove.

**N 5.1.1.1\*** All flame-resistant cloth face coverings shall have a label or labels permanently and conspicuously attached to each flame-resistant cloth face covering.

**5.1.2** At least one product label shall be conspicuously located inside each flame-resistant garment, shroud/hood/balaclava, and glove.

**5.1.3** Multiple label pieces shall be permitted in order to carry all statements and information required to be on the product label.

**5.1.4\*** 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.

**N 5.1.4.1** Flame-resistant cloth face coverings shall be exempt from the requirements of 5.1.4.

**5.1.5** All worded portions of the required label or product label shall be printed in English. Supplementary languages, in addition to English, shall be permitted.

**△ 5.1.6** Symbols and other pictorial graphic representations shall be permitted to be used to supplement worded statements on the label or product label.

**5.1.7** Graphic representations shall be consistent to clearly communicate the intended message.

**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 2112-2018. NFPA 2113 REQUIRES UPPER AND LOWER BODY COVERAGE.

**N 5.1.8.1** The following statement shall be printed legibly on the flame-resistant cloth face covering label in letters at least 2.5 mm (0.10 in.) high:

THIS CLOTH FACE COVERING MEETS THE REQUIREMENTS OF NFPA 2112-2018.

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

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

**N 5.1.9.1\*** At a minimum, the following information shall also be printed legibly on the flame-resistant cloth face covering label in letters at least 1.6 mm (0.063 in.) high:

- (1) Model name, number, or design

- (2) Manufacturer's name, identification, or designation
- (3) Manufacturer's garment identification number, lot number, or serial number
- (4) "DO NOT REMOVE"

**5.1.10** The product label shall also include the international symbol for "Read user instructions before use," as shown in Figure 5.1.10.

**5.1.11** The manufacturer shall be permitted to exclude the international symbol for "Read user instructions before use," as described in 5.1.10, when all of the information specified in 5.2.1 is provided on the product label or other labels adjacent to the product label.

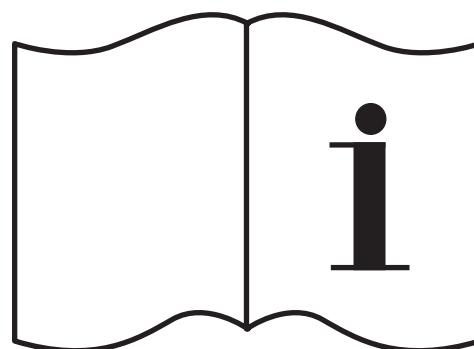
**5.1.12** Garments, shrouds/hoods/balaclavas, or gloves with multiple layers, including an outer layer and removable cold weather insulation material layer, shall specify the certified configuration and include a warning on the label stating that all layers must be properly secured and worn in accordance with the manufacturer's instructions.

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

### 5.2 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



**FIGURE 5.1.10 "Read User Instructions Before Use" Symbol.**

- (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.

## Chapter 6 Design Requirements

### N 6.1 Garments, Shrouds/Hoods/Balaclavas, Gloves, and Cloth Face Coverings.

**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.

**N 6.2 Use of a Liner for Cold Weather Insulation.** Garments shall be permitted to include liners in their construction including cold weather insulation materials where the liner is either integral to the garment or removable.

**N 6.2.1\*** Where garments incorporate a cold weather insulation material as part of a removable lining system, the garment shall be designed such that the removable liner consisting of the cold weather insulation material cannot be independently worn.

## Chapter 7 Performance Requirements

### 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  $25\text{ J/cm}^2$  ( $6.0\text{ cal/cm}^2$ ) and a "contact" HTP rating of not less than  $12.6\text{ J/cm}^2$  ( $3.0\text{ cal/cm}^2$ ).

**N 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.

**N 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 and cold weather insulation material 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 afterflame of not more than 2 seconds, and shall not melt and drip.

**N 7.1.2.1\*** Emblems that are placed on the exterior of the garment and are represented as being flame resistant shall be tested for flame resistance as specified in Section 8.3, shall have an afterflame of not more than 2 seconds, and shall not melt and drip.

**N 7.1.2.2** Reflective striping utilized in the construction of flame-resistant garments shall be tested for flame resistance as specified in Section 8.3, shall have an afterflame 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 7.1.4.2 and 7.1.4.3, 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.

**N 7.1.4.1** Where emblems on the exterior of the garment are represented as flame resistant, the emblems shall be tested for heat resistance as specified in Section 8.4, and shall not melt and drip, separate, or ignite.

**7.1.4.2** Labels and emblems not being represented as flame resistant shall not be required to be tested for heat resistance.

**△ 7.1.4.3** 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 layers intended to be worn separately, each wearable layer shall be tested separately. Where each wearable layer has been separately tested, the wearable combinations of these layers is not required to be tested.

**N 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.

**7.2 Thread Requirements.** Specimens of all sewing thread utilized in the construction of flame-resistant garments, excluding embroidery, shall be made of an inherently flame-resistant fiber, shall be tested for heat resistance as specified in Section 8.6, and shall not melt.

**7.3\* Hardware Requirement.** Specimens of hardware used in the construction of flame-resistant clothing items, including but not limited to buttons, fasteners, and nonfabric-based closures, shall be individually tested for heat resistance in their original form as specified in Section 8.4; shall not melt and drip, separate, or ignite; and shall remain functional.

**7.4 Label Requirement.** Specimen labels used in the construction of flame-resistant garments, shrouds/hoods/balaclavas, and gloves shall be tested, as specified in Section 8.7, for printing durability and shall remain legible and in place.

**N 7.4.1** Specimen labels used in the construction of flame-resistant cloth face coverings shall be exempt from the requirements of Section 7.4.

**N 7.5 Shroud/Hood/Balaclava Requirements.**

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

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

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

**N 7.5.4** Fabric and other textile materials other than those items described in 7.1.4.2 and 7.1.4.3 used in the construction of flame-resistant shrouds/hoods/balaclavas shall be individually tested for heat resistance in their original form as specified in Section 8.4, and shall not melt and drip, separate, or ignite.

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

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

**N 7.5.5** Sewing thread utilized in the construction of flame-resistant 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.

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

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

**N 7.6 Glove Requirements.**

**N 7.6.1** Gloves composites shall be tested for heat transfer protective performance (HTP) as specified in Section 8.2, and shall have a "spaced" HTP rating of not less than 25 J/cm<sup>2</sup> (6.0 cal/cm<sup>2</sup>) and a "contact" HTP rating of not less than 12.6 J/cm<sup>2</sup> (3.0 cal/cm<sup>2</sup>).

**N 7.6.2** Glove composites shall be tested for flame resistance as specified in Section 8.8 and as follows:

- (1) Have a char length of not more than 100 mm (4 in.)
- (2) Have an average afterflame of not more than 2 seconds

- (3) Not melt and drip
- (4) Not exceed 5.0 percent of the specimen's original weight in consumed material

**N 7.6.2.1** Exterior, nonmetallic hardware used in the construction of flame-resistant gloves, excluding fasteners and zippers, shall be tested for flame resistance as specified in Section 8.8 and as follows:

- (1) Have an average afterflame of not more than 2 seconds
- (2) Not melt and drip

**N 7.6.2.2** Trim; reinforcement materials; and external labels, tags, or emblems that are greater than 25.8 cm<sup>2</sup> (4 in.<sup>2</sup>) shall be included in these requirements.

**N 7.6.2.3** Hook and loop fasteners, where not in direct contact with the skin, shall be excluded from these requirements.

**N 7.6.3** Gloves shall be tested for thermal shrinkage resistance as specified in Section 8.4, and shall not have an average percent shrinkage of more than 10 percent in either direction.

**N 7.6.4** Gloves shall be tested for heat resistance as specified in Section 8.4 and as follows:

- (1) Not melt and drip, separate, or ignite
- (2) Have all hardware remain functional

**N 7.6.4.1** Trim; reinforcement materials; and external labels, tags, or emblems that are greater than 25.8 cm<sup>2</sup> (4 in.<sup>2</sup>) shall be included in these requirements. Separation shall not be evaluated.

**N 7.6.4.2** Internal liners, elastics, internal labels, and hook and loop fasteners, where not in direct contact with the skin, shall be excluded from these requirements.

**N 7.6.4.3** Internal liners, elastics, internal labels, and hook and loop fasteners, where in direct contact with the skin, shall not melt and drip, or ignite.

**N 7.6.5** Sewing thread utilized in the construction of flame-resistant gloves, excluding embroidery, shall be made of an inherently flame-resistant fiber.

**N 7.6.5.1** Specimens of this thread shall be tested for heat resistance as specified in Section 8.6, and shall not melt.

**N 7.6.6** Specimen labels used in the construction of flame-resistant gloves shall be tested for printing durability as specified in Section 8.7 and shall remain legible.

**N 7.7 Cloth Face Covering Requirements.**

**N 7.7.1** Fabric components used in the construction of cloth face coverings shall be compliant with all fabric requirements in Section 7.1.

**N 7.7.2** Sewing thread components used in the construction of cloth face coverings shall be compliant with the thread requirements in Section 7.2.

**N 7.7.3** Hardware components used in the construction of cloth face coverings shall be compliant with the hardware requirements in Section 7.3.

## Chapter 8 Test Methods

### 8.1 Sample Preparation Procedures.

#### 8.1.1 Application.

8.1.1.1 The sample preparation procedures contained in Section 8.1 shall apply to each test method in Chapter 8, as specifically referenced in the sample preparation section of each test method.

8.1.1.2 Only the specific sample preparation procedure or procedures referenced in the sample preparation section of each test method shall be applied to that test method.

#### 8.1.2 Room Temperature Conditioning Procedure.

8.1.2.1 Specimens shall be conditioned at a temperature of  $21^{\circ}\text{C} \pm 3^{\circ}\text{C}$  ( $70^{\circ}\text{F} \pm 5^{\circ}\text{F}$ ) and a relative humidity of 65 percent  $\pm 5$  percent for at least 4 hours.

8.1.2.2 Specimens shall be tested within 5 minutes of removal from conditioning.

**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  $1 \text{ m}^2$  (1 yd<sup>2</sup>) of each material.
- (12) Garments 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  $68^{\circ}\text{C} \pm 3^{\circ}\text{C}$  ( $155^{\circ}\text{F} \pm 5^{\circ}\text{F}$ ) without a load.
- (17) Wash water temperature shall be within  $\pm 3^{\circ}\text{C}$  ( $\pm 5^{\circ}\text{F}$ ) of the value in Table 8.1.3.

**N 8.1.3.1** In Table 8.1.3, carryover shall be accomplished with agitation.

#### 8.1.4 Dry Cleaning Procedure.

8.1.4.1 Where required, specimens shall be subjected to the required number of cycles of dry cleaning in accordance with the procedures of Sections 9.2 and 9.3 of AATCC 158, *Dimensional Changes on Dry-Cleaning in Perchloroethylene: Machine Method*.

8.1.4.2 Fabric samples for dry cleaning shall be at least  $1 \text{ m}^2$  (1 yd<sup>2</sup>) of each material.

**N 8.1.4.3** Garments shall be permitted for conditioning.

### 8.2 Heat Transfer Performance (HTP) Test.

**8.2.1 Application.** This test method shall apply to flame-resistant garment, shroud/hood/balaclava, glove, and cloth face covering fabrics.

#### 8.2.2 Specimens.

8.2.2.1 HTP testing shall be conducted on six specimens — three in the spaced configuration and three in the contact configuration — measuring  $150 \text{ mm} \pm 5 \text{ mm} \times 150 \text{ mm} \pm 5 \text{ mm}$  (6 in.  $\pm \frac{1}{4}$  in.  $\times$  6 in.  $\pm \frac{1}{4}$  in.) and shall consist of all layers representative of the garment, shroud/hood/balaclava, glove, and cloth face covering to be tested.

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

8.2.2.3 Specimens shall not include seams.

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

#### 8.2.3 Sample Preparation.

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

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

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

**8.2.4 Apparatus.** The test apparatus shall be that specified in ASTM F2700, *Standard Test Method for Unsteady-State Heat Transfer Evaluation of Flame Resistant Materials for Clothing with Continuous Heating*.

#### 8.2.5 Procedure.

8.2.5.1 Heat transfer performance testing shall be performed in accordance with ASTM F2700, *Standard Test Method for Unsteady State Heat Transfer Evaluation of Flame Resistant Materials for Clothing with Continuous Heating*.

8.2.5.2 Single layer specimen heat transfer performance testing shall use the Relaxed Single Layer configuration in ASTM F2700 for testing in spaced and contact orientation.

**8.2.5.3** Multilayer specimen HTP testing shall use the Multiple Layer Samples configuration in ASTM F2700 for testing in spaced and contact orientation.

### 8.2.6 Report.

**8.2.6.1** The individual test HTP rating of each specimen shall be reported separately for both "spaced" and "contact" tests.

**8.2.6.2** The individual average HTP ratings for both "spaced" and "contact" tests shall also be reported.

**8.2.6.3** If an HTP rating is greater than 60, then the HTP rating shall be reported as ">60."

### 8.2.7 Interpretation.

**8.2.7.1** Pass or fail determinations shall be separately based on the individual average HTP ratings for both "spaced" and "contact" tests.

**8.2.7.2** If an individual result from any test set varies more than  $\pm 10$  percent from the average result, the results from the test set shall be discarded and another set of specimens shall be tested.

## 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 cloth face covering 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 film, 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.

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

**N 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  $\times$  305 mm (3 in.  $\times$  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, cold weather insulation materials, shroud/hood/balaclava, and cloth face covering materials that are designated on the 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, shroud/hood/balaclava, and cloth face covering materials that are designated on the product label to be dry-cleaned, specimens

Δ Table 8.1.3 Washing Cycle Procedure

Operations	Time (min)	Temperature		Water Level	Quantity per Wash Load	
		°C	°F		g	oz
Break	10	66	150	Low	17	0.6
Sodium metasilicate (or equivalent)					11	0.4
Sodium tripolyphosphate					22	0.8
Tergitol 15.S.9 or equivalent						
Drain	1					
Carryover*	5	66	150	Low		
Drain	1					
Rinse	2	57	135	High		
Drain	1					
Rinse	2	48	118	High		
Drain	1					
Rinse	2	38	100	High		
Drain	1					
Sour	5	38	100	Low	6	0.2
Sodium silicofluoride						
Drain	1					
Extract	5					

\*See 8.1.3.1.

shall be tested before and after 100 cycles of dry cleaning as specified in 8.1.4.

**8.3.3.3** For fabrics, cold weather insulation materials, shroud/hood/balaclava, and cloth face covering materials that are designated on the product 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 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 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** Afterflame time and char length shall be reported for each specimen.

**8.3.6.2** The average afterflame time and char length for each material shall be calculated and reported.

**8.3.6.3** The afterflame 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 afterflame 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.

**N 8.3.11.1.1** For the purpose of this testing, the textile layer shall be permitted to be of navy 200 g/m<sup>2</sup> (6.0 oz/yd<sup>2</sup>), nominal 100 percent aramid material.

**N 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.

### N 8.3.13 Specific Requirements for Testing Cold Weather Insulation Materials.

**N 8.3.13.1** Samples for wash or dry-clean conditioning shall be prepared by cutting a 75 cm × 75 cm (30 in. × 30 in.) panel of the cold weather insulation material. A similar-sized piece of 200 g/m<sup>2</sup> to 270 g/m<sup>2</sup> (6.0 oz/yd<sup>2</sup> to 8.0 oz/yd<sup>2</sup>) 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.

**N 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.

**N 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.

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

**N 8.3.14 Specific Requirements for Testing Transfer Films.**

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

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

**N 8.3.14.3** Each specimen shall consist of a 76 mm × 305 mm (3 in. × 12 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 305 mm (12 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. Multiple adjacent transfer films shall be permitted to be utilized to achieve the minimum required area.

**N 8.3.14.4** Testing shall be performed as described in 8.3.2 through 8.3.7.

**N 8.3.14.5** Char length shall not be measured.

**8.4 Heat and Thermal Shrinkage Resistance Test.****Δ 8.4.1 Application.**

**N 8.4.1.1** This test method shall apply to flame-resistant garment, shroud/hood/balaclava, glove, and cloth face covering components, hardware, and cold weather insulation materials.

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

**N 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.

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

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

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

**N 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.

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

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

**N 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 at least three specimens for each hardware item, shroud/hood/balaclava, cold weather insulation material, and other flame-resistant garment material 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, and cloth face covering 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, cold weather insulation materials, shroud/hood/balaclava materials, and cloth face covering fabrics that are designated on the product 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, cold weather insulation materials, shroud/hood/balaclava materials, and cloth face covering fabrics that are designated on the product 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, cold weather insulation materials, shroud/hood/balaclava materials, and cloth face covering fabrics that are designated on the product 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 before and 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 be 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** The test procedure shall be as specified in ASTM F2894, with the following modifications stated in 8.4.5.1.1 and 8.4.5.1.2.

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

**8.4.5.1.2** The optional stretching frame shall be used for all knit specimens, where specified by the manufacturer.

**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 Garments and Shroud/Hood/Balaclava Textile Materials.**

**8.4.8.1** Each specimen shall be  $381 \text{ mm} \pm 13 \text{ mm} \times 381 \text{ mm} \pm 13 \text{ mm}$  (15 in.  $\pm$  0.5 in.  $\times$  15 in.  $\pm$  0.5 in.), with  $250 \text{ mm} \pm 6 \text{ mm} \times 250 \text{ mm} \pm 6 \text{ mm}$  (10 in.  $\pm$  0.25 in.  $\times$  10 in.  $\pm$  0.25 in.) benchmarks, 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 Garments, Shroud/Hood/Balaclava, Cloth Face Coverings, and 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  $0.84 \text{ m}^2$  (1 yd<sup>2</sup>) of 100 percent aramid material [navy dyed at  $200 \text{ g/m}^2$  (6.0 oz/yd<sup>2</sup>)] 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.

**N 8.4.11 Specific Requirements for Testing Cold Weather Insulation Materials.**

**N 8.4.11.1** Samples for wash or dry-clean conditioning shall be prepared by cutting a  $50 \text{ cm} \times 20 \text{ cm}$  (20 in.  $\times$  8 in.) panel of the cold weather insulation material. A similar-sized cloth piece of  $200 \text{ g/m}^2$  to  $270 \text{ g/m}^2$  (6.0 oz/yd<sup>2</sup> to 8.0 oz/yd<sup>2</sup>) 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.

**N 8.4.11.2** Following wash or dry-clean conditioning, three specimens measuring 152 mm  $\times$  152 mm (6 in.  $\times$  6 in.) shall be

removed from the cold weather insulation material layer of the conditioned panel.

**N 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.

**N 8.4.12 Specific Requirements for Testing Gloves.**

**N 8.4.12.1** Specimens shall include complete gloves.

**N 8.4.12.2** Three glove specimens shall be tested.

**N 8.4.12.3** Glove specimens shall be of a size such that they fit the following hand dimensions:

- (1) Hand length:  $19.25 \text{ mm} - 20.25 \text{ mm}$  (7.58 in.  $-$  7.97 in.)
- (2) Hand circumference:  $19.25 \text{ mm} - 23.25 \text{ mm}$  (7.58 in.  $-$  9.15 in.)

**N 8.4.12.4** Specimen gloves shall be conditioned as specified in 8.1.2 prior to testing.

**N 8.4.12.5** The dimensions of the glove specimen shall then be measured.

**N 8.4.12.5.1** 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.

**N 8.4.12.5.2** 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.

**N 8.4.12.6** The glove body shall then be filled with 4 mm ( $\frac{3}{16}$  in.) perforated soda-lime glass beads, with care taken to tightly pack the glass beads into the fingers of the glove and into the glove body.

**N 8.4.12.6.1** A total of 50 mL (1.7 fl oz) of beads shall be evenly distributed into the fingers.

**N 8.4.12.6.2** A mesh bag shall be filled with 375 mL (12.7 fl oz) of beads.

**N 8.4.12.6.3** The bag shall be closed to keep the beads from spilling out.

**N 8.4.12.6.4** The mesh bag filled with beads shall be placed inside the body of the glove.

**N 8.4.12.6.5** The glass beads shall be at a temperature of  $21^\circ\text{C} \pm 3^\circ\text{C}$  ( $71^\circ\text{F} \pm 5^\circ\text{F}$ ).

**N 8.4.12.7** 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.

**N 8.4.12.8** The test oven shall be heated and the test thermometer stabilized at  $260^\circ\text{C}$ ,  $6/-0^\circ\text{C}$  (500°F, 10/-0°F) for a minimum of 30 seconds.

**N 8.4.12.9** After 5 minutes, 15/-0 seconds, of oven exposure at  $260^\circ\text{C}$ ,  $6/-0^\circ\text{C}$  (500°F, 10/-0°F), the sample glove shall be removed and allowed to cool for a minimum of 2 minutes.

**N 8.4.12.10** The specimen shall be examined for evidence of melting and dripping, separation, or ignition.

**N 8.4.12.11** Hardware shall be evaluated for functionality within 10 minutes following removal from the oven.

**N 8.4.12.12** After the oven exposure, the dimensions of the glove specimen shall also be measured as described in 8.4.12.5 to determine pass/fail.

**N 8.4.12.13** 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.

**N 8.4.12.14** Testing shall be performed as described in 8.4.2 through 8.4.8.

#### **N 8.4.13 Specific Requirements for Testing Emblems, Including Transfer Films.**

**N 8.4.13.1** Specimens shall consist of emblems or transfer films placed on  $0.84 \text{ m}^2$  (1 yd<sup>2</sup>) of nominal 100 percent aramid material [navy 200 g/m<sup>2</sup> (6.0 oz/yd<sup>2</sup>)] fabric pieces that measure  $152 \text{ mm} \pm 6 \text{ mm} \times 152 \text{ mm} \pm 6 \text{ mm}$  (65 in.  $\pm 0.25$  in.  $\times$  6 in.  $\pm 0.25$  in.).

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

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

**N 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.

#### **8.5 Manikin Test.**

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

#### **8.5.2 Specimens.**

**8.5.2.1** Three specimens shall be tested.

**△ 8.5.2.2** Fabrics to be tested shall be used to construct the standard garment design specified in 8.3.2 of ASTM F1930, *Standard Test Method for Evaluation of Flame Resistant Clothing for Protection Against 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.

**N 8.5.4 Standard Reference Garments.** When tested in accordance with 8.5.4, results for 4.5 osy garments shall fall within range of 30 percent to 42 percent predicted body burn, and results for 6 osy garments shall fall within range of 16 percent to 24 percent predicted body burn to test garments for compliance to this standard.

**N 8.5.4.1** Standard reference garments made from both 4.5 osy and 6 osy 93 percent dyeable, low crystallinity meta aramid/5 percent para aramid/2 percent inductive antistatic fiber shall be tested at a frequency of six months or less in accordance with 8.5.4.

**N 8.5.4.1.1** The 4.5 osy reference garments shall be plain woven 4.5 osy/-0.2 osy 93 percent dyeable, low crystallinity meta aramid/5 percent para aramid/2 percent inductive antistatic fiber piece dyed royal blue with no finish. Fabric used to make garments shall be made from 38/2/-5 percent cotton count yarn and have construction of 66 ends /-2 ends  $\times$  42 picks/-2 picks.

**N 8.5.4.1.2** The 6.0 osy reference garments shall be plain woven 6.0 osy /-0.3 osy 93 percent dyeable, low crystallinity meta aramid/5 percent para aramid/2 percent inductive antistatic fiber piece dyed royal blue with no finish. Fabric used to make garments shall be made from 30/2/-5 percent cotton count yarn and have construction of 67 ends /-2 ends  $\times$  46 picks/-2 picks.

**N 8.5.4.2** The laboratory shall maintain consistent test methodology for specimen garment testing and for both standard reference garments.

#### **N 8.5.5 Apparatus.**

**N 8.5.5.1** Verify the system response annually, at a minimum, by performing the In-situ absorbed radiant energy testing specified in Section 10.3 of 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 extension wire can be used to extend the wiring from the manikin to a bench-top 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) Exposures levels of 4000, 8000, and 12,000 W/m<sup>2</sup> ( $\pm 5$  percent) shall be used as verified with the appropriate NIST (or equivalent) traceable reference heat flux sensor.
- (4) The following tables shall be used to verify the system is predicting burns within the ranges specified:
  - (a) Table 8.5.5.1(a) shall be used for the 4000 W/m<sup>2</sup> ( $\pm 5$  percent) exposure.
  - (b) Table 8.5.5.1(b) shall be used for the 8000 W/m<sup>2</sup> ( $\pm 5$  percent) exposure.
  - (c) Table 8.5.5.1(c) shall be used for the 12,000 W/m<sup>2</sup> ( $\pm 5$  percent) exposure.

#### **8.5.6 Procedure.**

**△ 8.5.6.1** 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*, with the following specifications:

- (1) All testing, including calibrations, shall be conducted with a 3.0-second ( $\pm 0.1$ ) exposure.
- (2) The average incident heat flux shall be 84 kW/m<sup>2</sup> (2.0 cal/cm<sup>2</sup>\*S) ( $\pm 5$  percent), as follows:
  - (a) Heat flux data from one second to three seconds shall be used to calculate the incident heat flux.

**N** Table 8.5.5.1(a) Table of Acceptable Heat Flux Exposures and Allowable Time to Second-degree Burn Predictions

Exposure (W/m <sup>2</sup> )	Predicted Time to Second-degree Burn(s)	Acceptable Range for Time to Second-degree Burn(s)
3800	39.3	35.4–43.2
3850	38.6	34.7–42.5
3900	38.0	34.2–41.8
3950	37.3	33.6–41.0
4000	36.7	33.0–40.4
4050	36.1	32.5–39.7
4100	35.6	32.0–39.2
4150	35.0	31.5–38.5
4200	34.5	31.1–38.0

**N** Table 8.5.5.1(b) Table of Acceptable Heat Flux Exposures and Allowable Time to Second-degree Burn Predictions

Exposure (W/m <sup>2</sup> )	Predicted Time to Second-degree Burn(s)	Acceptable Range for Time to Second-degree Burn(s)
7600	15.8	14.2–17.4
7650	15.6	14.0–17.2
7700	15.5	14.0–17.1
7750	15.4	13.9–16.9
7800	15.2	13.7–16.7
7850	15.1	13.6–16.6
7900	15.0	13.5–16.5
7950	14.8	13.3–16.3
8000	14.7	13.2–16.2
8050	14.6	13.1–16.1
8100	14.5	13.1–16.0
8150	14.4	13.0–15.8
8200	14.2	12.8–15.6
8250	14.1	12.7–15.5
8300	14.0	12.6–15.4
8350	13.9	12.5–15.3
8400	13.8	12.4–15.2

(b) A numerical curve-fitting function shall not be used solely to calculate from the average value of all the sensors to determine 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/m<sup>2</sup> (1.9 cal/cm<sup>2</sup>\*S) during a nude calibration exposure at the 1-second mark.

**8.5.6.2** The manikin shall be dressed in 170 g/m<sup>2</sup> (5.0 oz/yd<sup>2</sup>) ( $\pm$  5 percent), jersey knit, 100 percent cotton underwear briefs and 140 g/m<sup>2</sup> (4.2 oz/yd<sup>2</sup>) ( $\pm$  5 percent) jersey knit, 100 percent cotton short-sleeve crew-neck T-shirts before the garment specimen is placed on the manikin.

#### 8.5.7 Report.

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

**N** Table 8.5.5.1(c) Table of Acceptable Heat Flux Exposures and Allowable Time to Second-degree Burn Predictions

Exposure (W/m <sup>2</sup> )	Predicted Time to Second-degree Burn(s)	Acceptable Range for Time to Second-degree Burn(s)
11,400	9.1	8.2–10.0
11,500	9.0	8.1–9.9
11,600	8.8	7.9–9.7
11,700	8.7	7.8–9.6
11,800	8.6	7.7–9.5
11,900	8.5	7.7–9.4
12,000	8.4	7.6–9.2
12,100	8.3	7.5–9.1
12,200	8.2	7.4–9.0
12,300	8.2	7.4–9.0
12,400	8.1	7.3–8.9
12,500	8.0	7.2–8.8
12,600	7.8	7.0–8.6

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

**8.5.8 Interpretation.** The average predicted body burn shall be used to determine pass/fail performance for garment fabrics.

#### 8.6 Thread Heat Resistance Test.

**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, gloves, and cloth face coverings other than embroidery.

**8.6.2 Specimens.** A total of three different determinations shall be made.

#### 8.6.3 Sample Preparation.

**8.6.3.1** Specimens shall be tested after conditioning as specified in 8.1.2.

**8.6.3.2** Samples for conditioning shall be at least 10 cm (4 in.) long.

**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*.

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

**8.6.6 Interpretation.** One or more thread specimens failing this test shall constitute failing performance for the thread type.

#### 8.7 Label Print Durability Test.

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

**N 8.7.2** Modifications to this test method for testing glove labels shall be as specified in 8.7.7.

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

#### 8.7.4 Sample Preparation.

**8.7.4.1** For fabrics, cold weather insulation materials, and shroud/hood/balaclava materials that are designated on the product label to be washed, specimens shall be tested before and after 100 cycles of washing and drying as specified in 8.1.3.

**8.7.4.2** For fabrics, cold weather insulation materials, and shroud/hood/balaclava materials that are designated on the product label to be dry-cleaned, specimens shall be tested before and after 100 cycles of dry cleaning as specified in 8.1.4.

**8.7.4.3** For fabrics, cold weather insulation materials, and shroud/hood/balaclava materials that are designated on the product 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 before and after 100 cycles of dry cleaning as specified in 8.1.4.

• **N 8.7.4.4** Samples for conditioning by laundering or dry cleaning shall include labels sewn onto a square sample of fabric measuring 0.84 m<sup>2</sup> (1 yd<sup>2</sup>), meeting the requirements of Section 7.1. The labels shall be no closer than 51 mm (2 in.) apart in parallel strips.

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

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

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

#### N 8.7.8 Specific Requirements for Testing Glove Labels.

**N 8.7.8.1** For gloves that are designated on the flame-resistant glove 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.

**N 8.7.8.2** Specimens shall include complete gloves with labels attached.

### N 8.8 Protective Glove Flame Resistance Test.

#### N 8.8.1 Application.

**N 8.8.1.1** This test method shall be applied to glove materials.

**N 8.8.1.2** Modifications to this test method for testing small materials shall be as specified in 8.8.8.

#### N 8.8.2 Specimens.

**N 8.8.2.1** Each specimen to be tested shall be a rectangle at least 50 mm (2 in.) wide by 150 mm (6 in.) long.

**N 8.8.2.2** Specimens shall be the composite used in actual glove construction consisting of each single layer, with all layers arranged in proper order.

**N 8.8.2.2.1** Three specimens shall be tested for each composite.

**N 8.8.2.2.2** If a proposed glove construction has stitched-through seams, three additional specimens containing these seams shall be tested. The seam shall be in the direction of the 150 mm (6 in.) dimension.

**N 8.8.2.3** In each test, the specimen's normal outer surface shall be exposed to the flame.

#### N 8.8.3 Sample Preparation.

**N 8.8.3.1** Specimens shall be tested after conditioning as specified in 8.1.2.

**N 8.8.3.2** Additional specimens shall be tested after three cycles of washing and drying as specified in 8.1.3, or after three cycles of dry cleaning as specified in 8.1.4, followed by conditioning as specified in 8.1.2.

#### N 8.8.4 Apparatus.

**N 8.8.4.1** The test apparatus shall consist of a burner, crucible tongs, support stand, utility clamp, stopwatch, butane gas, gas regulator valve system, and measuring scale.

**N 8.8.4.1.1** The burner shall be a high-temperature, liquefied-type Fisher burner.

**N 8.8.4.1.2** The stopwatch or other timing device shall measure the burning time to the nearest 0.1 second.

**N 8.8.4.1.3** The butane shall be commercial grade, 99.0 percent pure or better.

**N 8.8.4.1.4** The gas regulator system shall consist of a control valve system with a delivery rate designed to furnish gas to the burner under a pressure of 17.3 kPa,  $\pm$  1.7 kPa (2.5 psi,  $\pm$  0.25 psi) at the reducing valve. The flame height shall be adjusted at the reducing valve to produce a pressure of 0.7 kPa,  $\pm$  0.07 kPa (0.1 psi,  $\pm$  0.01 psi).

**N 8.8.4.2** A freestanding flame height indicator shall be used to assist in adjustment of the burner flame height. The indicator shall mark a flame height of 75 mm (3 in.) above the top of the burner.

**N 8.8.4.3** A specimen support assembly shall be used that consists of a frame and steel rod of 2 mm ( $\frac{1}{16}$  in.) diameter to support the specimen in an L-shaped position, as shown in Figure 8.8.4.3.

**N 8.8.4.4** The horizontal portion of the specimen shall be not less than 50 mm (2 in.), and the vertical portion shall be not less than 150 mm (6 in.). The specimen shall be held at each end by spring clips under light tension, as shown in Figure 8.8.4.3.

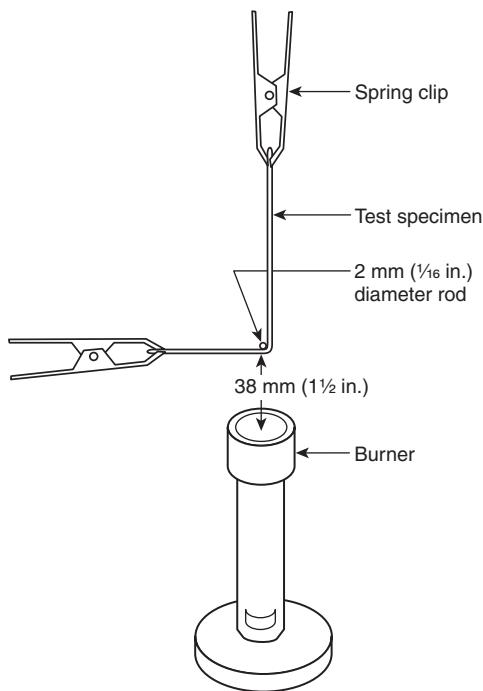
#### N 8.8.5 Procedure.

**N 8.8.5.1** A balance shall be used to determine the weight of each specimen to the nearest 0.1 g (0.04 oz) before and after testing.

**N 8.8.5.2** The burner shall be ignited, and the test flame shall be adjusted to a height of 75 mm (3 in.) with the gas on/off valve fully open and the air supply completely and permanently off, so that the flame height is closely controlled. The 75 mm (3 in.) height shall be obtained by adjusting the orifice in the bottom of the burner so that the top of the flame is level with the marked flame height indicator.

**N 8.8.5.3** With the specimen mounted in the support assembly, the burner shall be moved such that the middle of the folded corner contacts the flame, as shown in Figure 8.8.4.3.

**N 8.8.5.4** The burner flame shall be applied to the specimen for 12 seconds. After 12 seconds, the burner shall be removed.



**N FIGURE 8.8.4.3 Specimen Support Assembly.**

**N 8.8.5.5** The afterflame time shall be measured as the time, in seconds, to the nearest 0.2 second, that the specimen continues to flame after the burner is removed from the flame.

**N 8.8.5.6** Each layer of the specimen shall be examined for melting or dripping.

**N 8.8.5.7** Each tested sample shall be conditioned a second time as specified in 8.1.2 and then weighed to the nearest 0.1 g (0.04 oz).

**N 8.8.5.8** The specimen shall then be further examined for char length. The char length shall be determined by measuring the length of the tear through the center of the charred area as specified in 8.8.5.8.1 through 8.8.5.8.4.

**N 8.8.5.8.1** The specimen shall be folded lengthwise and creased, by hand, along a line through the highest peak of the charred area.

**N 8.8.5.8.2** A hook shall be inserted in the specimen or a hole that is 6 mm (1/4 in.) in diameter or less that is punched out for the hook, at one side of the charred area 6 mm (1/4 in.) from the adjacent outside edge at the point where the specimen contacted the steel rod, and 6 mm (1/4 in.) in from the lower end.

**N 8.8.5.8.3** A weight of sufficient size such that the weight and hook together shall equal the total tearing load required in Table 8.8.5.8.3 shall be attached to the hook. The specific load for determining char length applicable to the weight of the composite specimen shall be as listed in Table 8.8.5.8.3.

**N 8.8.5.8.4** A tearing force shall be applied gently to the specimen by grasping the side of the material at the edge of the char opposite from the load and raising the specimen and weight clear of the supporting surface. The end of the tear shall be

marked off on the edge, and the char length measurement shall be made along the undamaged edge.

**N 8.8.6 Report.**

**N 8.8.6.1** The afterflame time and char length shall be recorded and reported for each specimen.

**N 8.8.6.2** The average afterflame time and char length shall be calculated, recorded, and reported.

**N 8.8.6.3** The afterflame time shall be recorded and reported to the nearest 0.2 second, and the char length shall be recorded and reported to the nearest 2.5 mm (1/10 in.).

**N 8.8.6.4** Observations of melting or dripping for each specimen shall be recorded and reported.

**N 8.8.6.5** The percent consumed shall be calculated using the following formula:

[8.8.6.5]

$$\text{Percent Consumed} = \left[ \frac{(W - R)}{W} \right] \times 100$$

where:

$W$  = original preconditioned weight

$R$  = conditioned weight 24 hours after testing

**N 8.8.6.5.1** The percent consumed shall be recorded and reported for each specimen to the nearest 0.1 percent. The average percent consumed shall be calculated, recorded, and reported to the nearest 0.1 percent.

**N 8.8.7 Interpretation.** Pass or fail performance shall be based on any observed melting or dripping, the average afterflame time, the average char length, and the average percent consumed.

**N 8.8.8 Specific Requirements for Testing Small Materials.**

**N 8.8.8.1** No fewer than three specimens attached to the glove exterior layer shall be tested.

**N 8.8.8.2** The specimens shall be attached to the glove exterior layer such that the exposure of the items is centered on the support rod with equivalent area extending vertically and horizontally along the sample.

**N 8.8.8.3** Testing shall be performed as described in 8.8.4 through 8.8.6, except char length and percent consumed shall not be measured.

**N Table 8.8.5.8.3 Tearing Weights for Determining Charred Lengths**

Specified Weight of Material Before Any Fire-Retardant Treatment or Coating	Total Tearing Weight for Determining Charred Length		
g/m <sup>2</sup>	oz/yd <sup>2</sup>	kg	lb
68–203	2.0–6.0	0.1	0.25
Over 203–508	Over 6.0–15.0	0.2	0.5
Over 508–780	Over 15.0–23.0	0.3	0.75
Over 780	Over 23.0	0.45	1.0

## Annex A Explanatory Material

Annex A is not a part of the requirements of this NFPA document but is included for informational purposes only. This annex contains explanatory material, numbered to correspond with the applicable text paragraphs.

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

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

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

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

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

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

▲ **A.1.3.2** Organizations responsible for fire-fighting applications should use protective clothing and equipment specifically designed for those activities. Applicable standards include the following:

- (1) NFPA 1971, *Standard on Protective Ensembles for Structural Fire Fighting and Proximity Fire Fighting*
- (2) NFPA 1977, *Standard on Protective Clothing and Equipment for Wildland Fire Fighting*

Organizations responsible for hazardous materials emergencies should use protective clothing and equipment specifically designed for those activities. Applicable standards include the following:

- (1) NFPA 1991, *Standard on Vapor-Protective Ensembles for Hazardous Materials Emergencies and CBRN Terrorism Incidents*
- (2) NFPA 1992, *Standard on Liquid Splash-Protective Ensembles and Clothing for Hazardous Materials Emergencies*

Organizations responsible for emergency medical operations should use protective clothing and equipment specifically designed for those activities. The applicable standard is NFPA 1999.

**A.3.2.1 Approved.** The National Fire Protection Association does not approve, inspect, or certify any installations, procedures, equipment, or materials; nor does it approve or evaluate testing laboratories. In determining the acceptability of installations, procedures, equipment, or materials, the authority having jurisdiction may base acceptance on compliance with NFPA or other appropriate standards. In the absence of such standards, said authority may require evidence of proper installation, procedure, or use. The authority having jurisdiction may also refer to the listings or labeling practices of an organization that is concerned with product evaluations and is thus in a position to determine compliance with appropriate standards for the current production of listed items.

**A.3.2.2 Authority Having Jurisdiction (AHJ).** The phrase "authority having jurisdiction," or its acronym AHJ, is used in NFPA documents in a broad manner, since jurisdictions and approval agencies vary, as do their responsibilities. Where public safety is primary, the authority having jurisdiction may be a federal, state, local, or other regional department or individual such as a fire chief; fire marshal; chief of a fire prevention bureau, labor department, or health department; building official; electrical inspector; or others having statutory authority. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the authority having jurisdiction. In many circumstances, the property owner or his or her designated agent assumes the role of the authority having jurisdiction; at government installations, the commanding officer or departmental official may be the authority having jurisdiction.

**A.3.2.4 Listed.** The means for identifying listed equipment may vary for each organization concerned with product evaluation; some organizations do not recognize equipment as listed unless it is also labeled. The authority having jurisdiction should utilize the system employed by the listing organization to identify a listed product.

**NA.3.3.6 Cloth Face Covering.** Cloth face coverings are not shrouds/hoods/balaclavas because they are not designed to provide primary thermal protection to the wearer's head or neck, or both. Cloth face coverings provide primary thermal protection to the nose and mouth that is consistent with the performance levels that are applied for shrouds/hoods/balaclavas. These clothing items are primarily intended to attenuate the volume of bioaerosols that are exhaled or released during coughing and sneezing by the individual wearer to aid in lessening the transmission of airborne pathogens such as SARS-CoV-2, the virus responsible for COVID-19. These clothing items are not protective masks or medical masks and are not evaluated for their protective performance in accordance with this standard.

The selection of materials used in the construction of cloth face coverings should account for the ability of the material to filter bioaerosols and to offer levels of acceptable breathing resistance. Materials that are very porous can have low efficiencies to prevent the passage of bioaerosols while tightly woven fabrics or multiple layers of fabrics could create resistance to breathing that forces the passage of inhaled and exhaled air around the edges of the cloth face covering rather than through the material. Useful measurements of bioaerosol filtration performance is performed in accordance with ASTM F2101, *Standard Test Method for Evaluating the Bacterial Filtration Efficiency (BFE) of Medical Face Mask Materials, Using a Biological Aerosol of Staphylococcus aureus*. The measurement of breathing

resistance is performed in accordance with Annex C of EN 14683, *Medical face masks—Requirements and test methods*. It is important to note that measurement of cloth face covering performance in accordance with these test methods do not connote that these clothing items are protective masks or medical masks but instead provide useful benchmarks for relevant areas of performance.

**A.3.3.7 Cold Weather Insulation Material.** Examples of insulation materials include textile batting(s) alone or batting(s) that are attached to a face cloth. For example, an insulation material consisting of two layers is considered nonseparable by the attachment that combines the two layers. The insulation material might or might not have a face cloth. Cold weather insulation materials generally are provided within the garment such that their area of coverage coincides with the majority of garment area covering the wearer's body.

Cold weather insulation material as defined in this standard does not preclude the use of intermediate layers for additional protection against thermal hazards.

Cold weather insulation material is not an interlining (see 3.3.24, *Interlining*).

**N A.3.3.11 Emblem.** Emblems can include transfer films that are thin films applied to fabric via the application of heat.

**A.3.3.12 Fabric.** Where a garment is constructed of multiple, nonseparable layers, such as an outer layer and cold weather insulation material, *fabric* is intended to mean the composite of those layers for the purpose of testing.

**N A.3.3.13 Fire.** Fire is the result of combustion, or the chemical process of rapid oxidation (burning) that requires an ignition source, a flammable substance or fuel, and oxygen (usually from air). In an industrial environment, different fires can result from a variety of events. "Jet" fires typically arise from line breaks or ruptures of pressurized flammable materials. These fires can create directed "jets" or "flares," which can project flames in any direction for considerable distances, depending on the characteristics of the source, and burn until the fuel is exhausted or the break is isolated. A pool or running pool fire arises from the ignition of spills and leaks of flammable liquids. The size and intensity depends on the amount of material involved and typically extends upward from the surface of the pool. These fires also continue until the fuel is exhausted, and the source of the leak isolated. A flash or vapor cloud fire arises from the release or presence of a flammable gas or combustible, finely divided particles (e.g., coal dust or grain) that contain a concentration above the lower explosive limit of the chemical. Flash fire characteristics depend on the size of the gas or vapor cloud and local conditions. When ignited, the flame front can expand outward in the form of a fireball or be driven by external convection (wind). The effect of the fireball or flame front's energy with respect to radiant heat significantly enlarges the hazard areas around the released gas.

**A.3.3.14 Flame Resistance.** Flame resistance can be an inherent property of a material, or it can be imparted by specific treatment.

**A.3.3.18.2 Single-Use Garment.** What constitutes a "use" will be defined by the garment manufacturer. A single use could include unpacking, or one donning, or one wearing. In the absence of any manufacturer's specific information, one "use" should be considered any one-time wearing of the garment.

**N A.3.3.24 Interlining.** The outer and inner layers are compliant to the fabric requirements of this standard. Examples of an interlining are a fabric layer used to stiffen the waistband in a pair of pants or a facing fabric used inside the closure flap of a coverall. Interlining materials do not contact the wearer's skin or underclothing.

**N A.3.3.28 Product.** Cloth face coverings are intentionally omitted from the definition of product because they are exempt from many requirements that are imposed on products throughout this standard.

**A.3.3.29 Product Label.** The product label is not the label, symbol, or identifying mark of the certification organization; however, the label, symbol, or identifying mark of the certification organization can be attached to, or can be part of, the product label.

**N A.3.3.35 Short-Duration Thermal Exposure from Fire.** This standard establishes minimum requirements for clothing that provides limited protection from short-duration thermal exposure from fire with the aim of limiting potential injury to persons egressing from or encountering accidental hazardous exposures to fire. See the requirements established in NFPA 2113 for selection, care, and maintenance of these clothing items.

**N A.3.3.36 Shroud/Hood/Balaclava.** Shrouds/hoods/balaclavas that incorporate mouth and nose coverage that is intended to provide primary thermal protection are still to be considered as shrouds/hoods/balaclavas and not cloth face coverings.

**N A.4.1.1** Cloth face coverings are intentionally omitted from several sections pertaining to certification because they are not intended to be certified products. Where applicable, certain language around compliance and components might include reference to cloth face coverings.

**N A.4.1.1.2** Given the nature of the flame-resistant cloth face coverings and their intended widespread use for national health emergencies including pandemics, the conformity assessment approach applied for this clothing is a self-declaration in accordance with the criteria established in ANSI/ISEA 125, *American National Standard for Conformity Assessment of Safety and Personal Protective Equipment*, that includes conformance testing, corrective and preventive actions, record-keeping, and the supplier's Declaration of Conformity.

**A.4.1.5** NFPA occasionally receives complaints that certain items of fire and emergency services protective clothing or protective equipment might be carrying labels falsely identifying them as compliant with an NFPA standard. The requirement for placing the certification organization's mark on or next to the product label helps to ensure that the purchaser can readily determine compliance of the respective product through independent third-party certification.

**A.4.2.1** The certification organization should have sufficient breadth of interest and activity so that the loss or award of a specific business contract would not be a determining factor in the financial well-being of the agency.

**A.4.2.5** The contractual provisions covering a certification program should contain clauses advising the manufacturer that if requirements change, the product should be brought into compliance with the new requirements by a stated effective date through a compliance review program involving all currently listed products.

Without the clauses, certifiers would not be able to move quickly to protect their name, marks, or reputation. A product safety certification program would be deficient without these contractual provisions and the administrative means to back them up.

**A.4.2.9** Investigative procedures are important elements of an effective and meaningful product safety certification program. A preliminary review should be carried out on products submitted to the agency before any major testing is undertaken.

Good practice should be followed regarding the use of laboratory manuals, form data sheets, documented calibration and calibration routines, performance verification, proficiency testing, and staff qualification training programs.

**A.4.2.11** Such inspections should include, in most instances, witnessing of production tests. With certain products, the certification organization inspectors should select samples from the production line and submit them to the main laboratory for countercheck testing. With other products, it might be desirable to purchase samples in the open market for test purposes.

**A.4.2.15** For further information and guidance on recall programs, see 21 CFR 7, Subpart C.

**A.4.4.1.3** ISO 9000, *Quality Management Systems — Fundamentals and Vocabulary*, defines quality terms and concepts. It gives an overview of the content and use of the entire ISO 9000 series. A useful cross-reference to the series' quality system elements is found in Annex A of ISO 9000.

ISO 9001, *Quality Management Systems — Requirements*, is used when the quality system to be assessed covers several stages of one firm's processes. It prescribes quality system requirements for design, development, production, installation, and servicing.

**A.5.1.1** Purchasers might wish to include a requirement in the purchase specifications for an additional label that includes certain information such as the date of manufacture, manufacturer's name, and protective clothing item identification number to be located in a protected location on the protective clothing item in order to reduce the chance of label degradation and as a backup source of information to aid in protective clothing item tracking or during an investigation.

**N A.5.1.1.1** By definition, cloth face coverings are excluded from product requirements and are exempted from many product label requirements. Therefore, they should have a label as opposed to a product label.

**A.5.1.4** See A.4.1.5.

**N A.5.1.9.1** The reduced minimum label information for flame-resistant cloth face coverings is intended to minimize the size of the label relative to the inherently small size of the item.

Additional label information is permitted if requested by the end-user.

**Δ A.5.2.1** The required information can be provided either with the use of a suitable electronic link or with accompanying printed literature packaged with each clothing item.

**A.5.2.2** The selection of protective clothing size relates directly to the clothing items' ability to function properly. In occupations such as the petrochemical industry, proper fit and function relate directly to the wearer's ability to perform assigned jobs. Issues of proper fit are directly associated with the risk of injury. Protective clothing that restricts movement will result in lost efficiency and can promote injury and illness. Proper sizing is a factor in the ability of a person to perform tasks that often involve life or death situations. Protective clothing must fit well to function properly when additional safety equipment or other garments are worn. In addition, the selection of flame-resistant clothing item size has a direct impact on maintaining appropriate protection in areas where the flame-resistant clothing item has an interface with safety equipment or other protective clothing items. ASTM F1731, *Standard Practice for Body Measurements and Sizing of Fire and Rescue Services Uniforms and Other Thermal Hazard Protective Clothing*, might be found useful when selecting protective clothing for technical operations. ASTM F1731 primarily addresses processes for sizing flame-resistant clothing item; however, the techniques described are useful in the selection of protective clothing addressed in this standard. The required information can be provided either with the use of a suitable electronic link or with accompanying printed literature packaged with each clothing item.

**N A.6.2.1** Removable liners are permitted to be worn separately if the liner material(s) independently meets the appropriate fabric requirements in Chapter 7 including 7.1.1 for heat transfer performance and 7.1.5 for overall flash fire performance. If the liner contains cold weather insulation materials that are not evaluated to 7.1.1 and 7.1.5 and do not pass the thermal shrinkage resistance requirement in 7.1.3, then the manufacturer must label the liner as specified in 5.1.13 and provide a design that does not allow separate wearing of the liner without the outer layer. This can be demonstrated by the absence of a means of closure for the closure area of shirts, pants, and coveralls.

**N A.7.1.2.1** If non-flame-resistant emblems are attached to the exterior of a garment, the maximum number should be five with no individual emblem covering an area greater than 103 cm<sup>2</sup> (16.0 in.<sup>2</sup>) or total area from all these emblems covering an area greater than 258 cm<sup>2</sup> (40 in.<sup>2</sup>).

**N A.7.1.5.2** Paragraph 7.1.5.2 does not apply to rainwear.

**N A.7.3** Hook and pile fasteners are considered fabric-based components.

**A.8.1.3** Tergitol 15.S.9 is available from Union Carbide. Sodium metasilicate is available from Tilly Chemical Co. under the trade name Metso 2048 beads, anhydrous sodium metasilicate. Sodium tripolyphosphate is available from Tilly Chemical Co. under the trade name Amoto. Sodium silicofluoride is available from UNX Chemical Co. under the trade name Sourcide. Materials from other sources that are of equivalent chemical composition and concentration can be used in place of the laundry chemicals listed herein.

One example of a suitable industrial laundry machine is a Milnor Model 30015C6M-AAC. Equivalents can be used.

One example of a suitable industrial tumble dryer is a Huebsch Originator, Model 37CSH. Equivalents can be used.

**A.8.1.3(2)** The two chemical-free cycles are intended to remove any residuals from the test specimens.

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

**Annex B Properties for Evaluating Flame-Resistant Garments, Shrouds/Hoods/Balaclavas, and Gloves**

*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, and gloves. A number of additional properties can be used in the evaluation of flame-resistant garments, shrouds/hoods/balaclavas, and gloves that are not required as part of this standard. Table B.1 also lists these additional properties, recommended test methods, and their suggested application.

**Δ Table B.1 Performance Properties and Additional Evaluation Properties for Flame-Resistant Garments, Shrouds/Hoods/Balaclavas, and Gloves**

Property (Section No.)	Test Method Cited	Description of Test Method	Application of Test Method
<b>Mandatory Tests</b>			
Heat transfer performance (HTP) (7.1.1)	Method appears in Section 8.2.	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/m <sup>2</sup> (2.0 cal/cm <sup>2</sup> · 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 (1/4 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.	This test is a measure of the unsteady state heat transfer properties of garment, shroud/hood/balaclava, and glove 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/cm <sup>2</sup> (3.0 cal/cm <sup>2</sup> ) or more when measured in "contact," simulating direct contact with the skin, and 25 J/cm <sup>2</sup> (6.0 cal/cm <sup>2</sup> ) 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.
Flame resistance (7.1.2)	ASTM D6413; washing and drying per commercial laundering procedure or dry cleaning (100 cycles) (Section 8.3)	A 75 mm × 305 mm (3 in. × 12 in.) fabric specimen is placed in a holder that is suspended vertically over a 38 mm (1½ in.) high methane-fueled flame. The specimen is placed 19 mm (3/8 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.	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.

(continues)

△ Table B.1 *Continued*

Property (Section No.)	Test Method Cited	Description of Test Method	Application of Test Method
Thermal shrinkage resistance (7.1.3)	Method appears in Section 8.4; washing and drying per commercial laundering procedure or dry cleaning (3 cycles)	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.	A fabric's resistance to shrinkage 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.
Heat resistance (7.1.4/ Section 7.3)	Method appears in Section 8.4; washing and drying per commercial laundering procedure or dry cleaning (3 cycles)	The exposure used for thermal shrinkage is also used for measuring heat resistance. Fabrics or garment components not required to meet thermal shrinkage requirements can be 152 mm (6 in.) square specimens. Following a 5-minute exposure, the specimen is examined for evidence of melting and dripping, separation, or ignition. Specimens that demonstrate such behavior fail the test. The test is also applied to hardware items.	This test measures how garment, shroud/hood/balaclava, and glove 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, and gloves.
Manikin testing (7.1.5)	ASTM F1930; washing and drying per commercial laundering procedure or dry cleaning (1 cycle) (Section 8.5)	The fabric is made into a standardized overall 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/m <sup>2</sup> (2.0 cal/cm <sup>2</sup> · 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.	This test provides an overall evaluation of how the fabric performs in a standardized overall 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.
Thread melting resistance (Section 7.2)	FTMS 191A, 1534 (Section 8.6)	A small segment of thread used in the stitching of flame-resistant garments, shrouds/hoods/balaclavas, or gloves 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.	Thread used in flame-resistant garments, shrouds/hoods/balaclavas, and gloves 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.
Label legibility (Section 7.4)	Method appears in Section 8.7; washing and drying per commercial laundering procedure or dry cleaning (100 cycles)	Sample labels containing the required product information are subjected to 100 wash/dry or dry cleaning cycles and then examined for legibility.	This requirement checks for label durability. Following this test, the labels must remain legible from a distance of at least 305 mm (12 in.).

(continues)

Δ Table B.1 *Continued*

Property (Section No.)	Test Method Cited	Description of Test Method	Application of Test Method
<b>Other Property Evaluations</b>			
Fabric weight	ASTM D3776	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.	Fabric weights are commonly used to reference materials.
Tensile strength (grab method)	ASTM D5034	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.	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.
Tear strength (Elmendorf method)	ASTM D1424	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.	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.
Material burst strength	ASTM D3787	This test measures the force required to burst a knit or stretch woven fabric. A material specimen is clamped over a diaphragm that is inflated until the specimen bursts. The pressure at which the fabric bursts is the burst strength.	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.
Laundering shrinkage	AATCC 135; machine cycle 3; wash temp. IV; and drying procedure Aiii (number of cycles to be specified)	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.	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.
Laundering colorfastness	AATCC 61; color change procedure	A fabric sample is subjected to controlled washing and drying conditions. Following exposure, the color of the material sample is compared to a color scale chart that 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.	Laundering colorfastness assesses the amount of color 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.

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