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

NFPA, 1 Batterymarch Park, Quincy, MA 02169-7471
An International Codes and Standards Organization

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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

This edition of 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*, was prepared by the Technical Committee on Flash Fire Protective Garments. It was issued by the Standards Council on April 29, 2014, with an effective date of May 19, 2014, and supersedes all previous editions.

This edition of NFPA 2113 was approved as an American National Standard on May 19, 2014.

Origin and Development of NFPA 2113

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, *Standard on Flame-Resistant Garments for Protection of Industrial Personnel Against Flash Fire*, and NFPA 2113 — which were then released for public proposals and comments. NFPA 2113 specified the minimum selection, care, use, and maintenance requirements for flame-resistant garments that were compliant with NFPA 2112 for use by industrial personnel 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 included amendments to the 2001 standard. Definitions were reviewed and modified to be consistent with both NFPA 2112 and the *NFPA Glossary of Terms*. The Committee also clarified elements of the hazard analysis and considerations for garment selection.

In the 2012 edition, the scope and sections pertaining to workplace hazard assessment were modified to reflect that flame-resistant garments for industrial personnel can protect against other types of short-duration flame exposure. New annex material was added that described other types and possible sources of short-duration flame exposure. The definitions were updated to be consistent with NFPA 2112 and the *NFPA Glossary of Terms*.

In the 2015 edition, the Committee revised the title to better reflect the intended application for the standard, which is to address protection of industrial personnel from short-duration thermal exposures from industrial fires, not just flash fires. The Committee also revised the scope and application provisions of the standard to be consistent with the broader concept of fire. In addition to modifying the scope and application requirements, the Committee added a new section on responsibility to clarify that both the employer and employee have specific responsibilities for selection, care, use, cleaning, and maintenance of protective garments. Definitions of extracted terms were modified to be consistent with updated terms in the NFPA Glossary of Terms, and definitions for risk and risk assessment were added to correlate with the new section in Chapter 4 permitting risk assessments to be used when evaluating where flame-resistant garments should be used. Throughout the standard, the Committee replaced "hazard assessment" with "hazard analysis" as being more appropriate for the application within this standard and more consistent with industry terminology.

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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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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

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.

1.1.1* This standard shall specify the minimum selection, care, use, and maintenance requirements for flame-resistant garments for use by industrial personnel in areas at risk from short-duration thermal exposures from industrial fires that are compliant with NFPA 2112, *Standard on Flame-Resistant Garments for Protection of Industrial Personnel Against Flash Fire.*

1.1.2* 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.

1.1.3 This standard shall not apply to protection from electrical flashes, radiological agents, biological agents, or hazardous materials.

1.2 Purpose. The purpose of this standard shall be to reduce the health and safety risks associated with the incorrect selection and use of flame-resistant garments and those risks associated with incorrectly maintained, contaminated, or damaged flame-resistant garments.

1.3 Application.

1.3.1* This standard shall not purport to address all the safety aspects associated with its use.

1.4 Responsibility.

1.4.1 To ensure the greatest possible protection within the organization for employees in the workplace, the cooperative efforts of both employers and employees shall establish and maintain a safe and healthy work environment.

1.4.2 As a minimum, employers shall be responsible for the following:

(1) Performing a hazard analysis of the workplace to identify and control physical and health hazards
(2) Identifying and providing appropriate personal protective equipment (PPE) for employees
(3) Training employees in the use and care of PPE
(4) Maintaining PPE, including replacing worn or damaged PPE
(5) Periodically reviewing, updating, and evaluating the effectiveness of the PPE program

1.4.3 As a minimum, employees shall be responsible for the following:

(1) Properly wearing PPE
(2) Attending training sessions on PPE
(3) Ensuring proper care, cleaning, and maintenance of PPE
(4) Informing a supervisor of the need to repair or replace PPE

1.5 Equivalency. Nothing herein shall be intended to restrict any individual or organization 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 2112, *Standard on Flame-Resistant Garments for Protection of Industrial Personnel Against Flash Fire,* 2012 edition.

2.3 Other Publications.

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

ASTM F 1449, *Standard Guide for Industrial Laundering of Flame, Thermal, and Arc Resistant Clothing*, 2008.

ASTM F 2757, *Standard Guide for Home Laundering Care and Maintenance of Flame, Thermal, and Arc Resistant Clothing*, 2009.

2.3.2 CSA Publications. Canadian Standards Association, 5060 Spectrum Way, Mississauga, ON, L4W 5N6, Canada.

CSA Z96, *High-Visibility Safety Apparel*, 2009.

2.3.3 ISEA Publications. International Safety Equipment Association, 1901 North Moore Street, Arlington, VA 22209-1762.

ANSI/ISEA 107, *American National Standard for High-Visibility Safety Apparel and Headwear*, 2010.

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 79, *Electrical Standard for Industrial Machinery,* 2015 edition.

NFPA 921, *Guide for Fire and Explosion Investigations,* 2014 edition.

NFPA 1851, *Standard on Selection, Care, and Maintenance of Protective Ensembles for Structural Fire Fighting and Proximity Fire Fighting,* 2014 edition.

NFPA 1971, *Standard on Protective Ensembles for Structural Fire Fighting and Proximity Fire Fighting,* 2013 edition.

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

NFPA 1983, *Standard on Life Safety Rope and Equipment for Emergency Services,* 2012 edition.

NFPA 1991, *Standard on Vapor-Protective Ensembles for Hazardous Materials Emergencies,* 2005 edition.

NFPA 2112, *Standard on Flame-Resistant Garments for Protection of Industrial Personnel Against Flash Fire,* 2012 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* 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.

3.2.2 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.

3.2.3 Shall. Indicates a mandatory requirement.

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

3.2.5 Standard. A document, the main text of which contains only mandatory provisions using the word "shall" to indicate requirements and which 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 *Manual of Style for NFPA Technical Committee Documents.*

3.3 General Definitions.

3.3.1 Agents.

3.3.1.1 *Biological Agents.* Biological materials that are capable of causing an acute disease or long-term damage to the human body. [**1991,** 2005]

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

3.3.2 Body.

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

3.3.2.2 *Upper Body.* The area of the body above the waist and extending to the shoulders, including the arms and wrists but excluding the hands. [**2112,** 2012]

3.3.3 Care. Procedures for cleaning, decontamination, and storage of protective clothing and equipment. [**1851,** 2014]

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 of labeled and listed products with the requirements of this standard. [**1971,** 2013]

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,** 2013]

3.3.6 Cleaning. The removal of dirt and debris.

3.3.7 Compliance/Compliant. Meeting or exceeding all applicable requirements of this standard. [**1971,** 2013]

3.3.8 Component(s). Any material, part, or subassembly used in the construction of the compliant product. [**1971,** 2013]

3.3.9 Contamination/Contaminated. The process of transferring a hazardous material from its source to people, animals, the environment, or equipment, which may act as a carrier.

3.3.10 Cross-Contamination. The transfer of contamination from one item to another or to the environment.

3.3.11 Decontamination. The physical and/or chemical process of reducing and preventing the spread of contamination from persons and equipment used in a contaminated environment.

3.3.12 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.

3.3.13 Fabric. The one or more layers of textile material(s) used in the primary construction of protective garment(s).

3.3.14 Fire. A rapid oxidation process, which is a chemical reaction resulting in the evolution of light and heat in varying intensities. [**921**, 2014]

3.3.15 Fit. The quality, state, and manner in which clothing, when worn, relate to the human body.

3.3.16* 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.

3.3.17* Flash Fire. A fire that spreads by means of a flame front rapidly through a diffuse fuel, such as dust, gas, or the vapors of an ignitible liquid, without the production of damaging pressure. [**921,** 2014]

3.3.18 Functionality/Functional. The ability of the flame-resistant garment or a component of the flame-resistant garment to continue to be utilized for its intended purpose.

3.3.19 Garments. Clothing including, but not limited to, coveralls, trousers, shirts, outerwear, and rainwear.

3.3.20 Hardware. Nonfabric components of the flame-resistant garment including, but not limited to, those made of metal or plastic.

3.3.21 Hazard Analysis. The process by which an organization identifies hazards in the workplace and then determines appropriate controls, including the use of personal protective equipment (PPE), to eliminate or reduce worker exposure to those hazards.

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

3.3.23 Hazardous Materials Emergencies. Incidents involving the release or potential release of hazardous materials. [**1971,** 2013]

3.3.24 Interlining. Any textile that is incorporated into any garment as a layer between outer and inner layers. [**1975,** 2014]

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 Maintenance. Procedures for inspection, testing, repair, and retirement of the product.

3.3.27 Melt. A response to heat by a material resulting in evidence of flowing or dripping. [**1983,** 2012]

3.3.28* Organization. The entity that provides the direct management and supervision for the industrial personnel.

3.3.29* Product Label. A label or marking affixed to a product by the manufacturer that provides general information, warnings, instructions for care and maintenance, and other information.

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 Retirement. The process of removing protective clothing from service.

3.3.33 Risk. A combination of the probability and the degree of possible injury or damage to health in a hazardous situation. [**79**, 2015]

3.3.34 Risk Assessment. An assessment of the likelihood, vulnerability, and magnitude of incidents that could result from exposure to hazards.

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

3.3.36 Service Life. The period for which the protective clothing is useful before retirement.

3.3.37 Static Electricity. The acquisition and retention of electrical charge through induction (by means of corona discharge) or by triboelectric means (rubbing with another material).

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

3.3.39 Wind/Moisture Barrier. A component of a protective garment designed to inhibit wind penetration and prevent the penetration of liquid water.

3.3.40 Wristlet. The circular, close-fitting extension of the coat sleeve, usually made of knitted material.

Chapter 4 Selection

4.1 General. The organization's selection process for flame-resistant garments shall be based on the following:

(1) The conduct of a hazard analysis of the workplace to determine the need for the wearing of flame-resistant garments
(2) An evaluation of flame-resistant garment designs and characteristics to determine the type of flame-resistant garments suitable for protecting workers
(3) The development of specifications for purchasing flame-resistant garments

4.2* Workplace Hazard Analysis.

4.2.1 The organization shall conduct a hazard analysis of the work environment to determine the requirement for wearing flame-resistant garments.

4.2.2 The hazard analysis shall be performed based on a review of the facility to determine if flammable materials are present in quantities that will present a fire hazard and endanger a person.

4.2.3* The general workplace hazard analysis process shall include consideration of the following:

(1) Determination of the type of hazard or hazards present in the workplace and the potential magnitude, thermal intensity, and duration of the hazard
(2) Determination of the adverse effects of unprotected exposure to the hazards identified
(3) Determination of whether other control options (engineering, administrative, and so forth) can be used instead of flame-resistant garments
(4) Determination of garment performance characteristics needed for protection
(5) Determination of the need for garment decontamination where applicable
(6) Determination of ergonomic constraints of work to be performed while wearing the garment
(7) Comparison of risks and costs of all options
(8) Implementation of selected option(s)

4.2.4 A specific evaluation of the work environment to determine the requirement for the wearing of flame-resistant garments shall be based on the potential hazards that workers are exposed to as part of their work duties.

4.2.5 Factors in determining if flame-resistant garments are required shall include, but not be limited to, the following:

(1)*Proximity of the work to be performed to a fire hazard
(2) The presence of flammable materials in the environment during process operations
(3) The potential for the task being performed to increase the possibility of a flammable release, which could result from a mechanical failure such as a line breaking
(4) Operating conditions of the process, for example, the potential for flammable fumes or vapors
(5) The presence of engineering controls designed to reduce exposure to flammable materials present during normal operations
(6) Accident history
(7) Means and duration of egress within potential exposure zone (e.g., location and distance to exits, potential congestion, elevated or restricted areas, connections to lifelines/fall protection, capability of workers to escape)

4.2.6* The initial review of a facility shall determine if flammable materials are present in quantities necessary to present a fire hazard and endanger a person.

4.2.7 The organization shall reassess the hazard analysis at least every 5 years, or when a significant change is made to the work environment, to verify that the requirements for wearing flame-resistant garments or the levels of protection required have not changed.

4.2.8 A comprehensive risk assessment shall be permitted to be used in combination with a hazard analysis for the purpose of evaluating the work environment for protection strategies and the management of flame-resistant garment use.

4.2.8.1 Where a risk assessment is used in combination with a hazard analysis, it shall include consideration of the following:

(1) The nature of potential fire-related injuries in the work environment
(2) The likelihood of fire-related injuries occurring
(3) The time period over which fire-related injuries might be expected

4.2.8.2* The generation of geographic- or work location–based risk contours, showing the expected frequency of a fire event capable of causing a specified level of injury at specified locations, shall be permitted to be used in conjunction with the fire hazard consequence analysis to assess the implementation of specific engineered and administrative preventive measures and the selection of appropriate flame-resistant personal protective equipment (PPE) or other acceptable risk assessment tools.

4.3* Selection of Flame-Resistant Garments.

4.3.1 In addition to flame-resistant garments complying with NFPA 2112, *Standard on Flame-Resistant Garments for Protection of Industrial Personnel Against Flash Fire*, the organization shall consider factors in selecting flame-resistant garments including, but not limited to, the following:

(1)*Thermal protective characteristics of the fabric over a range of thermal exposures (e.g., to evaluate the effect of delayed egress)
(2)*Physical characteristics of the fabric
(3)*Garment construction and components (e.g., pockets, types of closures)
(4)*Avoidance of static charge buildup
(5)*Design type of the garment
(6)*Type of conditions under which the garments will be worn
(7)*Comfort properties of the fabric and garment
(8)*Cleaning and maintenance considerations

4.3.2 Garments shall be selected that cover both the upper and lower body and flammable underlayers as completely as possible.

4.3.3* Garments shall be selected that contain primary closure systems that do not melt (e.g., non–flame-resistant hook-and-loop).

4.3.4 Garments shall be selected that offer minimal interference and minimal hindrance to perform the work task required in the fire hazard zone.

4.3.5* For optimum protection, garments shall be selected that are not tight fitting.

4.3.6 Non–flame-resistant heraldry attached to the exterior of the garment (e.g., logos, name tags, non–flame-resistant silk-screened artwork, etc.) shall be kept to a minimum, both in surface area and number.

4.3.7 When garments are selected to provide daytime or nighttime visibility, garments shall also conform to the relevant requirements of ANSI/ISEA 107, *American National Standard for High Visibility Safety Apparel and Headwear*, or CSA Z96, *High-Visibility Safety Apparel*.

4.4 Purchase Specifications.

4.4.1* Where the organization develops purchase specifications, the criteria specified in 4.4.1.1 through 4.4.1.4 shall be included.

4.4.1.1 Clothing to be purchased shall comply with NFPA 2112, *Standard on Flame-Resistant Garments for Protection of Industrial Personnel Against Flash Fire*.

4.4.1.2 Where the organization selects criteria that exceed the minimum requirements of NFPA 2112, *Standard on Flame-Resistant Garments for Protection of Industrial Personnel Against Flash Fire*, such criteria shall be stipulated in the purchase specifications.

4.4.1.3 Manufacturer bids shall include substantiation of certification for the protective clothing stated in the bid.

4.4.1.4 The organization shall compare each bid submittal against purchase specifications.

4.4.2* In addition to compliance with NFPA 2112, *Standard on Flame-Resistant Garments for Protection of Industrial Personnel Against Flash Fire*, the organization shall provide additional specifications addressing those design features and performance characteristics specified in Section 4.3.

4.4.3 Upon receipt, organizations shall inspect purchased garments to ensure they meet their specifications and to verify quantity and sizes of protective garments received.

4.4.4 Organizations shall establish procedures for returning unsatisfactory products if their specifications are not met.

4.4.5 Organizations shall examine information supplied with the products, including instructions, warranties, and technical data.

Chapter 5 Use

5.1 General.

5.1.1* Organizations shall provide users with the instructions provided by the manufacturer on the care, use, and maintenance of flame-resistant garments, including any warning provided by the manufacturer.

5.1.2 Organizations shall instruct workers in the limitations, use, care, and maintenance of flame-resistant garments, including the use of undergarments or overgarments.

5.1.3 For maximum protection, organizations shall require that flame-resistant garments be worn as described in the manufacturer's instructions.

5.1.4 Flame-resistant garment collars shall be worn closed.

5.1.5 Sleeves and cuffs shall be worn down and secured.

5.1.6 When a shirt and pair of trousers, both flame-resistant, are worn together, the shirt shall be tucked in.

5.1.7* Organizations shall require that protective neck, head, hand, and foot coverings be worn if the occupational hazard warrants their use.

5.1.8* Other personal protective equipment (PPE) shall be worn if determined as necessary from a review of the potential hazards to which workers are exposed from the hazard analysis.

5.1.9 Organizations shall not permit workers to wear non–flame-resistant clothing over flame-resistant garments.

5.1.10 Flame-resistant or nonmelting undergarments (closest to the skin) shall be used. An incidental amount of elastic used on nonmelting fabric underwear or socks shall be permitted.

5.2* Specific Requirements for Wearing Flame-Resistant Garments. The organization shall define those facilities and areas of the workplace and tasks that require personnel to wear flame-resistant garments.

Chapter 6 Care

6.1 Cleaning.

6.1.1* Flame-resistant garments shall be kept clean.

6.1.2* New flame-resistant garments shall be washed or dry-cleaned at least once prior to their initial use.

6.1.3* Flame-resistant garments shall be cleaned in accordance with manufacturer instructions, or if cleaning instructions are not provided, in accordance with the recommendations provided in ASTM F 2757-09, *Standard Guide for Home Laundering Care and Maintenance of Flame, Thermal and Arc Resistant Clothing*, or ASTM F 1449, *Standard Guide for Industrial Laundering of Flame, Thermal, and Arc Resistant Clothing*.

6.1.4 Flame-resistant garments shall be laundered or dry-cleaned with such frequency so as to prevent buildup of contaminants that reduce flame resistance.

6.2 Decontamination.

6.2.1* Flame-resistant garments contaminated by flammable substances, hazardous materials, or biological agents shall be cleaned and decontaminated in accordance with manufacturer instructions.

6.2.2* If decontamination instructions are not provided, or if decontamination is not recommended for the specific contaminant(s) and the contamination is judged to present hazards to the end user, then contaminated flame-resistant garments shall be disposed of.

6.2.3* Contaminated flame-resistant garments shall be handled in such a manner so as to prevent cross-contamination.

6.2.4 Contaminated flame-resistant garments shall not be laundered or dry-cleaned in public facilities.

6.3* Storage.

6.3.1 Flame-resistant garments shall be stored in accordance with manufacturer instructions.

6.3.2 Flame-resistant garments shall not be stored in direct or indirect sunlight.

6.3.3 Flame-resistant garments shall be clean and dry before long-term storage.

6.3.4 Flame-resistant garment storage areas shall be clean, dry, and well ventilated.

6.3.5 Soiled flame-resistant garments shall not be stored with personal belongings.

Chapter 7 Maintenance

7.1 Inspection.

7.1.1* The organization shall develop a systematic inspection program for all flame-resistant garments to confirm their serviceability.

7.1.2 The end user shall inspect flame-resistant garments for damage, soiling, or contamination after each use.

7.1.3 Inspections of flame-resistant garments shall be performed by the organization or the end user following each cleaning and following any use where there was potential for damage or contamination.

7.1.4 All flame-resistant garments shall be inspected by the organization or the end user for fabric or material damage.

7.1.4.1 The inspection shall include an examination of all components, including, if present, the outer shell, lining, interlining, wind/moisture barrier, hardware, wristlets, and reinforcements.

7.1.4.2 Damaged flame-resistant garments shall be immediately removed from service.

7.1.4.3 The decision to repair or retire the damaged flame-resistant garments shall be made by the organization.

7.1.5 All seams of the flame-resistant garment shall be inspected by the organization or end user for thread or seam damage as evidenced by skipped, broken, or missing stitches.

7.1.6 All hardware on the flame-resistant garment, including, but not limited to, zippers, buttons, snaps, and other fasteners, shall be inspected by the organization or end user for functionality.

7.1.7* The organization shall establish criteria for determining the extent of damage to a flame-resistant garment to warrant its removal from service for repair or disposal.

7.1.8* At intervals specified by the organization, a selection of protective garments shall be permitted to be removed from use, inspected, and tested to the performance requirements of NFPA 2112, *Standard on Flame-Resistant Garments for Protection of Industrial Personnel Against Flash Fire*.

7.2 Repairs.

7.2.1 Flame-resistant garments shall be repaired in accordance with the manufacturer's instructions.

7.2.2* Flame-resistant garments shall be cleaned as specified in Section 6.1 before undergoing repair work.

7.2.3* All repairs and alterations to flame-resistant garments shall be performed in the same manner and using the same materials as the manufacturer.

7.2.4* Each organization shall be permitted to keep records on repairs made to flame-resistant garments.

7.3 Retirement.

7.3.1 Damaged or deteriorated flame-resistant garments shall be retired when they can no longer be repaired.

7.3.2* Flame-resistant garments shall be retired when they exceed the manufacturer-stated service life, if indicated.

7.4* Disposal. Retired flame-resistant garments shall be destroyed or disposed of in a manner assuring that they will not be used for protection of industrial personnel.

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.1.1.1 The use of garments providing protection against short-duration thermal exposures from fire should be incorporated into a proper safety program that also utilizes appropriate administrative and engineering controls in addition to proper, safe work procedures.

Flame-resistant garments are available from a variety of manufacturers, in a range of items (e.g., coveralls, pants, shirts, vests, parkas, rainwear, disposable garments, aprons, etc.). Flame-resistant garments are made out of a variety of either inherently flame-resistant fabrics or fabrics that have been treated with a flame retardant.

NFPA 2112–compliant clothing is intended to reduce the probability and extent of burn injury during exposure or escape.

A.1.1.2 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*
(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, *Standard on Protective Clothing for Emergency Medical Operations*.

A.1.3.1 Anyone using this standard should consult the authority having jurisdiction and establish health and safety practices in conjunction with any existing applicable regulatory requirements prior to its use.

A.3.2.1 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.3.3.16 Flame Resistance. Flame resistance can be an inherent property of a material, or it can be imparted by specific treatment.

A.3.3.17 Flash Fire. A flash fire requires an ignition source and a hydrocarbon or an atmosphere containing combustible, finely divided particles (e.g., coal dust or grain) having a concentration greater than the lower explosive limit of the chemical. Both hydrocarbon and dust flash fires can generate temperatures from about 500°C to 1500°C. The intensity of a flash fire depends on multiple factors, including, but not limited to, type of fuel, heat release rate, environmental conditions, size, and type of the space. When ignited, the flame front can expand outward in the form of a fireball depending on the preceeding factors. The resulting effect of the fireball's energy with respect to radiant heat significantly enlarges the hazard areas around the gas released.

A.3.3.28 Organization. The organization can include contractors.

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. *(See 3.2.2.)*

A.4.2 Information and examples regarding hazard analysis and risk assessment can be found in the following publications: *Guidelines for Chemical Process Quantitative Risk Analysis (CCPS), JOIFF Handbook on Personal Protective Equipment (PPE) to Protect Against Heat and Flame*, and NFPA 550, *Guide to the Fire Safety Concepts Tree*.

A.4.2.3 These hazards include, but are not limited to, the following:

(1) Exposure to radiant and convective energy from fires
(2) Generation of static electricity on garments or other personal protective equipment (PPE) worn by workers
(3) Physical hazards
(4) Person-position hazards (work near waterways, on elevated platforms, or near roadways)
(5) Hazards created by the wearing of PPE

Also, the hazard classification of the work area needs to be determined, for example, chemical, electrical, or explosion.

A.4.2.5(1) Short-duration flame exposures can arise from numerous fire types in industrial environments. These fires include, but are not limited to, vapor cloud fires, jet fires, liquid fires (pool fires or running liquid fires), solids fires (fires of solid materials or dust fires), and fires associated with oxygen. Short-duration thermal exposures can also arise from the radiant energy generated by these fires (radiated by the flame front).

A.4.2.6 Examples of operations meeting the criteria include, but are not limited to, the following:

(1) Areas containing combustible dust in process equipment
(2) Processes containing flammable liquids or gases with an NFPA flammability rating of 4 (F4)
(3) Processes containing flammable liquids being processed above their flash point or boiling point

A.4.2.8.2 See A.4.2 for references to information on and examples of risk assessments.

A.4.3 The flame-resistant garments addressed in NFPA 2112, *Standard on Flame-Resistant Garments for Protection of Industrial Personnel Against Flash Fire*, provide a level of protection against unplanned exposure to fire [testing done at an intensity of 84 kW/m^2 (2.0 $cal/cm^2 \cdot sec$) and cumulative energy of 252 kJ/m^2 (6 cal/cm^2)] for relatively short periods of time. This standard directs end users to conduct a hazard analysis for the appropriate tasks and work environments prior to selecting flame-resistant garments. The protection identified in NFPA 2112 might not be appropriate for the thermal hazards faced or meet the PPE requirements of applicable OSHA regulations.

Flame-resistant garments can reduce the severity of burn injury as a result of a fire but cannot completely prevent an injury. Testing of selected garments and material systems is recommended at the hazard levels identified in the hazard analysis so that overall performance can be understood, especially in situations where egress times are approximate or the nature of the hazard might change.

Note that garments that continue to burn after a fire incident are hazardous. NFPA 2112 was developed specifically to minimize this hazard.

NFPA 2112 specifies several requirements for flame-resistant garments in terms of flame resistance, heat resistance, thermal shrinkage, and body burn prediction to a specific exposure. Descriptions of these performance requirements are provided in Annex B.

One requirement that warrants additional explanation is the manikin test requirement. This test involves placement of a flame-resistant garment on a manikin with exposure to a 3-second duration, 84 kW/m^2 (2.0 $cal/cm^2 \cdot sec$) intensity engulfment "jet" fire. The test is used as a qualification of garment fabric performance, not the garment design, since a standard garment design is used for evaluating the fabric. The standard garment is a coverall with a front slide fastener (zipper) closure and no pockets. Flame-resistant garments with different designs are not evaluated using this test. Organizations should judge the performance of their garment designs by comparing their design with that of the standard garment design or conduct independent testing. Garment designs that provide different areas of body coverage, have different closure systems, or have pockets can demonstrate lesser or better performance than the standard garment design.

A.4.3.1(1) Users are reminded that NFPA 2112, *Standard on Flame-Resistant Garments for Protection of Industrial Personnel Against Flash Fire*, provides certification to minimum thermal protective requirements. Garments can exceed the requirements of NFPA 2112. The result of the hazard analysis performed in accordance with 4.2.3 should identify a possible range of thermal exposures, which should be considered when selecting appropriate protective clothing.

The principal method used for evaluating the thermal protective characteristics of the fabric is the heat transfer performance (HTP) test, described in Annex B. Two different HTP ratings are provided from this test. "Spaced" HTP ratings are considered representative of those areas of the garment where air spaces exist between the garment and the wearer's skin. "Contact" HTP ratings are considered representative of those areas of the garment where the garment fabric is in direct contact with the wearer's skin. Consideration should be given to maximizing these values in relation to other garment fabric properties described in A.4.3.1(2) through A.4.3.1(8). Increasing HTP ratings can come at the expense of increased garment weight and reduced wearer comfort.

A.4.3.1(2) Fabrics used in the construction of flame-resistant garments have different physical characteristics. These characteristics can be based on the style of fabric construction (e.g., knit versus woven fabric) or other characteristics of the fabric such as its weight, thickness, and stiffness. Annex B provides a description of some of the physical characteristics of flame-resistant garment fabrics.

A.4.3.1(3) Flame-resistant garments are generally constructed of a primary fabric or set of fabrics but also include other fabrics and components. NFPA 2112, *Standard on Flame-Resistant Garments for Protection of Industrial Personnel Against Flash Fire*, addresses the performance of many of these components, but not all components. Emblems such as patches or logos are used to identify the organization or individual. Because emblems are usually constructed of non–flame-resistant materials (such as cotton or nylon), the overall area of the emblem should be minimized on the garment. For example, large company logos across the back of the garment should not be applied. A preferable approach when large logos or identifications are needed could be silk-screening with flame-resistant films. In addition, the use of several patches over the entire garment should be avoided.

A.4.3.1(4) The end user's body can store a large static charge. It is imperative that organizations not rely on clothing static-dissipative properties in place of grounding or other practices to avoid static charge buildup. Friction between clothing layers or between clothing and other surfaces can generate static electricity of sufficient energy to ignite combustible atmospheres. For these reasons it is important to minimize the buildup of static electricity on flame-resistant garments in order to prevent the garments from becoming a source of ignition. Therefore, workers should be grounded before entering a high-risk area and should avoid removing garments while inside the high-risk area.

At low humidity levels (less than 20 percent relative humidity), garments made from either natural fibers (such as cotton or wool) or synthetic fibers (such as aramids and rayon) that rely on water content to dissipate static electricity are not static dissipative. One approach to reduce the static of these garments is to use a static-dissipative treatment during laundering in keeping with the manufacturer's recommended care procedures. This treatment works by trapping water on the fabric to distribute the static charge through conductivity. The static-dissipative treatment needs to be added during each laundering cycle according to most manufacturers' instructions. Overdrying in the dryer should also be avoided to minimize static buildup. The organization should verify with the manufacturer that the static-dissipative treatment does not reduce the flame resistance or other properties of the garment.

An alternative approach is to use garments made of inherently static-dissipative fibers or other equally efficient anti-static construction. These blended fibers dissipate static charges by induction and are effective regardless of the environmental conditions, where the relative humidity can be 20 percent or less.

A.4.3.1(5) Flame-resistant garments are available in different types such as coveralls, shirts, trousers, jackets, and rainwear. These garments can be constructed of single-layer or multilayer fabrics. In addition, the garments can include different design features such as closures (zippers, snaps, or buttons) and pockets. The selection of the design type should consider the work environment, the types of other clothing or equipment to be worn, and the tasks being performed by the wearer.

A.4.3.1(6) The selection of the garment should take into consideration the working conditions of the end users wearing the garments. Conditions include the range of temperatures and relative humidities, the location of the work, and the tasks to be performed by the wearer.

A.4.3.1(7) Several factors relate to fabric or garment comfort, including fabric weight and thickness, air permeability, water vapor transport, evaporative resistance, moisture regain, and wickability. Comfort assessment also has a subjective dimension that is not readily measured in a laboratory. Wear trials are recommended and often provide other useful information.

A.4.3.1(8) Certain fabrics can be laundered, while others should be subjected to special cleaning procedures such as dry cleaning. The organization should consider the cleaning procedures associated with a particular fabric or garment type for its selection. In addition, the fabric's durability should also be a consideration for selection.

A.4.3.3 The selection of garments should include consideration that removing the garment following a thermal exposure limits the transfer of heat to the body from the garment.

A.4.3.5 Flame-resistant garments should fit for maximum protection and comfort on the job. Users should be aware that the fit of the garment (i.e., too tight or too loose) can have a direct influence on how much protection can be provided by a particular garment or garment system.

A.4.4.1 Organizations should require evidence of certification to NFPA 2112, *Standard on Flame-Resistant Garments for Protection of Industrial Personnel Against Flash Fire*, as part of the specification package. The evidence of certification should include the name of the certification organization, its address, phone number, and a contact name. This certification can be further verified by contacting the certification organization directly to determine if the flame-resistant garment has been certified and meets the requirements of NFPA 2112.

Evidence of certification for a flame-resistant garment can also be determined by examining the product label. The product label should include the mark of the certification organization.

A.4.4.2 Any additional specifications should be provided as specific performance criteria with a minimum or maximum requirement, as appropriate, together with a reference to a specific test method.

A.5.1.1 Organizations should train their workers in the proper use and care of flame-resistant garments. The basis of this training should, as a minimum, be the user information provided by the manufacturer of the flame-resistant garment. Manufacturers are required to provide extensive information about their flame-resistant garments in the form of user information as specified by NFPA 2112, *Standard on Flame-Resistant Garments for Protection of Industrial Personnel Against Flash Fire*. This information includes the following:

(1) Pre-use information
   (a) Safety considerations
   (b) Limitations of use
   (c) Garment 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) Use considerations
(6) Maintenance and cleaning
   (a) Cleaning instructions and precautions
   (b) Decontamination instructions and precautions
   (c) Maintenance criteria and methods of repair, where applicable
(7) Retirement and disposal criteria

End user training should also encompass when and where to wear flame-resistant garments and specific organization policies regarding the wearing of flame-resistant garments.

A.5.1.7 Organizations should recognize the need for wearing other types of PPE while wearing flame-resistant garments. Other types of PPE include, but are not limited to, head protection, eye and face protection, foot protection, fall protection, personal flotation devices, high-visibility garments, and other types of garments. As with the use of flame-resistant garments, the selection of other PPE should be based on the hazard analysis . It is also important that the other selected PPE be compatible with and not adversely affect the performance properties of the flame-resistant garments. *(See A.5.1.8.)*

A.5.1.8 Organizations and end users are cautioned that wearing overgarments or other PPE that are not flame-resistant over flame-resistant garments can compromise the performance of the flame-resistant garments. Clothing or items worn over flame-resistant garments that are not flame-resistant, such as jackets, rainwear, and high-visibility vests, can ignite and transfer significant heat through the flame-resistant garment and to the exposed body areas such as the head and face, causing severe burn injuries.

Undergarments should be melt-resistant. Certain synthetics or synthetic blends worn as undergarments can be inappropriate for use under flame-resistant garments, since the transferred heat could cause them to melt. Undergarments with melt-resistant properties are recommended (e.g., cotton, aramid, wool).

A.5.2 Employees should be required to wear flame-resistant garments in facilities or areas where any of the following materials or conditions are present:

(1) Materials having a degree of hazard of 4 when ranked in accordance with NFPA 704, *Standard System for the Identification of the Hazards of Materials for Emergency Response*, where flammable vapors are present in normal operations
(2) Materials having a degree of hazard of 3 when ranked in accordance with NFPA 704, at temperatures above their flash points where flammable vapors are present in normal operations
(3) Materials having a degree of hazard of 2 or 1 when ranked in accordance with NFPA 704, when heated above their boiling points where flammable vapors are present in normal operations
(4) Combustible dust (components present in the material where particle size is less than 75 microns, required ignition energy is less than 100 mJ, and moisture content is less than 10 percent), where such dust is present in normal operation

Flame-resistant garments should be required for specific tasks for employees working in areas meeting any of the following process hazards and performing a task where the hazard analysis indicates that the work increases the possibility of loss of containment of the material:

(1) Processes involving materials having a degree of hazard of 4 when ranked in accordance with NFPA 704, where flammable vapors will be present only if loss of containment occurs
(2) Processes involving materials having a degree of hazard of 3 when ranked in accordance with NFPA 704, at temperatures above their flash points where flammable vapors will be present only if loss of containment occurs
(3) Processes involving materials having a degree of hazard of 2 or 1 when heated above their boiling points when ranked in accordance with NFPA 704, where flammable vapors will be present only if loss of containment occurs and experience indicates a frequency of incidents due to equipment design or arrangement
(4) Processes involving combustible dust [components present in the material where particle size is less than 75 microns, required ignition energy is less than 100 mJ (1 micron (μ) = 10^{-6} m), and moisture content is less than 10 percent], where such dust is present in enclosed systems and loss of containment is required to generate a dust cloud

Examples of combustible dust environments include locations of operations where charging equipment is used with dusty materials, locations where dust is present on equipment or structural members, and areas where filter bags in dust collectors are changed.

Additional information is offered in *Assessing Flame-Resistant Clothing Use, CMA Manager's Guide*.

Engineering controls designed to reduce exposure to materials present in normal operation and experience should be considered in the evaluation of areas or tasks requiring the wearing of flame-resistant garments. Where multiple tasks require the wearing of flame-resistant garments, consideration should be given to standardization of the garment as normal work wear for the area.

A.6.1.1 Adequate cleaning of flame-resistant garments, according to the manufacturers' recommendations, by laundering or dry cleaning is imperative in order to maintain flame resistance and thermal protection. Soiling can reduce the protective qualities and increase the risk of second- and third-degree burns. Garments that are contaminated with a significant amount of oily soil or a flammable substance should be decontaminated (or cleaned) to remove the substance.

A.6.1.2 Initial washing or dry cleaning of flame-resistant garments removes fabric finishes that are added for ease in manufacturing and makes garments less stiff prior to use.

A.6.1.3 Note any laundry precautions on the garment label that will lessen the effectiveness of the garment's flame resistance, in particular the following:

(1) Whether the use of chlorine bleach is advised or should be avoided
(2) Whether a heavy-duty soap can be used or whether laundering should be limited to a heavy-duty synthetic detergent

Some soaps and detergents for dry cleaning can rapidly affect the flammable properties of protective garments. Certain petroleum solvents should be avoided, as they commonly leave flammable grease deposits and reduce protective properties.

A.6.2.1 Contamination can occur from exposure to hazardous chemicals or biological agents. Hazardous chemicals can include solvents, acids, bases, and other substances that could leave a visible stain on garment fabrics. These chemicals could affect garment performance properties but can otherwise pose health hazards to the wearer if not removed through decontamination. Some chemicals, especially heavy organic solvents, can leave a flammable residue on the flame-resistant garment that will affect its level of protection. Other organic chemicals can cause dermatitis or other reactions with the skin, or can cause long-term health effects that do not become evident until much later after the exposure. Acids and bases can cause physical deterioration of garment fabrics or components and cause burns to the end user if not removed. The most common form of biological contamination is from blood or other body fluids from persons other than the end user. Based on Centers for Disease Control (CDC) regulations, all blood and body fluids should be assumed to contain bloodborne pathogens (e.g., human immunodeficiency virus or hepatitis). CDC guidelines prescribe that the combination of high wash temperatures [greater than 60°C (140°F)] and detergents should be used to inactivate this biological contamination. Specific regulations addressing protection from bloodborne pathogens are contained in 29 CFR 1910.1030, *Occupational Exposure to Bloodborne Pathogens, Final Rule*.

A.6.2.2 On a case-by-case basis, the organization should attempt to identify and assess the contamination of flame-resistant garments. The organization should also contact the manufacturer to determine if specific procedures are recommended for removing the particular contaminant(s). If safety and health data for the contaminant indicate a potential harm to the end user, and no specific guidelines are offered by the manufacturer to remove the specific contaminant, then the affected flame-resistant garments should be disposed of. Organizations should also consult with outside cleaning facilities to determine if services are available that can be effective in decontaminating the affected flame-resistant garments.

A.6.2.3 Flame-resistant garments that are suspected of being contaminated with hazardous substances should be segregated from uncontaminated flame-resistant garments. As a

minimum, persons handling contaminated flame-resistant garments should wear protective gloves. Persons handling contaminated flame-resistant garments should also wear protective aprons and respirators as necessary, depending on the type and hazards of the contamination present. Contaminated flame-resistant garments should not be returned to service until the organization has made an assessment that the contamination has been removed. In some instances, this can require that contaminated flame-resistant garments be extracted and evaluated for the presence of contaminants.

A.6.3 Appropriate storage practices for flame-resistant garments include storing garments inside out of direct sunlight in a dry, ventilated area. Flame-resistant garments are preferably stored on hangers. Cleaned flame-resistant garments should be stored in a separate area from uncleaned flame-resistant garments. Manufacturers should advise if any deleterious effect of storage is known.

A.7.1.1 One effective practice for routinely and systematically inspecting all clothing is to inspect garments after they have been cleaned. Organizations using outside cleaning services establish criteria and have the outside cleaning organization perform this function and then report any garment discrepancies to an identified representative within the organization.

A.7.1.7 The criteria used for determining when to retire or repair flame-resistant garments should provide measurable or easily identifiable damage. Examples of possible damage that should be listed by the organization include the following:

(1) Missing components (pockets, linings, reflective striping)
(2) Areas of fabric that show a significant reduction of fabric thickness (by more than 25 percent) as compared to new garment fabric material when measured using an appropriate fabric thickness gauge
(3) Discoloration of fabric over more than 10 percent of the garment that cannot be accounted for
(4) Holes in or abraded areas of the outer fabric layer that are greater than 645 mm^2 (1 $in.^2$)
(5) Individual rips, tears, or punctures in the garment fabric that are longer than 25 mm (1 in.) in length
(6) Individual seams showing separation or thread loss for a distance greater than 25 mm (1 in.) in length
(7) Missing, corroded, or nonfunctional hardware

A.7.1.8 Although periodic testing of flame-resistant garments can yield information about specific changes in tested garments, this approach is capable of providing only limited information about the overall use of flame-resistant garments from which samples are taken. The extent of wear and changes in the performance properties of flame-resistant garments will be dependent on the specific use and care of the individual garments sampled. Sampling of garments for testing to provide a determination of the overall lot of flame-resistant garments used requires a relatively large number of garments. This is not practical since specimens need to be taken from each flame-resistant garment, effectively destroying each tested garment. Furthermore, it is likely that flame-resistant garments used by an organization will involve different wearing histories that do not predict performance of all flame-resistant garments for that organization.

A.7.2.2 It is important that garments be clean, dry, and free from contamination before repairs are attempted to minimize the spread of contamination to repair workers.

A.7.2.3 Methods and materials include, but are not limited to, fabric, thread type, stitch construction, and hardware.

When repairs are made to flame-resistant garments, it is important that the fabrics and components used for repairing the garments be the same as the original fabrics or components used in their construction to avoid reducing the performance properties of the flame-resistant garment. It is especially important that the fabrics and components used in repairs meet the performance requirements specified in NFPA 2112, *Standard on Flame-Resistant Garments for Protection of Industrial Personnel Against Flash Fire*. For example, non–flame-resistant fabrics should never be used as patches or replacement pockets on flame-resistant garments. Thread used in stitching repaired areas should meet the melting temperature requirement in NFPA 2112.

A.7.2.4 Organizations could find it useful to track the repairs on flame-resistant garments in order to monitor their life cycle. This practice will require that each garment has a unique identifying number or other means for separately tracking specific flame-resistant garments. Information that could be kept as part of these records includes, but is not limited to, the following:

(1) Garment manufacturer
(2) Manufacturer's garment identification
(3) Date of production
(4) Date of repair
(5) Who performed the repair
(6) Brief description of the repair
(7) Person authorizing return of the garment to service

A.7.3.2 Some manufacturers can specify a maximum service life based on the total number of cleanings that a flame-resistant garment is subjected to or other criteria. If the life cycles (e.g., time of service, length of wear, number of cleanings and repairs) of specific flame-resistant garments are tracked, then it should be possible for the organization to determine which garments have reached the maximum service life, if specified.

A.7.4 Organizations should either destroy or mark retired flame-resistant garments in a manner that is clear to anyone picking up the garment that it cannot be used for protection of industrial personnel. Methods for ensuring this practice include cutting clothing into pieces or marking "Do Not Use for Protection" on the outside of the clothing.

Annex B Properties for Evaluating Flame-Resistant Garments

This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

B.1 Properties and Test Methods. Table B.1, extracted from NFPA 2112, *Standard on Flame-Resistant Garments for Protection of Industrial Personnel Against Flash Fire*, 2012 edition, provides a description of the test properties and methods used for evaluating flame-resistant garments. A number of additional properties can be used in the evaluation of flame-resistant garments that are not required as part of this standard. Table B.1 also lists these additional properties, recommended test methods, and their suggested applications. The section numbers referenced in Table B.1 refer to sections in NFPA 2112.

Table B.1 Performance Properties and Additional Evaluation Properties for Flame-Resistant Garments

Property (Section No.)	Test Method Cited	Description of Test Method	Application of Test Method
Mandatory Tests			
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^2 (2.0 cal/cm^2 sec). A weighted sensor containing a copper calorimeter is placed on top of the specimen and measures the heat transfer through the specimen. A water-cooled shutter between the specimen and heat source is withdrawn to begin the exposure. The test measures the amount of time with continuous heating for heat breakthrough resistance (using an arbitrary criterion of heat through the specimen to cause a second-degree burn). This time is multiplied by the exposure heat flux to provide an HTP rating. HTP ratings are measured with the sensor both in "contact" with the specimen and "spaced" 6 mm (¼ in.) away from the specimen. Note that this test method does not result in a burn injury prediction. The heat remaining in a test sample is not accounted for, which would otherwise contribute to a predicted skin burn injury.	This test is a measure of the unsteady state heat transfer properties of garment materials. The HTP test uses an exposure heat flux that is representative of a JP4 (Jet Fuel) pool fire environment. NFPA 2112 requires that specimens have an HTP rating of 12.6 J/cm^2 (3.0 cal/cm^2) or more when measured in "contact," simulating direct contact with the skin, and 25 J/cm^2 (6.0 cal/cm^2) 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 D 6413; 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 (¾ in.) into the flame for 12 seconds. After exposure to the flame, the amount of time during which the specimen continues to burn (after-flame) is recorded. The length of the burn or char length is then measured by attaching a weight to the specimen and measuring the length of the tear along the burn line. Observations are recorded if any melting and dripping are observed. Samples are tested in this manner both before and after 100 wash/dry cycles or 100 dry cleaning cycles.	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.

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 flash 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 (7.1.4/7.3)	Method appears in Section 8.4; washing and drying per commercial laundering procedure or dry cleaning (3 cycles)	The exposure used for thermal shrinkage above 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 fabrics and components react to the high heat that could occur during a flash fire. The purpose of the test is to prevent materials or components that will easily ignite, melt, drip, or separate during exposure to high heat from being used in garments.
Manikin testing (7.1.5)	ASTM F 1930; washing and drying per commercial laundering procedure or dry cleaning (1 cycle) (Section 8.5)	The fabric is made into a standardized coverall design and placed on an instrumented manikin that is dressed in cotton underwear. The manikin is subjected to an overall flame and heat exposure averaging 84 kW/m^2 (2.0 $cal/cm^2 \cdot sec$) 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 coverall design. NFPA 2112 requires a body burn prediction of 50 percent or less of the surface area covered by sensors (hands and feet are excluded). Lower percent body burn predictions indicate greater protection provided by the fabric.
Thread melting resistance (7.2)	FTMS 191A, 1534 (Section 8.6)	A small segment of thread used in the stitching of station/work uniforms is placed in a flask containing an organic solvent and heated. (The solvent extracts substances that would interfere with the test.) Next, the extracted thread segment is put in a device that slowly heats the thread. The temperature at which the thread begins to melt is the melting temperature.	Thread used in flame-resistant garments must withstand temperatures of up to 260°C (500°F). If the melting temperature is less than 260°C (500°F), the thread fails the test. The temperature, 260°C (500°F), is consistent with the heat resistance test.

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Table B.1 *Continued*

Property (Section No.)	Test Method Cited	Description of Test Method	Application of Test Method
Label legibility (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.).
Other Property Evaluations			
Fabric weight	ASTM D 3776	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 D 5034	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 D 1424	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 D 3787	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.

Table B.1 *Continued*

Property (Section No.)	Test Method Cited	Description of Test Method	Application of Test Method
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.
Dry cleaning colorfastness	AATCC 132	A fabric sample is subjected to controlled dry cleaning conditions. Following exposure, the color of the material sample is compared to a color scale chart that indicates the degree of a color change. Color scale ratings range from Grade 1 (change in color) to Grade 5 (negligible or no change) in 0.5 increments.	Dry cleaning colorfastness assesses the amount of color change, or fading, that occurs in the fabric following exposure to dry cleaning solvents. Fabrics with high color scale ratings are more resistant to color changes in dry cleaning.
Crocking colorfastness	AATCC 8	In this test method, a fabric sample is placed in a device against a white transfer cloth. The device rubs the fabric against the transfer cloth. The amount of color that is transferred to the white transfer cloth is assessed by a rating scale of Grade 1 to 5 in 0.5 increments (similar to laundering colorfastness).	Crocking colorfastness is a measure of the amount of color or dye that is transferred from the fabric by rubbing or abrasion. Fabrics with high color scale ratings are more resistant to loss of color through rubbing from wearing.
Light colorfastness, continuous xenon-arc lamp exposure	AATCC 16, Option e	A fabric specimen is placed in a weatherometer using a water-cooled xenon-arc lamp, which simulates intense exposure to sunlight and humidity. The exposure test is conducted for a total of two weeks. Following the exposure, the fabric is compared to a color scale chart that indicates the degree of color change. Color scale ratings range from Grade 1 to 5 in 0.5 increments (similar to laundering colorfastness).	Light colorfastness is a measure of the amount of color loss in a fabric due to extended exposure to light. Fabrics with high color scale ratings are more resistant to fading when exposed to outdoor light.

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Table B.1 *Continued*

Property (Section No.)	Test Method Cited	Description of Test Method	Application of Test Method
Seam efficiency	ASTM D 1683	The strength of a seam is measured in the same way as fabric tensile strength. In this test, a garment seam specimen is placed between two grips in a tensile testing machine and pulled in a direction perpendicular to the seam line until it breaks. The force to break the seam can be compared to the force to break the fabric by itself. The location of the break in the specimen can also be reported.	Seam efficiency compares the strength of a seam to the fabric that it joins. Higher seam strength indicates stronger seams; however, seams that break in the fabric, as opposed to at the stitching or seam area, are stronger than the fabric itself.

Annex C Informational References

C.1 Referenced Publications. The documents or portions thereof listed in this annex are referenced within the informational sections of this standard and are not part of the requirements of this document unless also listed in Chapter 2 for other reasons.

C.1.1 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 550, *Guide to the Fire Safety Concepts Tree*, 2012 edition.

NFPA 704, *Standard System for the Identification of the Hazards of Materials for Emergency Response*, 2012 edition.

NFPA 1971, *Standard on Protective Ensembles for Structural Fire Fighting and Proximity Fire Fighting*, 2013 edition.

NFPA 1977, *Standard on Protective Clothing and Equipment for Wildland Fire Fighting*, 2011 edition.

NFPA 1991, *Standard on Vapor-Protective Ensembles for Hazardous Materials Emergencies*, 2005 edition.

NFPA 1992, *Standard on Liquid Splash–Protective Ensembles and Clothing for Hazardous Materials Emergencies*, 2012 edition.

NFPA 1999, *Standard on Protective Clothing for Emergency Medical Operations*, 2013 edition.

NFPA 2112, *Standard on Flame-Resistant Garments for Protection of Industrial Personnel Against Flash Fire*, 2012 edition.

C.1.2 Other Publications.

C.1.2.1 AATCC Publications. American Association of Textile Chemists and Colorists, P.O. Box 12215, Research Triangle Park, NC 27709.

AATCC 8, *Colorfastness to Crocking: AATCC Crockmeter Method*, 2007.

AATCC 16, *Colorfastness to Light (Option 3)*, 2004.

AATCC 61, *Colorfastness to Laundering, Home and Commercial: Accelerated*, 2009.

AATCC 132, *Colorfastness to Dry Cleaning*, 2009.

AATCC 135, *Dimensional Changes of Fabrics After Home Laundering*, 2004.

C.1.2.2 AIChE Publications. American Institute of Chemical Engineers, 345 East Street, New York, NY 10017.

Guidelines for Chemical Process Quantitative Process Risk Analysis (CCPS), 2000.

C.1.2.3 ASTM Publications. ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959.

ASTM D 1424, *Standard Test Method for Tearing Strength of Fabrics by Falling Pendulum Type (Elmendorf) Apparatus*, 2009.

ASTM D 1683, *Standard Test Method for Failure in Sewn Seams of Woven Apparel Fabrics*, 2007.

ASTM D 3776, *Test Methods for Mass Per Unit Area (Weight) of Woven Fabric*, 2009.

ASTM D 3787, *Standard Test Method for Bursting Strength of Textiles: Constant-Rate-of-Transverse (CRT) Ball Burst Test*, 2007.

ASTM D 5034, *Standard Test Method for the Breaking Strength and Elongation of Textile Fabrics (Grab Test)*, 2009.

ASTM D 6413, *Standard Test Method for Flame Resistance of Textiles (Vertical Test)*, 2008.

ASTM F 1930, *Standard Test Method for Evaluation of Flame Resistant Clothing for Protection Against Flash Fire Simulations Using an Instrumented Manikin*, 1998 (Reaffirmed 2008).

C.1.2.4 GSA Publications. U.S. General Services Administration, Specifications Activity, Printed Materials Supply Division, Building 197, Naval Weapons Plant, Washington, DC 20407.

Federal Test Method Standard 191A, *Textile Test Methods*, July 20, 1978.

C.1.2.5 U.S. Government Publications. U.S. Government Printing Office, Washington, DC 20402.

Title 29, Code of Federal Regulations, Part 1910.1030, "Occupational Exposure to Bloodborne Pathogens, Final Rule."

C.1.2.6 Other Publications. Fulcrum Consultants, *JOIFF Handbook on Personal Protective Equipment (PPE) to Protect Against Heat and Flame*, 2007.

C.2 Informational References. The following documents or portions thereof are listed here as informational resources only. They are not a part of the requirements of this document.

C.2.1 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 472, *Standard for Competence of Responders to Hazardous Materials/Weapons of Mass Destruction Incidents*, 2013 edition.

NFPA 473, *Standard for Competencies for EMS Personnel Responding to Hazardous Materials/Weapons of Mass Destruction Incidents*, 2013 edition.

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

NFPA 1983, *Standard on Life Safety Rope and Equipment for Emergency Services*, 2012 edition.

C.2.2 Other Publications.

C.2.2.1 AATCC Publications. American Association of Textile Chemists and Colorists, P.O. Box 12215, Research Triangle Park, NC 27709.

AATCC Evaluation Procedure 8, *AATCC 9-step, Step Chromatic Transference Scale*, 2007.

C.2.2.2 ACGIH Publications. American Conference of Governmental Industrial Hygienists, 1330 Kemper Meadow Drive, Cincinnati, OH 45240-1634.

TLVs and BEIs, 2006.

C.2.2.3 ASTM Publications. ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959.

ASTM D 6431, *Standard Guide for Using the Direct Current Resistivity Method for Subsurface Investigation*, 1999 (Reaffirmed 2005).

ASTM F 2757, *Standard Guide for Home Laundering Care and Maintenance of Flame, Thermal and Arc Resistant Clothing* , 2009.

C.2.2.4 CMA Publications. Chemical Manufacturers Association (now American Chemistry Council), 1300 Wilson Boulevard, Arlington, VA 22209.

Assessing Flame-Resistant Clothing Use, CMA Manager's Guide, July 1997.

C.2.2.5 U.S. Government Publications. U.S. Government Printing Office, Washington, DC 20402.

NIOSH Pocket Guide to Chemical Hazards, 2005.

C.2.2.6 Other Publications. Sax, Irving N., *Dangerous Properties of Industrial Materials*, New York: Van Nostrand Reinhold Co., 1979.

C.3 References for Extracts in Informational Sections.

NFPA 2112, *Standard on Flame-Resistant Garments for Protection of Industrial Personnel Against Flash Fire*, 2012 edition.

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